

**14<sup>th</sup> IQC**  
QUALITY  
RESEARCH

**International Quality Conference**

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# **14. International Quality Conference**



**CONFERENCE MANUAL**

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**14<sup>th</sup> IQC**  
**QUALITY  
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# **14. International Quality Conference**



**PLENARY SESSION**

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Slavko Arsovski <sup>1</sup>

## THE SUSTAINABLE TRANSITION FROM QUALITY 4.0 TO QUALITY 5.0: A ROLE OF SUSTAINABLE, SPIRITUAL AND INTELLIGENT LEADERSHIP IN CREATION OF INTANGIBLE CAPITAL FOR FUTURE

**Abstract:** *A world is in process of rapid changing in all areas of living. In all of them exists old and new problems with urgent needs for solving. Transition from Industry 3.0 to Industry 4.0 changed view on industry in 21st century and also there are challenges based on Quality 3.0 and Quality 4.0 concept. In last ten years is developed concept of Japan's „Society 5.0“ which needs Quality 5.0 concept. This is main motive for researching possibility for transition quality into Quality 5.0 concept. In the paper are presented basic information about Industry 4.0 and Quality 4.0 based on new challenges in 21st century. Based on literature and own research is defined concept of Quality 5.0 and ways of transition to Quality 5.0, specially in transition counties as Serbia in next 30 years. The first analysis pointed out that it is possible with using intangible capital-including smart technologies, smart leadership, smart people and other smart „things“ for achieving smart/integrated quality, quality of life, resilience and all human-centric activities. The new concept of Quality 5.0 needs new role of leadership (Sustainable, Spiritual, Intelligent Leadership), the new model of the effective transition from Quality 4.0 to Quality 5.0 and creating quality capital needed for the future.*

**Keywords:** *Transition from Quality 4.0 to Quality 5.0. Sustainable, Spiritual and Intelligent Leadership, Intangible capital, ANN, DEA, Grounded theory, Reframing organizations*

### 1. Introduction

A digital future is started in 21. century and in four waves Tompston N. (2014) is recognized as key for resolving different socio technological challenges. It practically means that is necessary to review existing and create new business models and paradigms as. (1) Sustainable Intelligent, and Spiritual Leadership (SISL), (2) Industry 4.0,

(3) Quality 4.0, (4) Quality 5.0 and (5) intangible for its transition.

In new digital era business and social environment is also changing because concepts of Industry 4.0 and Society 5.0 need new view of a future of civilization. Now is necessary to include redesigned old and created new paradigms related to intangible capital as: SISL capital, knowledge capital, intellectual capital and

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other with mutual impact on quality and society as whole. In area of leadership are developed Intelligent Leadership, ICT Leadership, Cultural Leadership, Shared Leadership, Team Leadership, Change Leadership, Ethical Leadership, Complexity Leadership, Smart Leadership, Virtual Leadership and so on.

In Industry 4.0 concept of fourt industri revolution dominant role have smart technologies, smart manufacturing, smart factories (enterprises), cyber-physical systems, cloud manufacturing, Internet of Things (IoT), and others.

Related to concept of Industry 4.0 is developed concept of Quality 4.0 which covers aspects of technologies for quality, human resources for quality and processes related to quality. These aspects are analyzed in future chapters using identified sub-variables.

In concept Quality 5.0 defined by works of Arsovski S. (2019) are included soft factors related to cultural, social and eco-environment. On maturity top level of Quality 5.0 impact has a man with his spiritual, biological and social performances.

A capital needed for efficient and effective transition from Quality 4.0 to Quality 5.0 is key for this transition. For it is more important intangible capital. All emphasized factors are more detailed described in next chapters.

The purpose of the research presented in the article is to integrate a key enablers for efficient and effective transition from Quality 4.0 to Quality 5.0 in a Enterprises.

The goal of presented research is threefold, i.e.. (1) defining concept of SISL, (2) defining model of smart transition from Quality 4.0 to Quality 5.0, and (3) simulate impact of SISL and maturity level of Quality 4.0 on Quality 5.0 concept in praxis..

In the presented research are used the new research model with four independent variables (SISL), Quality 4.0 maturity,

Intangible capital, and Quality 5.0 as dependent variable. For creating the model is used Grounded theory, reframing organization concept and Process Modeling approaches.

The theoretical novelty includes: (1) model of transition from Quality 4.0 to Quality 5.0, (2) defining SISL, (3) analysis of key enablers in the proposed model using statistical methods Artificial Neural Network (ANN) and DEA methods for predicting the success of transition.

The practical novelty are results of case study based on research of 235 enterprises in potential for the transition and simulation of impact of key enablers on transition process.

## **2. Literature review**

The literature review is made based on levels of maturity of new quality concepts (figure 1). Among them are common areas and time for resolving dilemas, goals, needed intangible capital and so on. In Serbia, as developing cantry, dominant role has Quality 3.0 concept in last ten years. The process of transition to Quality 5.0 is very complex and is described partly in literature with emphasizing soft factors as SISL and intangible capital.

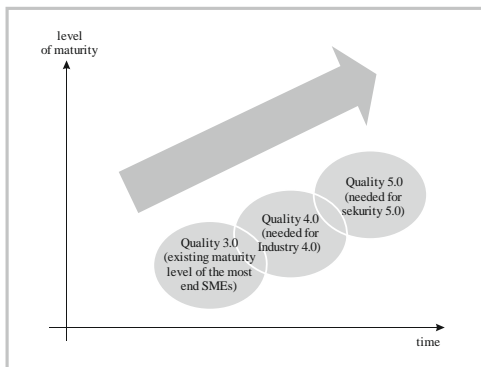
The first identified variable in the model is SISL related to new role of leadership.

A leadership in the digital age according Khan S. (2016) has three interconnected concepts i.e.: (1) value based leadership, (2) transformational leadership, (3) autentic leadership.

Fry L. (2016) defined model of spiritual leadership with impact on spiritual well-being and triple botton line. It starts from hope/vision, inner life and altruistic love. In the middle of the model are calling and membership. At the end are life satisfaction, social responsibility, performance excellence, organizational productivity, organizational

commitment, and employee engagement.

Fry I. And Matherly L. (2006) in one exploratory study analyzed spiritual leadership and organizational performance on the proposed model, using SLT survey questions they find high correlation among variables: (1) hope/faith and altruic love, vision, (2) vision to altruistic love and calling meaning, (3) meaning/calling for achieving sales, organisational commitment, (4) membership to organizational commitment and productivity).



**Figure 1.** Levels of maturity

For new age in the work of Khan S. (2016) are proposed perspectives of holistic leadership, virtual leadership and hub-and networked-based leadership.

Sustainable leadership is based on theory of sustainability through three types of indicators: (1) economic, (2) social and (3) environmental in different business and social areas (Brandt E., 2016; Malik H., Mahmood M., 2022., Kanters N., 2013). According standard ISO 9004:2009 are emphasized five maturity level, i.e.: (1) the leadership is reactive and based on top-down instructions, (2) leadership is reactive and based on decisions by managers at different organisation levels, (3) leadership is proactive and the authority to take decisions is delegated, (4) leadership is reactive with high involvement of the employees in

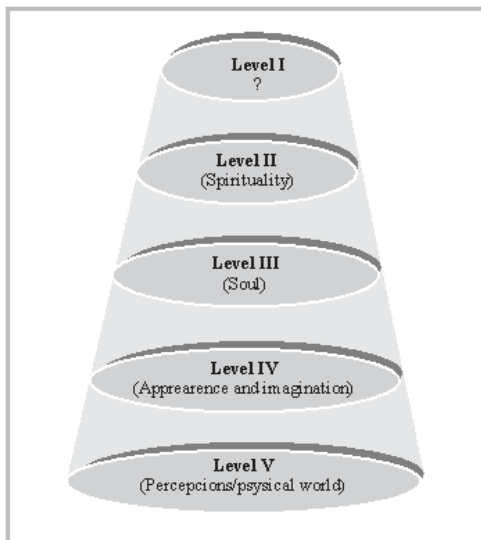
decision making, (5) leadership is reactive and learning-oriented with the empowerment of people at all levels. In this standard a sustainable structure is related to following components used for the own research: (SS1) organizational effectiveness for achieving desired sustainable levels, (SS2) knowledge and skills of the staff, (SS3) motivation of the staff and (SS4) social, environmental, legal and business pressures for achieving desired level of sustainability.

Intelligent leadership is concept developed for intelligent organizations, as organizations in concept Industry 4.0 (Sydänmaanlakka P., 2003). In proposed leadership model a intelligent leadership can be defined as follows: „Intelligent leadership is a dialoge between leader(s) and folowers where they come together in a certain situations in order to achieve shared vision (purpose) and take place in a certain team and organization which is shaving same values and culture. The macro environment-industry and society-also affects this process“. On this way is possible to achieve an efficient, learning and well-being organization. For this role of leaders have to develop a lot of new competences, including digital oriented knowledge, artificial intelligence, orientation to change, what is used as components for own research.

Spiritual leadership (SL) is developed as incorporation of spirituality into leadership concept (Burke R., 2006). He analyzed different aspects of leadership and introduced role of spirituality which included ethical, responsible sustaining, hope inspiration and purpose. Fry L. and Kriger M. (2009) introduced term spiritual intelligence as a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from expirience. It is not merely book learning, a narrow academic skill or test-taking smarts. Rather, it reflects a broader and deeper capability for

comprehending our suproundings – „catching on“, „making sense“ of things, or „figuring out“ that to do.

All of them are used as components SL They made hierarchy with five levels of spiritual intelligence: (5) the sensible/physical world, (4) images and imagination, (3) the soul, (2) spirit, and (1) SQ based on in the nondual in oneness and constant reconcillation of apparent opposities (figure 2).



**Figure 2.** Levels of leadership and human being

### 2.1. Performances related to Industry 4.0

According study of Deloitte (2008) the fourth industrial revolution (Industry 4.0) has four main carracteristics:

1. Vertical networking of smart production systems,
2. Horizontal integration using a new generation of global value-creation network with integration of business processes in business environment (business partners, customrs, new global business and cooperation models),
3. Engineering throughtout the entire value chain in the entire product life

cycle,

4. Acceleration through emerging technologies capable for mass-market applicatia with increased compatitivity based on productivity, security, safety, reducing risks and vulnerability, quality etc.

Government has to promote to radical innovation, as conditio sine qua non for long term competivity and sustainability (Kelly R., 2019). using bibliometric and bibliographic analysis they identity research fields and stage of growth necessary for radical innovation.

An Industry 4.0 environment exists with smart enterprise in center connected with after smart elements as: smart mobility, smart grid, smart logistics, smart buildings, smart homes, social web, business web, cyber-physical production systems (CPPs), and smart people with smart specialization. On the periphery are: Internet of things, Internet of services, Internet of people, and Internet of data.

In study of Deloitte (2018) are analyzed Switzerland readiness for Industry 4.0. On scale 1 – 5 in most enterprises are reorgnized needs for digital transformation to Industry 4.0 (more then 80%), but feeling the impact in company on Industry 4.0 were between 3 – 4 (more then 52% ansvers), high involvement of customers in process transformation into Industry 4.0 (more than 67%), middle range of resource efficiency for analyzing production process (between 2,3,4 about 75%), and high cyber risk (more than 86% of ansvers). Also, dominant current transformational segments and future potential on scale 1-5 were highest in: (1) research and development 43%, (2) procurement and purchasing -39%, (3) production (30%), worchonsing and logistics -26%, (4) marketing -29%, (5) sales -39%, (6) services -45%, and internal enterprise administration -26%. in this transformation is emphasized innovation processes, corporate venturing and the learning

organization with higher role of leadership based on knowledge and motivation of employees.

All of previous sub-variables are related to global characteristics of Industry 4.0: (1) vertical networking, (2) horizontal integration, (3) through-engineering, and (4) acceleration through exponential technologies (Deloitte, 2018). On global business scene are lot new and old aspects and variables related to global business environment, as global competitiveness, opportunities and threats, resource used, future potential of the market, new technologies etc.

A global economy has different names according main goals. So knowledge economy (Saisana M., Munda G., 2008) defined measures and drivers for it for EU countries. They emphasized key indicators: (1) production and diffusion of IT, (2) human resources, skills and creativity, (3) knowledge production and diffusion, (4) innovation, entrepreneurship, creative production, (5) economic outputs, (6) social performance, and (6) internationalisation. All of them is included in proposed model of smart enterprise because knowledge is included in concept of smart enterprise.

## 2.2. Literature review of Quality 4.0/Quality 5.0 concepts

According Jacob D. (2017) research in a Quality 4.0 has 11 axes, i.e.:

1. data,
2. analytics,
3. connectivity,
4. collaboration,
5. application development,
6. scalability,
7. management systems,
8. compliance,
9. culture,
10. leadership, and
11. competences.

On this approach Quality 4.0 is transformed in CIA (Connectedness, Intelligence, and

Automation). In focus of this system are Neural Networks and Deep Learning. Mourtzis D. et al. (2019) emphasized aspects of internal and external complexity and relations in Cyber-Physical Systems) of Industry 4.0.

Relations among Quality management in the 21st Century and Industry 4.0 are analyzed in work of Gunasekaran A., Subramanian N., and Ngoi E. (2018) with emphasized following quality topics for Industry 4.0, i.e.:

1. economic aspects,
2. decision models for quality,
3. business model with integrated quality,
4. human aspect in quality (including leadership and culture), and
5. technological aspects in quality.

In smart society is higher role of ethical and well-being aspects. Ethical government realizes through: (1) impact of regulatives, (2) regulation of collective actions, (3) building/modernising existing regulation, (4) anticipating strength of transformation of collective adaptive systems (ACS), (5) balancing government decisions, (6) deciding adaptive government, etc.

Transition of concept Industry 4.0 to Society 5.0 has impact on planning big social transformation in Japan with destroying five walls related to:

- ministries/agencies,
- legal system,
- technology,
- human resources and
- social acceptance.

A transition from Industry 4.0 to Industry 5.0 is practically transformation of digital manufacturing to digital society (Skobelev P.O., Borovik S.Y., 2017) with convergence of science and technologies in society 5.0 from technology to society.

A concept of enterprise value management defined for smart enterprise in Industry 4.0 could be make broader for Society 5.0 and Quality 5.0 (Fujitsu Consulting, 2002).

According Kearney A.T. (2017) value dimensions from converging technologies have levels:

- value for the factory,
- value to the firm (enterprise),
- value to the industry,
- value to society, and
- value to the individual.

In all of the levels are included elements of Quality 4.0 (level 1, 2 and 3) and Quality 5.0 (level 4 and 5).

Kueper D. et al. (2019) analyzed Quality 4.0 and concluded that cca 63% companies had not decision or plan for it, but only 16% had some form of implementation. The challenges of implementation were: (1) cost of quality check, (2) first-pass yeald, (3) defect rate, (4) rework rate, (5) on-time delivery, (6) customer satisfaction, (7) warranty claims, and (8) product-related complaints. All challenges are base for Quality 4.0 and Quality 5.0, also on levels 1 and 2 in value creation.

### 2.3. Literature review of intangible capital needed for sustainable transition from Quality 4.0 to Quality 5.0

A intangible capital resources needed for sustainable transition from Quality 4.0 to Quality 5.0 consist from: (1) human capital, (2) cognitive capital, (3) intellectual capital technologies, (4) scienction capital, (5) social capital, (6) financial capital, (7) environmental capital, (8) spiritual capital, etc.

According Deloitte (2019) Global Human Capital Trends are emphasized trend importance for industry: (1) learning, (2) human expirience, (3) leadership, (4) talent mobility, (5) HR cloud, (6) talent access, (7) rewards, (8) superjobs, (9) teams, and (10) alternative workforce.

According Deloitte (2015) a digital transformation included intangible capital for improvement of competitivity flexible customer integration and boosting quality

and efficiency, as well as ICT infrastructure, now forms of marketing etc.

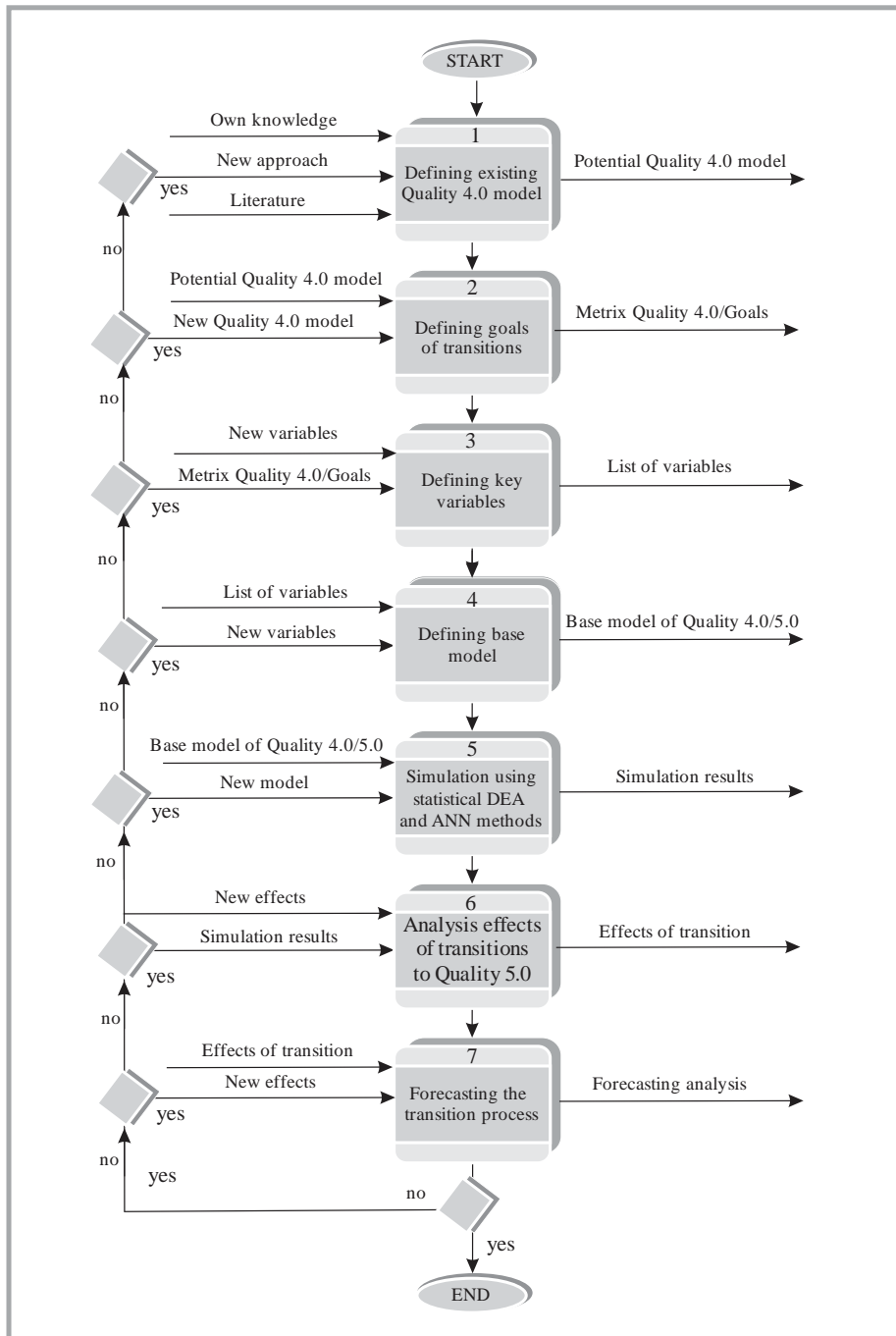
Smart and intelligent technologies cover data technologies smart-production technologies, artificial intelligence, cubersecurity technologgiies, IoT, etc. Other resources are described in broder literature (Hunter I., Webster E., Wyatt A. 2005; Rosman M.I., Nor L.A., Zizah C.S. 2010; Sharon S. (2015); Marphy E. (2022); Noghiu A.A. (2015); Mantog A.M. (2021); Prett T., Shaw E., Dodd S.D. (2016); Gloor P. (2017); Mc Carter B., White B. (2013); Sydanmaanlakka P. (2003); Hazan E. et all. (2021); Sullivan P. JR., Sullivan P. SR. (2000).

### 3. The proposed methodology

The proposed methodology has purpose to: (1) define process of transition from Quality 4.0 to Quality 5.0, based on analysis of existing Quality 4.0 model and goals of transition, (2) definining the key variables for assessment levels of Quality 4.0 and Quality 5.0 based on Grounded Theory (Glaser, Straus, 2006), (3) defining the base model for transition, (4) assessment values of the key variables, (5) simulation effects of transition using statistical methods, DEA (Data Anvelope Analysis) and ANN (Artificial Neural Network), (6) analysis effects of transition to Quality 5.0 and (6) forecasting the transition process in the future. It is presented in Figure 3.

The first step is deefining existing Quality 4.0 using literature presented in previos chapter. Based on it is proposed es autcome potential Quality 4.0 model based on work by Jacob D. (2017) with 11 axes (variables). The key sub-variables is level of Quality management system in broad sense. In second step is defined goals of transition from Quality 4.0 to Quality 5.0 and as autcomes is recognised metrix Quality 4.0/goals. In our research this metrix is presented in Table 1 with assessed weight of component goals.



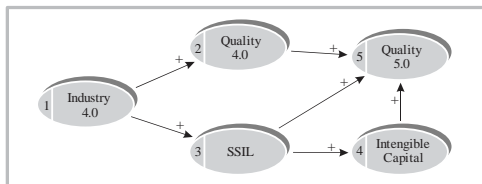


**Figure 3.** Model of transition Quality 4.0 to Quality 5.0

**Table 1.** Matrix of axis/goals for Quality 4.0.

No of axes	Goals					
	Quality level	Relation with customers	Integration with Industry 4.0	Social responsibility	Reduction resources	Higher safety and security
Data	10	5	10	5	5	5
Analytics	5	5	10	5	5	5
Convertivity	5	5	10	5	5	5
Collaboration	5	5	10	10	5	5
Aplication development	5	5	10	5	5	5
Scalability	5	5	5	5	5	10
Management system	30	20	10	20	30	20
Compliance	10	10	10	10	10	10
Culture	10	10	5	20	15	10
Leadership	10	20	10	10	10	10
Competences	10	10	10	10	5	5
Σ	100	100	100	100	100	100

According assess ed goals is used Technique Nominal Group (TNG) for defining key variables for achieving proposed goals of Quality 4.0 (step 3). The list of eleven variables are weighted and it is base for defining the base model for transition of Quality 4.0 into Quality 5.0 (Figure 4).



**Figure 4.** Base model for transition from Quality 4.0 to Quality 5.0

The variables are: (1) Industry 4.0 level, (2)

Quality 4.0 level, (3) broader then structure of leadership in model of Quality 4.0. and Quality 5.0 is broader with interconnections with envionment, and (4) intangible capital needed for transition and (5) Quality 5.0.

The metrix for variable SISL is presented in Table 2 with weights for assessing.

Using this metrix is calculated value of varriable v3 (SISL).

Variable v1 (Industry 4.0) is also assessed based on literature review presented in previos chapter. The metrix for assesment Industry 4.0 level is presented in Table 3 (Yang K., 2018).

**Table 2.** Metrics for (Sustainable, Intelligent and Spiritual Leadership)

Weight	Spiritual leadership	Intelligent leadership	Sustainable leadership	Average value
Enterprise				
Micro enterprise	20	10	5	13
Smal enterprise	20	20	15	17
Medium enterprise	30	30	30	30
Big enterprise	30	40	50	40
Σ	100	100	100	100

**Table 3.** Metrics for assessing level of Industry 4.0

Weight Enterprise	Cuber security	Smart logistics	Smart manufact. systems	Big data/ AI, IoT	Mass customization	System integration	Average value
Micro enterprise	5	10	15	10	10	15	12
Smal enterprise	10	15	20	20	20	25	20
Medium enterprise	20	30	30	30	30	35	30
Big enterprise	65	45	35	40	40	35	33
Σ	100	100	100	100	100	100	100

Variable v5 (Quality 5.0) is assessed based on Metrix presented in Table 4. Variable v4 (Intangibles needed for transition) is

assessed based on Metrix presented in Table 5.

**Table 4.** Metrix for assessing Quality 5.0

Weight Enterprise	Inclusion	Competi-tivity	Concern to customer	Government support	Strategy of digitalization	Quality of Life	Average value
Micro enterprise	10	15	15	25	10	10	15
Smal enterprise	15	20	25	25	20	15	20
Medium enterprise	20	25	30	25	30	20	25
Big enterprise	55	40	30	25	40	55	40
Σ	100	100	100	100	100	100	100

**Table 5.** Metrix for assessing v4 (Intangible capital needed for transition)

Weight Enterprise	Human capital	Cognitive capital	HR capital	Scientific capital	Social capital	Spiritual capital	Sustainable capital	Average value
Micro enterprise	5	10	15	20	10	10	5	10
Smal enterprise	10	15	20	20	25	25	20	20
Medium enterprise	20	25	30	20	30	30	30	30
Big enterprise	65	50	35	40	35	35	45	40
Σ	100	100	100	100	100	100	100	100

In step 5 (Figure 3) are calculated inputs data from sample, which will be explained in next chapter, made simulation using statistical methods, DEA and ANN methods. Outcome from this step are simulation results presented in next chapter.

On this way are related steps 6 and 7. At the end is proved realization of stated goals and eventually repeated some steps until achieving the common goal.

**4. Case study**

The case study is provided in Republic

Serbia on sample of 235 enterprises with higher level of smartnesses. For each enterprise the assessment on scale 1-10 gave quality manager, consultant, production manager, logistic manager. The final assessment is calculated as average value. In the data base are included average values of all assessed variables. Using simulation software SPSS v.21 is calculated average value for each variable and thits standard deviation (Table 6). In the step 5 is calculated also regression coefficients (Table 7).

**Table 6.** Descriptive statistics

Descriptive Statistics							
	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
V1	235	3,79	1,66	5,45	3,6351	,86574	,750
V2	235	4,20	2,20	6,40	4,3771	1,01361	1,027
V3	235	4,66	1,85	6,51	4,3399	1,09214	1,193
V4	235	4,35	2,08	6,43	4,9531	,99759	,995
V5	235	3,97	2,39	6,36	4,1308	,94980	,902
Valid N (listwise)	235						

**Table 7.** Regression coefficients

Correlations						
	V1	V2	V3	V4	V5	
V1	1	,692	,573	,535	,367	
V2		1	,644	,676	,671	
V3			1	,622	,552	
V4				1	,726	
V5					1	

The correlation among v5 and other variables are between 0.367 until 0.726 what is very high values.

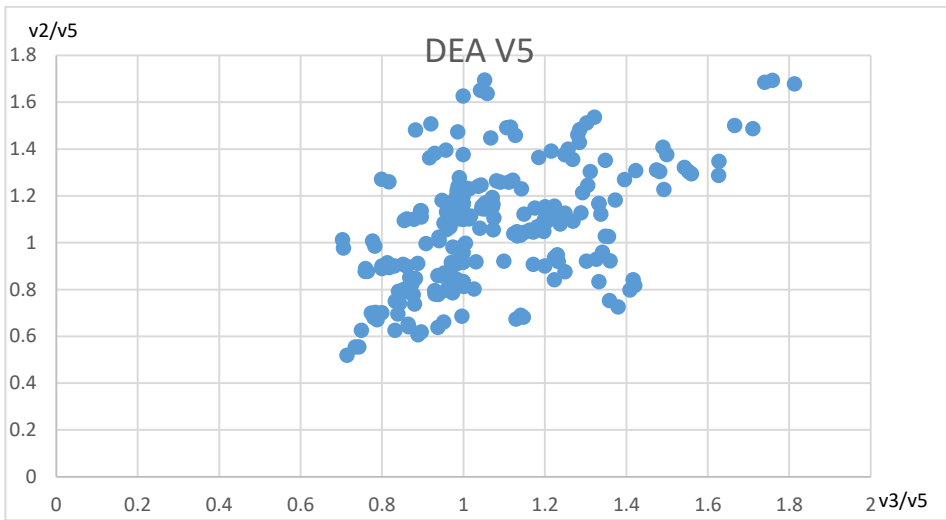
For predicting impact of independent variables v2, v3 and v4 on dependent variable v5 are presented model summary

for v1 (table 8), impact of v1 on v2 (table 9), impact of v3 on v4 (table 10), model summary for predictor v3, impact of v3 on v4 (table 11), and model summary for predictors v2, v3 and v4 (table 12). All impacts are positive effects. Impact of v3 (SSIL) is 0.050 and impact of v4 (Intangible

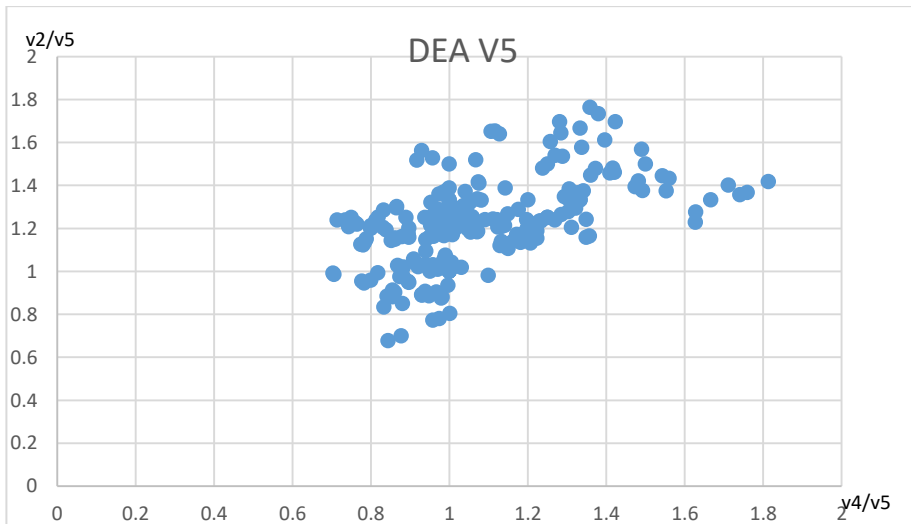
Capital) is 0.485. Aftor analysis is possible to recognise that impact of SSIL is relative low (because is not recognized by questionared persons) and impact of intangible Capital is mach higher (0.485) and it can be used as base for sucefull transition from Quality 4.0 to Quality 5.0.

In next phase is performed DEA (Data Envelope Analysis based on DEAP version

2.1). Efficiencies plotet on diagrams (figures 5, 6 and 7) pointed out that exists groups of assesment near optimal values. On this base view is possible to find optimal way for improving transition to Quality 5.0 (variable v5) in dependance of variables v2, v3 and v4. This prediction is based on existing state of level of variables in sample.



**Figure 5.** Impact V2 and V3 on V5



**Figure 6.** Impact V2 and V4 on V5

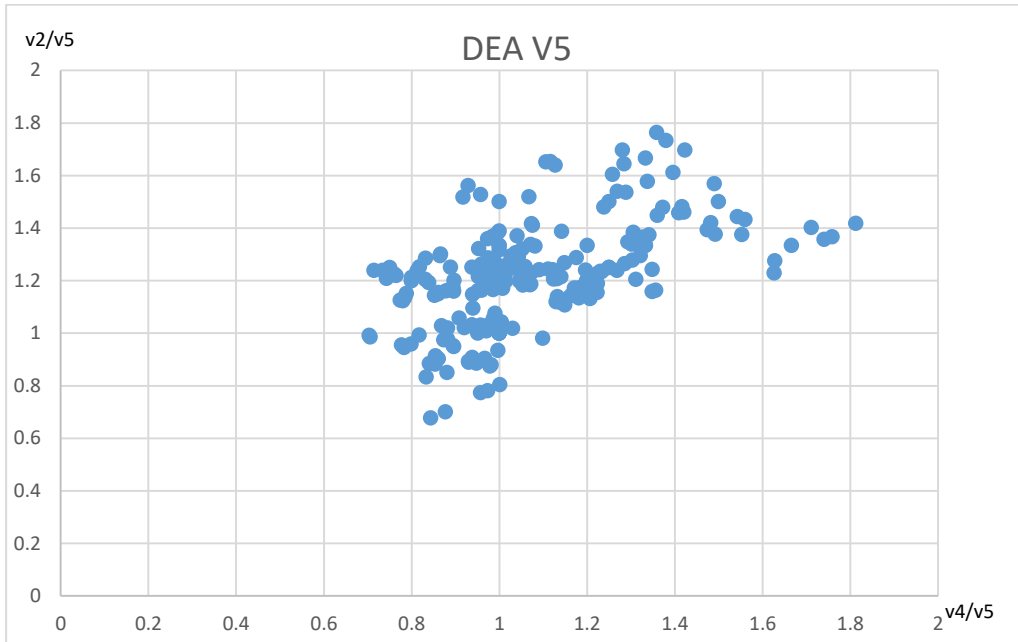


Figure 7. Impact V3 and V4 on V5

In purpose to predict level of Quality 5.0 in the future is used ANN (Artificial Neural Network) be using base model, key variables

and variation of their impact in the future (figures 8, 9, and 10).

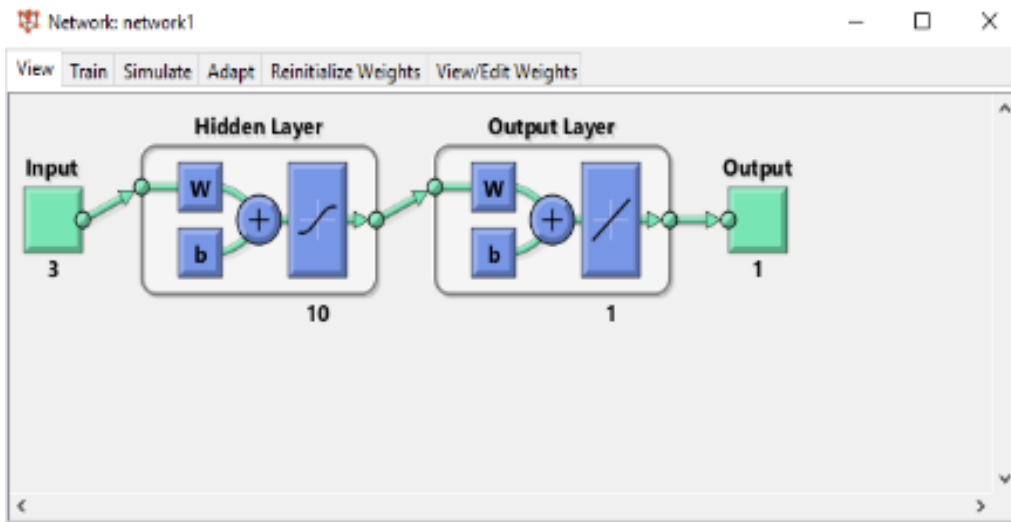
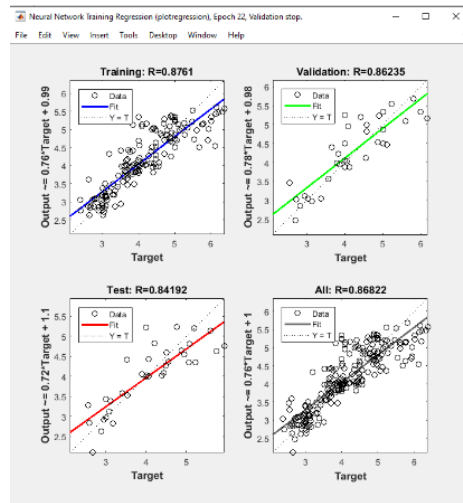


Figure 8. Layers in ANN model



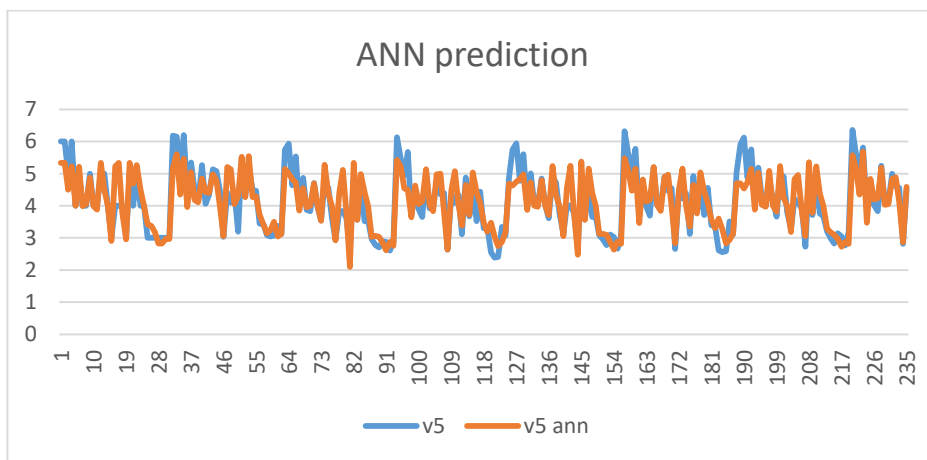
**Figure 9.** Validation of ANN model

Based on five inputs and one output is defined structure of neural network (Figure 8) with ten hidden layer and one output layer. Using appropriate software is made training of neural network (Figure 9). Results of training of neural network proved high correlation between output and target value ( $R=0.8761$ ). On this way is proved that exists conformity among real and forecasting values (Figure 10).

Using this approach is conducted ANN

predictions which also pointed out that is prediction of value of Quality 5.0 is very high for all 235 cases in sample.

In next step is analyzed impact of independent variables  $v_1, v_2, v_3,$  and  $v_4,$  on dependent variable  $v_5$ . For purpose to demonstrate accuracy of ANN in Figures 10 are presented ANN predictions in comparison with real values for all cases in sample. Author pointed out that in all cases are very high conformity among them.



**Figure 10.** ANN prediction

## 5. Conclusion

A concept of Quality 4.0 is emerging in different aspects but is related with a lot of dilemmas and different approaches. On the other side according concept Society 5.0 author made one step more to develop concept at Quality 5.0. This attempt is investigated in Center for Quality (CQM) last in four years from theoretical and applicative approaches.

In the research presented in the article is used scientific approach from Quality Science (Arsovski S., 2017) and using it avoid „sciles and haribdes“ in this new research thema „Quality 4.0/5.0“.

The results of research proved attractive goals, i.e.:

1. Defined new concept of Sustainable, Intelligent and Spiritual Leadership (SISL),
2. Defined Model of Smart Transition (MST) from concept Quality 4.0 to Quality 5.0 and
3. Assessed impact of SISL, in the transition process.

For the research are used concepts of Grounded Theory, Reframing organizations and Process Modeling approaches. In purpose to confirm proposed model is organised research in 235 with relative higher level of digitalization and quality. For each variable is defined metrics and answers of correspondens. Quality manager were collected and formed Data Base for further application of statistical method using IBM Software SPSS v21, DEA (Data Envelope Analysis) and ANN (Artificial Neural Network).

Using ANN software are performed prediction of value v5 in all 235 enterprises. Impact of independent variables v2, v3 and v4 is calculated according statistical analysis presented in table 10, i.e.:

$$V5 = 0.379 + 0.291 \times v2 + 0.044 \times v3 + 0.462 \times v4$$

For improvent in next five years for 10 percent the new espected value of v5 will be:

$$V5 = 0.379 \times 0.291 \times 4.8 + 0.044 \times 4.9 + 0.462 \times 5.5 = 4.532$$

This value of v5 is higher for 0.393 of mean value (4.1308) calculated by software SPSS v.21. It is improvement of 8 percent.

Results of statistical analysis proved base model with relative high correlation among independent and dependent variable v5 (level of Quality 5.0). In period of collecting input data of SISL authors recognised that correspondent dont persons adopt and recognize structure of SISL, they in many cases missundstand it and as result the impact of SISL on v5 small. In next period author plan to educate quality managers about significance of SISL and tray to improve their spirituality, smart intelligence and sustainable aspects of leadership. All variables had positive impact on v5 and with their positive improvement as results we can expect higher v5 in future. Level of improvement depends on possibility to investments in Intargible Capital and social support. In this time it is not sufficient in Serbia, as transition state, with relative small financial capacity. The greatest impact on v5 has v4 (level of Intargible Capital). Authors expected it because all analysed enterprises had establish with generally high values of components of Intargible Capital.

Variables V1, V2, V3 and V4 have impact on other enablers of V5 and its ipact in total on V5is much higher. For estimtion of this impact is not sufficient linear model used for calculating by software SPSS. Author proposed for further research using non-linear model and broather model of V5 based on monitoring key enablers (a new variables in model) in purpose to estimate small improvement in each of them and its sinergy and total impact on Quality 5.0. It is so caled „Buterfly effects“.



Using DEA is analysed efficiency of impact of underdent variables on v5 (level of Quality 5.0). In all casses is calculate efficiency for each of 235 enterprises. Overal firm efficiency varied from 0.6 to 0.8, what is relative good results for the sample of 235 enterprises.

Through using ANN is also confirm that exist very good accuracy between real data of v5 and value of v5 calculate using ANN. This is base for conform the proposed methodology and impact of variables v1, v2, v3, and v4 on v5 (level of Quality 5.0) in the future.

This model is related with meny difficulties. The first, the assessing of SISL is conected with personal assessment without enough knowledge about Spirituality, Intelligent and Smart Leadership. On the other side knowledge related to Industry 4.0 are also relative on lower level and assessments were in some cases problematic. Next problem is

support of government which is different for different enterprises and also were different investment from own financial sources.

All of previos difficulties can override in next research in four areas, i.e.:

1. higher education of SISL and other human resources of enterprises,
2. higher sample and providing analysis for different type of industries,
3. Using methods of Artificial Intelligence and cooperation with foreign research,
4. Including other independent variables and making new hierarchical model appropriated for application of new simulation tools,
5. Developing the new international project related to enabling factors on Quality 4.0/5.0 and their impact on Society 5.0 as answer on Millenium goals of our civilization.

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**14<sup>th</sup> IQC**  
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## GROUP DECISION-MAKING APPROACH FOR RANKING AND SELECTING MAINTENANCE TASKS FOR JOINT SCHEDULING WITH PRODUCTION ORDERS

**Abstract:** *Group decision-making has captured the attention of researchers for decades but due to its importance and complexity further explorations and studies, namely for its application in industrial engineering continue to be needed in the current digital age. In this paper, a group decision-making approach is put forward for evaluating and selecting maintenance tasks to enable joint maintenance and production management, by using a collaborative management system. The proposed approach includes a two-stage assessment method, which enables a set of decision makers to collaborate in ranking and selecting a set of maintenance tasks for being jointly scheduled with production orders. The group decision-making approach uses a dynamic multi-criteria decision model that aggregates information about historical, current and provisional data about maintenance tasks. The proposed collaborative approach is illustrated through an application example and further contextualized within the state of the art. This study permits to realize that collaborative management approaches, namely based on group decision making approach, enable conducting a dynamic, integrated, distributed, intelligent, predictive, time and condition based maintenance task management in real time, based on the fusion of past, present and future data, and that there is still a lack of contributions regarding the use of collaborative approaches in industrial management.*

**Keywords:** *Group decision making, dynamic, real time, integrated, distributed, time and condition based maintenance management*

### 1. Introduction

Group decision making (GDM) is a research topic that falls within collaboration, and collaborative management domain (Varela, Putnik, & Romero, 2022; Varela, et al., 2022a), and is of primer relevance in the

digitalization era, by promoting and enabling a sustainable development of companies (Varela, Putnik, & Romero, 2022, 2023; Varela, et al., 2022a,b, 2023).

The development of GDM approaches require the acquisition, processing and analysis of varying kind of data, which

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typically is expressed through Key Performance Indicators (KPI), for being monitored and controlled by using appropriate dashboards and systems (Simonov, et al. 2018).

Over the last 20 years, the processing industries have invested heavily in automation and plant information systems such that the data is now accessible. As a result, this data should now be possible to put into productive usage. The challenge with raw data, no matter how accessible, is that it is just data, and data still requires a lot of work before it can be turned into knowledge. In most cases, the data needs to be validated, analysed and converted into a level of knowledge that is actionable, and this can still require a significant investment of time and resources.

Several kind of KPI have been frequently used to analyse companies' performance in a given context intending to reach certain organizational goals. Every companies' functional group defines its objectives and targets, and if the raw operational data can be converted in KPI for being processed and analysed, preferably in real-time a better monitoring and control, on the processed data can be reached and thus better decision making processes can occur.

Information monitoring, based on proper DSS is fundamental for obtaining maximum profit out of KPI through the use of suitable systems' data visualization interfaces, and which are currently being improved by using advanced and dynamic digital dashboards, namely through the use of power BI graphics that enable real time generated data to be analysed. Although, the real potential of a system data visualization interface relies on its interactive ability to quickly sort and display the consolidated performance metrics in order to highlight the top priority requirements and provide guidance on further actions required. This is performed through a combination of filtering, uncertainty filtering, normalization,

weighting, aggregation, ranking, and selection techniques, and put available through appropriate collaborative systems and platforms (Campanella, et al., 2012; Arrais-Castro, 2015a,b, 2018; Jassbi, et al, 2016; Varela, et al., 2018; Simonov, et al., 2018).

As mentioned by Knoen, & Oerlemans (2006), inter-organizational collaboration enables to unify disparate systems and solutions in order to achieve overall strategic and operational excellence. Therefore, intra and intercompany and manufacturing environments collaboration should be intensified, and this can be accomplished by putting into use appropriate group decision support approaches. Such kind of approaches will permit to fully integrate decision-making processes among diverse manufacturing plants and resources interactions, by using suitable platforms and systems offering effective support to carry out distributed and integrated management. Such unified workflow environments will thus promote and enable collaboration and support different decision making teams to work together with an understanding of their specific requirements in the context of a general view over an extended and/or virtual enterprise, which is of upmost importance in manufacturing and management, for instance in collective maintenance and production management.

Maintenance planning plays an important role in every service and manufacturing system, as it makes them more reliable and keeps them at an optimal operational level in order to provide high quality services and products. Additionally, the proportion of maintenance costs to the total production costs, which ranges from 15% to 70% according to the type of the manufacturing firm (McCall, 1956), makes maintenance planning a critical issue. Maintenance models can be broadly classified into two types: time-based and condition-based models (Rahmati, et al., 2018). Recently, the

joint optimization of production and maintenance plans has gained more attention. However, it has not been well studied compared to research on optimizing maintenance planning and production schedules independently (Pan, Liao, & Xi, 2012; Bajestani, Banjevic, & Beck, 2014; Fitouhi, et al., 2017). In addition to the above-mentioned classification of maintenance models, integrated maintenance and production scheduling models can also be classified into two types: integrated maintenance and production scheduling models with time-based maintenance activities; and integrated maintenance and production scheduling models with condition-based maintenance activities.

Maintenance operations can be classified into two main large groups: corrective maintenance (CM) and preventive maintenance (PM). CM corresponds to the actions carried out when the failure has already taken place, and PM is the action taken on a system while it is still operating. PM is carried out in order to keep the system at the desired level of operation, and several PM policies can be defined (Rahmati, Ahmadi, & Govindan, 2018; Sloan, & Shanthikumar, 2000; Taghipour, & Azimpoor, 2018), with the aim of determining when it is necessary to carry out PM operations on the machines according to different criteria used.

Besides maintenance planning, the maintenance and production scheduling is a critical decision process for the gainful management of any manufacturing system. While the first ensures reaching the production goals, besides the satisfaction of customer demands, the second ensures that manufacturing assets are available and in the proper condition to perform their required production tasks when needed. The two decision processes are interdependent since they share a clear common issue, the manufacturing assets that are used through production and restored by maintenance

actions.

Integrating production and maintenance scheduling will thus enable optimizing the joint production orders and maintenance task programming, while avoiding penalising drawbacks in companies (Ladj A, Varnier C, Tayeb FB-S. IPro-GA, 2016).

Although, according to the study conducted, it is possible to realize that there is still a gap in this research domain, as insufficient work has been put forward regarding joint maintenance and production management strategies and tools.

In order to provide a contribution in this focused domain, in this paper, a group decision-making (GDM) approach for supporting maintenance tasks assessment and selection is presented, for enabling further joint maintenance tasks and production orders scheduling, to reduce the lack of research that still prevails in this scientific domain. The proposed GDM approach is based on a Dynamic Multi-criteria Decision Model (DMCDM) (Varela, et al., 2018), implemented through a two-stage maintenance tasks processing (2SMTP) methodology, which is put available through a Collaborative Management System (CMS) that does further permit the integrated maintenance tasks and production orders scheduling.

To properly expose the developed work, this paper follows with a resumed literature review about DSS, MCDM and GDM, along with a general overview about approaches and systems for supporting maintenance and industrial operations management, in section 2. Next, the developed collaborative management system for joint maintenance tasks and production orders processing, along with the underlying group decision-making approach, and the proposed two-stage maintenance tasks assessment and selection method is briefly described, in section 3, and being further illustrated through and industrial example of

application, in section 4. Follows, a final discussion and contextualization of this work within the state of the art, in section 5, and the main conclusion and proposed future work in section 6.

## 2. Literature review

In this section, a general overview about decision support methods and systems, along with group decision-making approaches is briefly presented next, in subsection 2.1, followed by a summarized description of maintenance and industrial operations management approaches and decision support systems, in subsection 2.2.

### 2.1. Decision making methods and systems for group decision-making support

A Decision Support System (DSS) can be explained as an interactive computer-based system, which can be helpful for decision makers to use quantitative models and data for solving complex problems (Bhatt & Zaveri, 2002; Lee & Huh, 2006). A DSS enables supporting more or less complex decision processes by using different kind of middleware and technology, and tools (Sprague & Carlson, 1982; Zarate, 1991; Vieira, et al., 2018; Vafaei, et al. 2019). Keenan (2016) referred that DSS have been developed since 1970s, and since then continued growing and improving, based on new technologies, namely about databases and visual interfaces applied for properly supporting decision-making processes. DSS mostly involve Management Science and Operations Research fields. DSS and management strategies have thus a meaningful relationship in manufacturing environments for reaching well-suited decisions (Brannback, 1994).

During recent decades, DSS have been developed in different contexts, and some contributions are summarized next.

Group Decision Support Systems (GDSS)

and Executive Information Systems, which was changed to the Enterprise Information Systems (EIS), introduced to support DSS tools are becoming much improved and more effective. GDSS currently provides many useful options, including brainstorming, idea assessment and some other facilities for enabling communication in more or less complex problem solving scenarios (Costa et al. 2003; Limayem & Banerjee, 2006; Varela, et al., 2021), along with other kind of the so-called Integrated Decision Support System (IDSS) that enable improving the effectiveness of classical DSS by combining them (Liu et al. 2010).

More recently, DSS has applied in integrated models with Multiple Attribute Decision Making (MADM) and Multiple Objective Decision Making (MODM) in general framework of Multiple Criteria Decision Making (MCDM) for endowing a better process and environment in decision support (Jaramillo et al. 2005; Qureshi et al. 2017). Bakshi et al. (2015) mentioned that when there is uncertainty in decision-making processes the MCDM models will become more complicated thus requiring appropriate Multi-Criteria Decision Support Systems to present appropriate solutions in practice. The authors mention a new decision support system established based on models, survey (literature review) and human experts interacting through a proposed framework. The main issue of their research was selecting the main criteria in MCDM models. Some other studies applied this kind of approaches in practice, and some are resumed next, to mention a few.

Taha & Rostam (2012) applied a hybrid fuzzy AHP-PROMETHEE as main part of a decision support system for machine tool selection in flexible manufacturing cell. They mentioned that their research shows that MCDM methods can be a useful part of a DSS and that their vision would be helpful in decision making in solving complex cases.



Razmak&Aouni (2015) reviewed research related to MCDA and DSS and found out more than 100 research articles for analysis. They categorized the articles into 9 different sections, regarding their application fields. These 9 sections were: Production and Supply Chain Management; Education; Human Resource Management; Finance and Investments; Real state and Constructions; Environmental aspects; Medical aspects; Electronic business and electronic commerce, and Multimedia.

Leyva Lopez et al. (2016) proposed a model and system for supporting group decision-making based on a MCDM approach. The authors state that their approach was structured based on ELECTRE method and designed completely based on the web to turn the underlying process more reachable and easier applicable in practice. Their proposed GDSS enable to put forward some advices for decision makers in order to help them manage their priorities and preferences to allow proper decision rules with some degree of consistency and consensus.

In other works, namely in (Arrais-Castro, et al., 2018; Simonov, et al., 2018; Varela, et al., 2018), DSS models were proposed by using different kind of approaches, in different application contexts. According to the examples provided, it is possible to realize that DSS and approaches are applied in many different context and manufacturing and management environments, thus there is still need for new contributions to increase its full practical capability and usability, for instance, in the industrial context. Furthermore, decision making with uncertainty treatment and future or prospected data processing, needs integrated and advanced DSS models and systems to continue being developed to decrease ambiguity and vagueness of knowledge about forecasted data, which has become, especially currently, in the digital age, more urgent and necessary, for putting into practical

use in manufacturing management (Putnik, et al., 2021).

## **2.2. Approaches and systems for supporting maintenance and industrial operations management**

Maintenance is a crucial activity in industry, with a significant impact on costs and reliability, being immensely influential on a company's ability to be innovative, while permitting costs reduction and global benefits, namely increased quality and general performance.

In the scope of maintenance management, any unplanned downtime of machinery equipment or devices does usually degrade or harm a company's core business, potentially resulting in significant penalties and unmeasurable reputation loss. According to some studies, operation and maintenance costs can range from 15% to 70% of total production cost in some companies (Bevilacqua, & Braglia, 2000; Gong, & Qiao, 2014). Therefore, it is critical for companies to develop a well-implemented and efficient maintenance strategy to prevent unexpected drawbacks, and improve overall reliability, while reduce manufacturing systems' operating and maintenance costs.

The evolution of modern techniques, namely with the emergence of the Internet of things (IoT), along with varying kind of sensing technology, and new or improved artificial intelligence approaches and tools, among others, stimulates a transition of maintenance strategies from Reactive Maintenance (RM) to Preventive Maintenance (PM), and to Predictive Maintenance (PdM) (Jimenez, et al., 2020). RM is only executed to restore the operating state of the equipment after failure occurs, and thus tends to cause serious unproductive times, while frequently resulting in high response and repairation costs. PM is carried out according to a planned schedule based on time or process iterations to prevent breakdown, and thus

may perform unnecessary maintenance, typically resulting in high prevention costs. In order to achieve the best trade-off between the RM and PM, the PdM can be performed, based on some online assessment of the condition of manufacturing assets, and thus reach timely interventions before failure occurs, while preventing from high maintenance frequency, unplanned RM, and the incurrance in increased costs associated to frequent PM.

Asset management deals with the optimization of manufacturing assets use for reducing costs. An asset management system manages the assets over the whole life cycle, especially their reliability and efficiency. It is also responsible to optimize utilization and cost-effective maintenance of the assets. Moreover, it generates and provides information regarding the so-called “asset health” development and prognosis to support decision making of the enterprises’ production management (Namur, 2009). Using the “asset health” information to generate an optimal production plan is a viable solution to better integrate a maintenance and a production planning system to increase the overall performance (e.g. in terms of costs) of manufacturing operations. Although some work was already carried out in this sense, industry is still lacking of appropriate and effective systems for supporting advanced maintenance and production management (Zhai, Gehring, & Reinhart, 2021).

Biondi and Harjunoski (2017) proposed a joint scheduling approach for the production and maintenance of process plants that explicitly keeps track of the assets life cycle. The scheduling system includes a simple model of the asset wear that can be based on the concept of residual useful life (RUL) or of probability of failure. The authors state that the asset monitoring system is responsible of providing two types of information to the scheduling system: on the one hand, an estimation of the parameters

describing the wear caused by the production on the asset. On the other hand, if an extraordinary condition of the asset is detected, it is responsible to update a current RUL in the asset wear model of the scheduling system. Assets health information, along with the production orders, is managed by the scheduling system that takes care of the sequencing and timing of production tasks on the plant and triggers a maintenance action on the assets whenever this is required. According to the authors, their proposed method makes an effective use of factory units’ health information to generate a feasible plan for joint production and maintenance planning (Biondi, & Harjunoski, 2017).

Based on (Staufen, 2018), PM has not been properly explored in industry. A survey in 2020 shows that PM continues being a hot topic, for example to determine the best point in time to do maintenance tasks (Zhai, et al., 2020).

Two types of flexible PM strategies, i.e., time-based PM (TBPM) and condition-based PM (CBPM), are commonly analysed and applied (Wang, Yan, & Zhang, 2021). According to these authors, the application of TBPM is straightforward and relative ease of implementation, however, TBPM may lead to under-or over-maintenance due to inaccurate estimate of the stability of production systems. In contrast, CBPM is of more complexity, which continuously monitors and analyses the machine status to determine the implementation of the maintenance activity. The authors state that despite the complexity of computational requirement and uneven maintenance cycles, CBPM strategy can reduce the maintenance frequency to a minimum necessary level, thus improve a global production system’s productivity level.

Some examples of application of TBPM in diverse kind of production scenarios, integrating different production scheduling strategies, are presented in (Chen, 2000;

Chen, et al., 2006; Mosheiov and Sarig, 2009; Yang, Ma, Xu and Yang, 2011), while CBPM has also been focused by several researchers, for instance in (Zandieh, Khatami and Rahmati, 2017; Rahmati, Ahmadi and Govindan, 2018; Sloan and Shanthikumar, 2000; and Ghaleb, Taghipour, Sharifi and Zolfagharinia, 2020), just to mention a few.

Prognostics and health management (PHM) is a relatively young engineering discipline that aims to enable “real-time health assessment of a system under its actual operating conditions as well as the prediction of its future state based on up-to-date information” (Kim N-H, An D, Choi J-H, 2017), with PdM being the underlying maintenance strategy that uses prognostics results of PHM.

The authors of (Li N, Gebrael N, Lei Y, Bian, 2019) state that varying operational conditions have two major effects on system degradation: Firstly, varying operational conditions influence the speed of degradation. Secondly, they lead to sudden signal changes and change points, which result in high variance of raw sensor readings. Thus, varying operational conditions pose an obstacle to prognostics (Zhang, et al., 2020) and are considered to be a focal point for modern PdM modelling (Aydemir, Acar, 2018).

According to (Assaf, Scarf, & Iung, 2019), prognostics incorporates three tasks: ‘State estimation’ (estimate the current health or degradation state of the system based on historical data), ‘State prediction’ (predict the health or degradation state for future periods based on historical data), ‘EoL’ (‘End of Life’) or ‘RUL prediction’: Determine the RUL before failure or before exceeding the failure threshold for some identified degradation behaviour. The author highlights that RUL can refer to actual failure or remaining time until certain quality requirements of a product cannot be met.

Databased RUL prediction can be

formulated as a supervised (Aggarwal, et al., 2018) or a semi-supervised machine learning (ML) problem (Yoon, et al., 2017). According to these authors, the high amount of required failure data to derive RUL labels for supervised prediction models is often not available in industrial practice.

Health prognostics approaches in PHM are commonly classified into physics-based, knowledge-based and data-driven approaches (Bektas, Marshall, & Jones, 2019). Physics-based models describe the phenomena of failure and degradation as physical or mathematical “white box”-model. Although physics-based models can achieve high accuracy, their development is usually costly (Bektas, Marshall, & Jones, 2019). Knowledge-based models collect identified degradation behaviors and failure events in a historic database and assess the similarity of a currently observed system state with the entries of a knowledge base (Sikorska, et al., 2011). Data-based approaches make use of the system condition monitoring (CM) data to derive transparency of the system health state and predict the RUL (Song, et al., 2018; Jia, et al., 2018; Wang, et al., 2017), further enabling to assess the uncertainty of the prediction (Benker, et al., 2020). Databased methods encourage the use of highly adaptable ML, including deep learning (DL) algorithms (Zhang, et al., 2018), in scenarios where large amounts of condition monitoring data are available and the system operation is subject to variations, partially unknown conditions or a variety of failure modes.

For an overview of knowledge-based approaches, as well as advantages and limitations of data- and knowledge-based approaches, the reader is referred to (Ran, et al., 2019), where a survey of predictive maintenancesystems purposes and approaches is presented. Next, some additional work is briefly referred.

The authors in (Malhotra, et al., 2016) propose an approach for combined health

indicator (HI) estimation and RUL prediction. The publications by (Wang, 2010; Wang, et al., 2008) are among the first research works to explicitly consider the effects of time-varying operating conditions on system degradation analysis.

Li et al. (2019) model a dynamic, operation-specific degradation rate as a state transition function based on Wiener process and time-scale transformations, which capture the effect of operating conditions on the degradation curve. A measurement function smoothens the jumps in the degradation signal at operation condition change points by mapping each condition to a condition-specific baseline. The approach proposed by the authors is evaluated on a simulated data set of bearings, which are subject to varying rotational speeds, as well as on a data set from an accelerated degradation experimental study of rolling element bearings.

Luo et al. (2019) propose a deep learning approach for health estimation and fault detection of CNC machine tools operating under time-varying conditions. In a first step, the authors use a DL model composed of stacked auto encoders (AE) and a feed forward neural network to extract impulse responses from vibrational CM data. The training and test data sets for the DL model are prepared manually by labelling whether randomly selected time windows contain an impulse response or not. In case of an impulse response, the vibration signal represents the reaction of the system to sudden forces and impacts during time-varying machining processes. After training, the DL model is used to automatically identify impulse responses in the CM data. Subsequently, the first four natural frequencies and the damping reactions of the machine tools are extracted from two different impulse responses representing two different working conditions. The authors find that the natural frequencies barely change with varying operational conditions

and thus are a robust feature for HI construction. The HI is computed as the cosine similarity in the space of extracted dynamic features comparing current observations with an initial vector representing the normal state. According to the authors, since the HI is based on operation-condition invariant features, the HI is robust to different working conditions. However, the approach is not capable of performing an operation-specific prediction of system health for future loads. In contrast to most other research, the approach was evaluated on a real industrial data set, composed of vibration signals from 288 days of industrial operation.

Michau& Fink (2019) propose an unsupervised approach for system monitoring in a setting where a fleet of similar safety-critical systems is to be monitored over time. The training data for a specific system instance is enhanced by CM data from other instances of the fleet to enable CM early in a system's operational life. The authors use a variational autoencoder (VAE) architecture to model a shared latent space for the fleet, which is trained in an adversarial manner. A new loss function is designed to preserve instance-specific behaviours in the shared latent space. The health prediction is framed as a one-class classification, which aims at predicting whether the CM data is faulty or healthy. The method is evaluated using a real data set from a fleet of 112 power plants operated in different geographical locations and under different operational conditions. The authors refer that their results show that the shared latent representation and feature alignment yield an efficient and unsupervised feature representation in a setting of complex systems subject to varying conditions, which is useful for downstream PHM modelling.

The integrated optimization of production scheduling and machine maintenance has been known as a complex combinatorial

optimization problem, in which heuristic or meta-heuristic approaches are commonly employed aiming to find some satisfied solutions in short time. With the advent of artificial intelligence and machine and deep learning, the application of scheduling rules-based reinforcement learning (RL) to the field of scheduling has become possible (Wang, & Usher, 2005). However, little empirical research concerning the application of RL to integrated decision making of production scheduling and machine maintenance has been conducted (S. Zhai, B. Gehring, G. Reinhart, 2021).

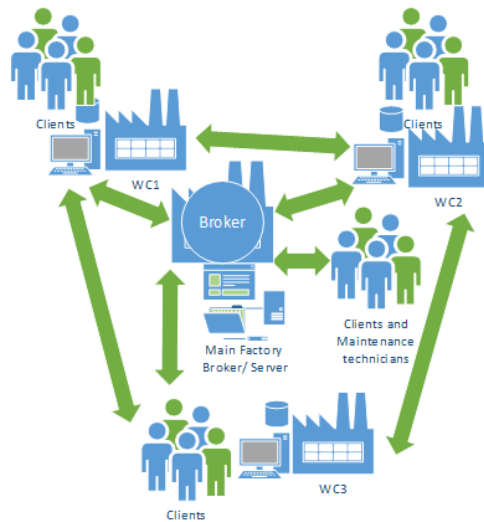
In (S. Zhai, B. Gehring, G. Reinhart, 2021) a machine degradation modelling under varying operational conditions, enabling subsequent integrated scheduling of maintenance and production (“PdM-integrated production scheduling”: PdM-IPS) is introduced. The underlying model is a conditional variational autoencoder (CVAE) that is used for calculating and quantifying the change of the machine health condition after producing specific product sequences.

The gap that continues existing regarding contributions of integrated maintenance and

production management approaches and systems motivated this work, in order to contribute to this scientific domain, and the proposed collaborative management system, based on a group decision-making approach is briefly described and illustrated in the next sections.

### 3. Collaborative management system based on a group decision making approach

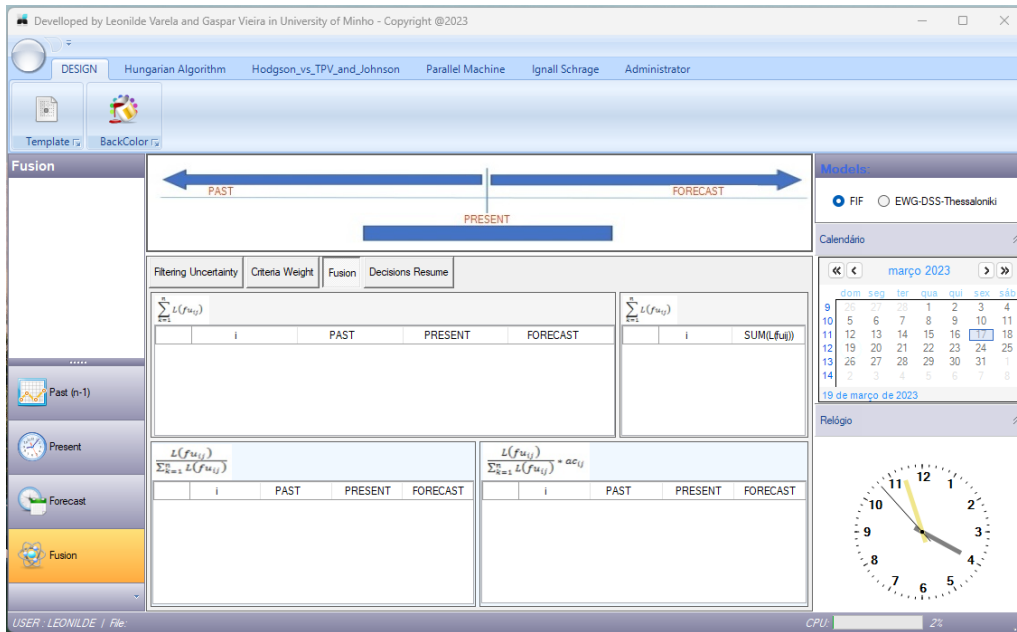
Collaborative management is of utmost importance in the current digital age, enabling and promoting a sustainable development of companies (Varela, Putnik, & Romero, 2022, 2023; Varela, et al., 2022a,b, 2023). In this paper, a group decision-making architecture is proposed to enable collaborative management, and Fig 1 shows an example of its application in an industrial company that includes three work centres (WC1, WC2, and WC3), which interact with each other and with the main company’s factory, through its underlying brokering service, besides communicating with clients, and maintenance technicians.



**Figure 1.** Group decision-making architecture

A collaborative management system (CMS) underlying the proposed group decision making architecture was developed to enable intra and inter factories and/ or work centres collaboration for jointly reaching integrated maintenance tasks and production operations

scheduling, and an interface of the CMS is shown in the Figure 2, about an interface for processing a data fusion function of the DMCDM used in this work that will be further explained through an application example.



**Figure 2.** Title (Times New Roman, 10pt, align Center, single spacing)

This CMS enables a wide range of diverse kind of other management functions in industrial management, namely underlying the proposed GDM approach, which is carried out by using a maintenance tasks processing methodology with three phases, based on a two-stage assessment method, which makes use of a DMCDM, as expressed

in the Figure 3.

The two-stage assessment method based on DMCDM was used in an industrial company, in the scope of a research project to enable the joint processing of maintenance and production orders information, and a case study is briefly described next.

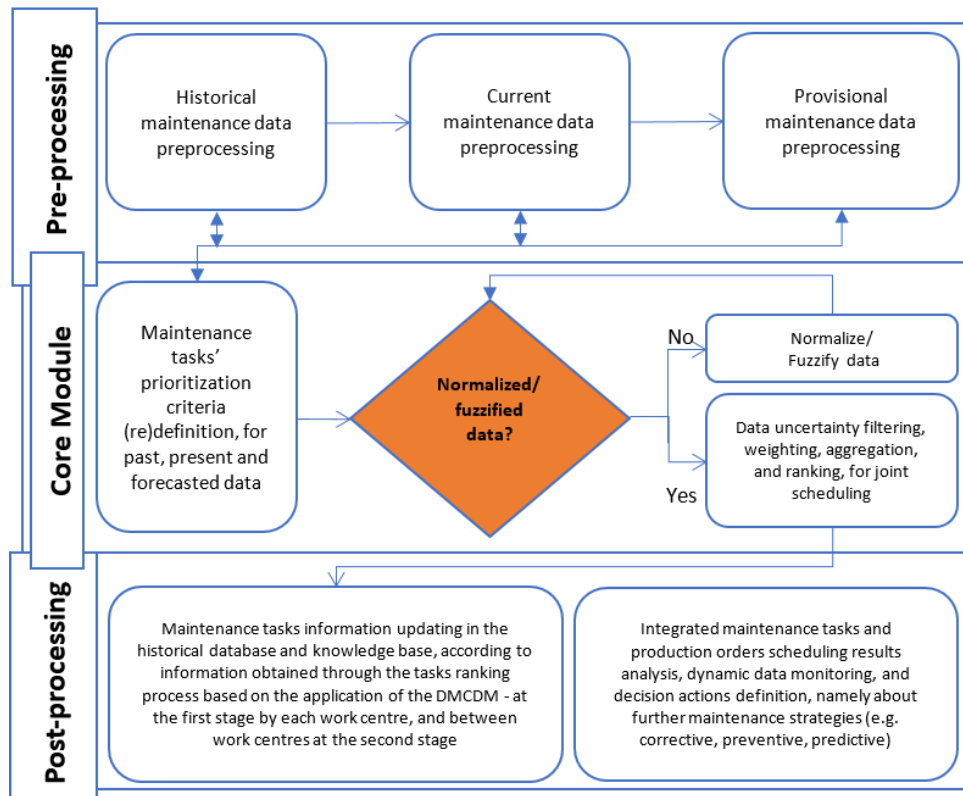


Figure 3. Title (Times New Roman, 10pt, align Center, single spacing)

## 4. Application example

### 4.1. Maintenance tasks assessment methodology based on a DMCDM

The maintenance tasks assessment methodology used in this work uses a DMCDM (Jassbi et al., 2013; Varela, Arrais-Castro, & Ribeiro, 2018), by including two stages, for intra and inter work centres tasks evaluation and selection.

**1st Stage) Intra work centres evaluation:** Includes 6 steps, for normalizing/ fuzzifying, weighting, uncertainty filtering, and data aggregation or fusion, for ranking and selecting the maintenance tasks (Varela, Arrais-Castro, & Ribeiro, 2018).

**Step 1) Data acquisition and matrices construction:** First, the definition of the evaluation criteria for processing the data about 3 moments: past, present and future, have to be defined, and Figs. 4 to 6 show an example for the company's WC1, by using different kinds of criteria, about: maintenance cost (MC), Lack of Production Quality (LPQ), Overall Equipment Effectiveness (OEE), Lack of Safety Indicator (LSI), Mean Time Between Failures (MTBF), Mean Time To Repair (MTTR), and Downtime (DT), for processing past and future maintenance tasks' data; and MC, along with Service Time (ST), and Lead Time (LT), for processing current maintenance tasks' data, which were applied for ranking a set of 6 maintenance tasks (M1\_1 to M1\_6) of WC1. The current or present data is acquired, in

real time from the shop floor, by using appropriate communication means and

devices (Vieira, et al., 2018; Varela, et al., 2021).

Maint. Task	Maint. Cost MC	Lack of Production Quality LPQ	Overall Equipment Effectiveness (100%) OEE	Lack of Safety Indicator LSI	Mean Time Between Failures MTBF	Mean Time To Repair MTRR	Downtime DT
MT1_1	630,00	28%	88	18%	28000	2	5
MT1_2	398,50	33%	79	14%	17500	4	4
MT1_3	400,00	17%	90	11%	18900	3	3
MT1_4	730,00	20%	85	13%	22400	2	3
MT1_5	490,00	15%	83	15%	15600	5	5
MT1_6	330,00	12%	92	12%	20580	1	4

Figure 4. Past data matrix

Maint. Task	Maintenance Cost MC	Service Time ST	Lead Time LT	Extended ST (EST) ST + (max(LT-d),0)
	MT1_1	635,00	100	5
MT1_2	405,00	120	2	122
MT1_3	410,00	85	4	89
MT1_4	650,00	90	3	93
MT1_5	450,00	100	4	104
MT1_6	335,00	115	3	118

Figure 5. Present data matrix

Maint. Task	Maint. Cost MC	Overall Equipment Effectiveness OEE	Downtime DT	Production Quality PQ	Mean Time To Repair MTRR	Mean Time Between Failures MTBF	Safety Indicator SI
MT1_1	640,00	85%	20	86%	5	23500	4
MT1_2	498,50	90%	35	92%	10	13000	4
MT1_3	410,00	70%	17	85%	6	25500	3
MT1_4	700,00	75%	10	73%	7	15000	3
MT1_5	395,00	73%	20	80%	9	14000	5
MT1_6	340,00	84%	18	90%	4	11000	4

Figure 6. Future data matrix

The future data can be obtained by applying some forecasting method, namely by using some machine learning approach (Putnik, et al. 2021) or be based on known real or estimated data. Prediction may also be performed using expert judgment or quantitative methods (forecasting), such as moving linear averages, quadratic averages, and other techniques.

**Step 2) Normalization/ fuzzification**

In the second step a normalization/ fuzzification process underlying the DMCDM (Varela, Arrais-Castro, & Ribeiro, 2018) was performed (Fig. 7), to process imprecision by using fuzzy logic for criterion evaluation. To guarantee that values are numerical and comparable simple triangular membership functions were used to represent the acceptable criterion values,



as all expected criteria fit in the “lower is better” and “higher is better” categories (Varela and Ribeiro, 2003). This process is essential to enable values aggregation, and the simplest method consists on dividing a value by the maximum existing one in the set (when high values are favourable to the decision) or by the minimum (when low values are favourable, such as a cost) (Jassbi et al., 2014).

MC			
	x	u(x)	
1,1	630,00	0,250	
2,1	398,50	0,829	
3,1	400,00	0,825	
4,1	730,00	0,000	
5,1	490,00	0,600	
6,1	330,00	1,000	
			730-330

bi	330
pi	400

**Figure 7.** Normalization and fuzzification example for the MC criterion

### Step 3) Uncertainty filtering

In order to filter uncertainty a method underlying the DMCDM referred in (Varela, Arrais-Castro, & Ribeiro, 2018) is used, which considers two parameters, accuracy and confidence to “filter” the membership function values. The accuracy parameter expresses deviations from nominal values and the confidence expresses the degree of trust on the data gathered.

The logic of this filtering process is that if we do not trust an input source (e.g. confidence on data is only 80%) then the initial value must decrease proportionally (e.g. a value 10 would be reduced to 8), Thus accommodating deviations in the value, for example +3 or -3 from a value of 10.

Let  $a_{ij}$  be the accuracy associated with criterion  $j$  for  $MT_i$ , representing a left or right deviation from the original value; when  $a_{ij}$  is zero it means we accept the gathered value without deviation errors.

The confidence,  $w_{cj}$ , is a percentage, as for

example, we trust with 90% the values for “Maintenance Cost, MC”.

Additionally,  $\lambda \in [0,1]$ , is a parameter that reflects the decision maker’s attitude. Values close to zero indicate an optimistic attitude; higher values indicate a pessimist attitude.

The accuracy rate, expressing the allowed deviation from the base values, is defined for each criterion, based on the associated data quality. The value also reflects the imprecision associated with the data gathering process. Based on the criteria and its associated confidence rates, the filtered imprecision values,  $\llbracket fu \rrbracket_{ij}$  (e.g.  $ac_{ij}$ ), were calculated, as illustrated next for the MC criterion.

Hence, the adjusted membership value is calculated using the following formula (Varela, Arrais-Castro, & Ribeiro, 2018):

$$f u_{ij} = w_{c_j} * (1 - \lambda * \max_{x \in [a,b]} \{ |\mu(x) - \mu(x_{ij})| \}) * \mu(x_{ij}) \tag{1}$$

Where  $[a,b]$  is the inaccuracy interval:

$$a = \begin{cases} \min(D), & \text{if } x_{ij} - a_{ij} \leq \min(D) \\ x_{ij} - a_{ij}, & \text{if } x_{ij} - a_{ij} > \min(D) \end{cases} \tag{2}$$

$$b = \begin{cases} x_{ij} + a_{ij}, & \text{if } x_{ij} + a_{ij} \leq \max(D) \\ \max(D), & \text{if } x_{ij} + a_{ij} > \max(D) \end{cases} \tag{3}$$

Using the function (1), along with (2) and (3), we are able to penalize input values, which display any of the two types of uncertainty, i.e. inaccuracies or lack of confidence on data, within an optimist or pessimist view from the decision maker.

MC

wc <sub>j</sub>	100%	λ <sub>j</sub>	1	(in)acuracy int.	0%	pi	400	
i, j	u(xij)	xij	a <sub>ij</sub>	a	u(a)	b	u(b)	a <sub>cij</sub>
1,1	0,250	630	0	630	0,250	630	0,250	0,250
2,1	0,829	399	0	399	0,829	399	0,829	0,829
3,1	0,825	400	0	400	0,825	400	0,825	0,825
4,1	0,000	730	0	730	0,000	730	0,000	0,000
5,1	0,600	490	0	490	0,600	490	0,600	0,600
6,1	1,000	330	0	330	1,000	330	1,000	1,000

Figure 8. Uncertainty filtering example for the MC criterion

**Step 4) Weighting**

The step 4 enables to allow different weights for different temporal stages or criterion. Here we will use linear weighting functions to express the relative importance of criteria. These functions allow penalizing or rewarding bad or good levels of criteria satisfaction, i.e., instead of assigning single weights, we represent them using a function that depends on criteria satisfaction (equation 4):

$$L(fu_{ij}) = \alpha * \frac{1+\beta fu_{ij}}{1+\beta}, 0 \leq \alpha, \beta \leq 1 \quad (4)$$

where  $\alpha$  defines the semantic importance of criteria ('1' – very important, ... '0' - ignored), and the  $\beta$  parameter defines the slope for the weighting function (a higher value or slope means a steeper function, thus a higher penalty, e.g. '1', and '0' – null penalization) to penalize, more or less, badly satisfied criteria. For example, if we assign to criterion Maintenance Cost, MC the values  $\alpha=1$  and  $\beta=0.67$ , we are defining this cost as a “very important” evaluation parameter with an average slope decrease. In this case, we want to reward the best quotes and penalize the bad ones (i.e. we want to reward lower costs).

j=1 (MC)

i, j	fu <sub>ij</sub>	alfa	beta	L(fu <sub>ij</sub> )
1,1	0,250	1	0,670	0,699
2,1	0,829	1	0,670	0,931
3,1	0,825	1	0,670	0,930
4,1	0,000	1	0,670	0,599
5,1	0,600	1	0,670	0,840
6,1	1,000	1	0,670	1,000

Figure 9. Weighting example for the MC criterion

**Step 5) Aggregation**

After the four previous steps, we have a weighted vector for each criterion. The step five is to determine the score (rating) for each time period, past, current and future, by using an approach that is illustrated for the past values about the MC criterion. The following results were obtained for historic information, using the data fusion equation 5:

$$r_i = \text{sum}(\frac{L(fu_{ij})}{\sum_{k=1}^n L(fu_{ij})} * fu_{ij}) \quad (5)$$

i	MC	OEE	DT	PQI	MTTR	MTBF	SI
1	0,037	0,083	0,026	0,142	0,000	0,020	0,177
2	0,145	0,111	0,166	0,041	0,074	0,057	0,062
3	0,170	0,022	0,013	0,000	0,072	0,043	0,000
4	0,000	0,040	0,056	0,032	0,041	0,022	0,000
5	0,100	0,011	0,067	0,061	0,107	0,088	0,167
6	0,220	0,000	0,000	0,014	0,055	0,000	0,073

i	r <sub>i</sub>	Maint. Task
1	0,485	MT1_1
2	0,656	MT1_2
3	0,320	MT1_3
4	0,191	MT1_4
5	0,601	MT1_5
6	0,362	MT1_6

Figure 10. Aggregation example for the MC criterion in the past data matrix.

**Step 6) Decision**

Once applying the steps underlying the DMCDM: normalization/ fuzzification, weighing, uncertainty filtering, and aggregation or data fusion to the past information of the WC1, it is possible to obtain the following rankings of the corresponding 6 maintenance tasks considered in this example:

Maint. Task	Score	Position
MT1_2	0,65644141	1
MT1_5	0,6009151	2
MT1_1	0,48491111	3
MT1_6	0,36222612	4
MT1_3	0,31985451	5
MT1_4	0,19085262	6

**Figure 11.** Decision matrices example for the MC criterion.

Next, we repeat the process underlying the DMCDM for future information, and in this case study the same criteria that have been used for past information evaluation were used for future data processing. Once having calculated the historical and prediction (future) scores for each alternative, we also

need to evaluate the present status (present data).

Evaluating the present or current data means to evaluate the proposals/ quotes that have been received and then fusion the respective information. For that purpose, the following criteria were used to evaluate present data: MC (Maintenance Cost), ST (Service Time), and LT (Lead Time), as previously shown.

Summarizing, the final ratings of the maintenance tasks regarding past, future and present data, for the WC1, along with the final ratings, after final data weighting and fusion, for the WC1 are the following, correspondingly:

<p>WC1 - past</p> <table border="1" style="width: 100%;"> <thead> <tr> <th>Maint. Task</th> <th>Score</th> <th>Position</th> </tr> </thead> <tbody> <tr> <td>MT1_2</td> <td>0,65644141</td> <td>1</td> </tr> <tr> <td>MT1_5</td> <td>0,6009151</td> <td>2</td> </tr> <tr> <td>MT1_1</td> <td>0,48491111</td> <td>3</td> </tr> <tr> <td>MT1_6</td> <td>0,36222612</td> <td>4</td> </tr> <tr> <td>MT1_3</td> <td>0,31985451</td> <td>5</td> </tr> <tr> <td>MT1_4</td> <td>0,19085262</td> <td>6</td> </tr> </tbody> </table>	Maint. Task	Score	Position	MT1_2	0,65644141	1	MT1_5	0,6009151	2	MT1_1	0,48491111	3	MT1_6	0,36222612	4	MT1_3	0,31985451	5	MT1_4	0,19085262	6	<p>WC1 - future</p> <table border="1" style="width: 100%;"> <thead> <tr> <th>Maint. Task</th> <th>Score</th> <th>Position</th> </tr> </thead> <tbody> <tr> <td>MT1_6</td> <td>0,26894646</td> <td>1</td> </tr> <tr> <td>MT1_3</td> <td>0,20261408</td> <td>2</td> </tr> <tr> <td>MT1_2</td> <td>0,19190658</td> <td>3</td> </tr> <tr> <td>MT1_5</td> <td>0,18941079</td> <td>4</td> </tr> <tr> <td>MT1_1</td> <td>0,17917192</td> <td>5</td> </tr> <tr> <td>MT1_4</td> <td>0,08739849</td> <td>6</td> </tr> </tbody> </table>	Maint. Task	Score	Position	MT1_6	0,26894646	1	MT1_3	0,20261408	2	MT1_2	0,19190658	3	MT1_5	0,18941079	4	MT1_1	0,17917192	5	MT1_4	0,08739849	6
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**Figure 12.** Past, future, present and final scores matrices examples for all the criteria in WC1.

After the application of the same procedure that has been used for processing the information related to WC1 to the other two work centres (WC2, and WC3), by accomplishing the same main 5 steps of the DMCDM, the following final maintenance tasks' rankings have been obtained for these WC2 and WC3.

Next, the two maintenance tasks, out of each WC, with the higher ratings shown next are selected for further processing in the 2nd stage of the maintenance data processing method.

It is important to notice that despite M1\_3 not having good rankings in terms of historical data evaluation, it benefits from the greater importance that has been given in WC1 to the present or current data.

WC2 – final scores

Maint. Task	Score	Position
MT2_2	0,5699688	1
MT2_6	0,5284007	2
MT2_5	0,4882188	3
MT2_4	0,3952934	4
MT2_3	0,3838716	5
MT2_1	0,3742694	6

WC3 – final scores

Maint. Task	Score	Position
MT3_1	0,6617229	1
MT3_2	0,5652877	2
MT3_5	0,4242146	3
MT3_3	0,4114283	4
MT3_6	0,3966577	5
MT3_4	0,3958268	6

Figure 13. Past, future, present and final scores matrices examples for all the criteria in WC1.

Although, regarding the MT1\_5, it reaches a higher rating than MT1\_6, besides being a little worse positioned in terms of present data ratings, and with considerably worse position regarding future data, as the past data has a higher impact in the final rating than the provisional of future data, which in this case this favours MT1\_5.

**2nd stage) Inter work centres evaluation**

In the 2ndstage, the DMCDN isrepeated for the best rankings obtained in the 1st stage. Thus, follows the application of the same approach to the six maintenance tasks from the 1st stage with a higher ranking to be further processed based on the application of the same DMCDM by the whole set of decision makers underlying the WC1, WC2, and WC3, to obtain the final list of the three maintenance tasks with higher priority for being jointly scheduled with the production

orders, by repeating the application of the same main 5 steps that were previously applied on each WC.

In this 2nd stage of the method, a higher importance has been given to the past data, followed by present and less importance to the future data, to obtain the final overall rankings.

Thus, the 3 maintenance tasks with better ratings - out of the set of the six maintenance tasks list including the two of each WC with a higher priority - that were reached for being jointly scheduled with the production orders are the following: MT2\_2 (being redefined as simply M2, the M3\_2, redefined as M3, and M1\_5, redefined as M1).

It is important to notice that eventually other criteria and importance could be defined for accomplishing this second stage of the decision method.

(a) Final scores of MTi from 1<sup>st</sup> stage

i	Score	Maint. Task
1	0,5652022	MT1_3
2	0,5343635	MT1_5
3	0,5699688	MT2_2
4	0,5284007	MT2_6
5	0,6617229	MT3_1
6	0,5652877	MT3_2

(b) Final rankings of MTi from 2<sup>nd</sup> stage

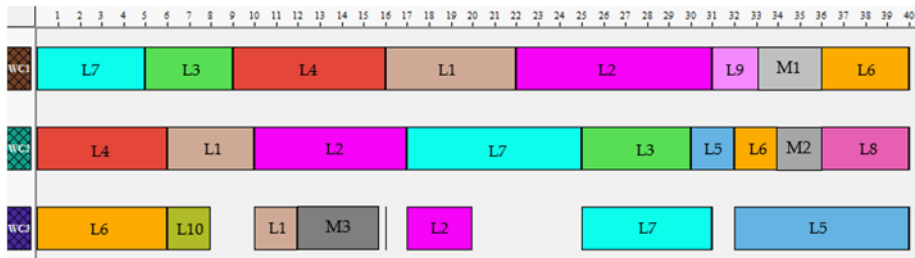
Maint. Task	Score	Position
MT2_2	0,6463834	1
MT3_2	0,5581164	2
MT1_5	0,4785514	3
MT3_1	0,4774147	4
MT2_6	0,4337532	5
MT1_3	0,1708652	6

Figure 14. (a)Aggregated final scores’ matrices about WC1, WC2, and WC2 from the application of the 1st stage and (b) the 2nd stage of the maintenance tasks assessment methodology.

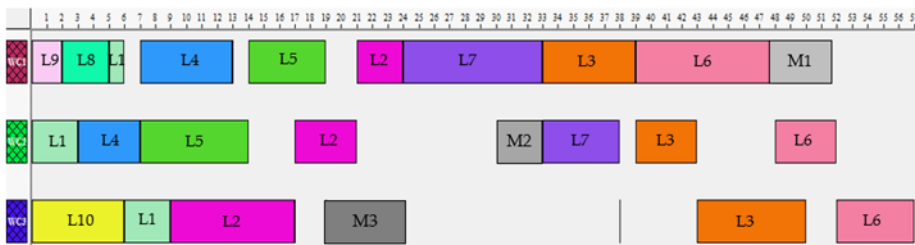
### 4.2. Collaborative scheduling: joint selected maintenance tasks and production orders programming

The joint collaborative scheduling is performed next, based on the model presented in (Varela, et al., 2022b), to jointly program a current set of companies' production orders, along with the previously selected set of the three maintenance tasks with higher scores: MT2\_2 that will now be defined simply as M2, MT3\_2 as M3, and M1\_5 as M1, related to the workcentres WC1, WC2, and WC3, correspondingly, and alternative possible solutions are shown in the Figs 15 to 17 below.

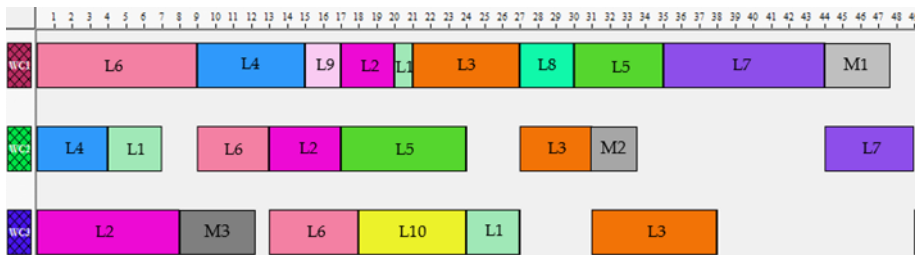
production orders, along with the previously selected set of the three maintenance tasks with higher scores: MT2\_2 that will now be defined simply as M2, MT3\_2 as M3, and M1\_5 as M1, related to the workcentres WC1, WC2, and WC3, correspondingly, and alternative possible solutions are shown in the Figs 15 to 17 below.



**Figure 15.** Gantt chart about the best solution found for scenario 1 (about the minimization of the internal performance measure, makespan, Cmax) (adapted from, (Varela, et al., 2022b))



**Figure 16.** Gantt chart about the best solution found scenario 2 (about the minimization of external measures, tardy jobs, Nt, and maximum tardiness, Tmax) (adapted from, (Varela, et al., 2022b))



**Figure 17.** Gantt chart about the best solution found for scenario 3 (about the combined (50%-50%) minimization of both kind of measures, Cmax, and Nt) (adapted from, (Varela, et al., 2022b))

These Gantt charts express possible alternative solutions for jointly scheduling the maintenance tasks and a set of ten lots of

production orders (L1 to L10), based on the preference that is given by the decision making team regarding internal oriented

performance measures(makespan) (Fig. 15) or external oriented ones(tardiness and tardy tasks) (Fig. 16) or a combination of internal and external measures (makespan and tardy tasks) (Fig. 17). Thus, the developed CMS provides additional flexibility by enabling to choose the best suited application scenario, by using appropriate scheduling algorithms put available for processing the joints maintenance and production tasks, according to a given industrial context and management preferences or goals of the decision making team.

## 5. Final Discussion

According to a study conducted, and by analysing a set of twenty publications about maintenance and production management a resume of main contributions from the literature were analysed, considering a set of seven main dimensions underlying this study about: dynamic, integrated, real-time, distributed, and predictive management strategies (Varela, et al., 2023), along with time and condition based maintenance, as synthesized in the Table 1.

**Table 1.** Resume of main dimensions of literature contributions and proposed approach

Dimension	Dynamic	Integrated	Real time based	Distributed	Predictive	Time based	Condition based
<b>Contribution</b>							
(Aggarwal, et al., 2018)	X		X		X	X	X
(Assaf, Scarf, & lung, 2019)	X					X	X
(Aydemir, Acar, 2020)	X		X		X		X
(Bektas, Marshall, & Jones, 2020)	X		X		X		
(Benker, et al., 2021)			X		X		
(Biondi, & Harjunkski, 2017)	X	X	X		X	X	X
(Lee, & Chen, 2000)		X				X	
(Ghaleb, Taghipour, Sharifi, & Zolfagharinia, 2020)		X				X	X
(Kim N-H, An D, & Choi J-H, 2017)			X		X	X	X
(Li, et al., 2019)	X		X		X	X	X
(Luo, et al., 2019)	X		X		X	X	X
(Malhotra, et al., 2016)			X		X	X	X
(Michau & Fink, 2019)	X		X	X	X	X	X
(Mosheiov, & Sarig, 2009)		X				X	
(Rahmati, Ahmadi, & Govindan, 2018)	X	X	X				X
(Sloan, & Shanthikumar, 2000)		X				X	X
(Wang, & Yu, 2010)		X				X	
(Yang, Ma, Xu, & Yang, 2011)	X	X				X	
(Zandieh, Khatami, & Rahmati, 2017)		X					X
(Zhai, B. Gehring, & Reinhart, 2021)	X	X	X		X	X	X
This work	X	X	X	X	X	X	X

The analysed publications listed in the Table 1 show that, on average, 3 to 4 of the dimensions proposed for carrying out the collaborative maintenance and production management are considered. Therefore, it is noticeable that this work is novel and that there is still a gap regarding this kind of contributions in the focused scientific and technological domain.

## 6. Conclusion

In this paper a group decision making (GDM) approach for maintenance tasks ranking and selection for being jointly scheduled with production orders was put forward. The proposed approach was implemented based on a two-stage assessment method, which makes use of a dynamic multi-criteria decision method (DMCDM). The DMCDM enables to merge and jointly process and analyse maintenance information regarding historical, current and provisional data, based on corresponding subsets of criteria, which are defined according to a group of decision makers that interact on its definition and application of the proposed underlying maintenance tasks processing methodology, which is accessible through a developed collaborative management system (CMS), accessible by a set of entities for enabling joint decision-making. The utilization of the proposed GDM approach was illustrated through an industrial example of application and it revealed to be promising in supporting joint maintenance and manufacturing orders processing, once permitting to rank and select a set of maintenance tasks with highest scores for being jointly scheduled with

production orders by using other functionalities included in the CMS. This is a novel contribution, as far as our knowledge, and based on the study conducted there are no similar contributions in the literature that enable a distributed and dynamic maintenance tasks assessment and selection, based on a DMCDM, for being further jointly programmed with production orders, through the CMS. Besides, the CMS includes other functionality, namely for predicting maintenance key performance indicators, which are considered through criteria included in the prognostic data processed using the DMCDM, such as mean time before failure. Thus, this works contributes to the maintenance and production orders management scientific domain, which continues lacking of contributions that enable collaborative decision-making, which is considered of utmost importance to promote a sustainable development of companies, and is supported by new technologies underlying the current digital age, being still necessary further developments and industrial applications to be explored.

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## **EMOI: AN INNOVATION MANAGEMENT MODEL PROPOSAL**

***Abstract:** In the last two centuries, mankind has developed an accelerated technology change process, since the first industrial revolution up to the present, so called by some, fourth industrial revolution. The innovation processes and activities have played a fundamental role in this evolution. In future decades innovation will continue playing central role in the way society faces challenges such as climate change, energy shortage or population growth. For organizations of any type, managing the innovations process is becoming essential, far from the idea that innovation is always based in brilliant, isolated good ideas. What we present in this paper is a model to manage innovation processes and activities inside organizations. Our EMOI (Excellence in the Management of Organizational Innovation) model proposes a series of steps to be followed and a catalog of useful tools to empower innovation processes. Competencies required in innovation management are also considered.*

***Keywords:** Innovation, Management, Innovation tools*

### **1. Introduction**

The concept of innovation is particularly important nowadays as it implies for many organizations a differential element of competitiveness. This has not always been the case. The term "innovative" has had a negative meaning since the first Greek philosophers (for whom it meant changes in the status quo, therefore, a malign or, at least, uncomfortable approach) until the late 19th and early 20th centuries (Castro and Fernández, 2013), when it is linked to "novelties in things" and not only in the social, political or economic order.

According to its usual interpretation, innovation would include the following five cases:

- The introduction into the market of a new good, that is, a good with

which consumers are not yet familiar, or of a new class of goods.

- The introduction of a new method of production, that is, a method not yet tried and tested in the branch of industry concerned, which needs to be based on a new scientific discovery.
- The opening of a new market in a country, whether the market already existed in another country or not.
- The conquest of a new source of supply of raw materials or semi-finished products, again regardless of whether this source already exists or is to be created anew.
- The implementation of a new structure in a market, such as the creation of a monopoly position.
- The following are some definitions provided by leading authors that we

consider important because of the ideas they incorporate:

- Process by which, from an idea, invention or recognition of a need, a useful product, technique or service is developed (S. Gee, 1981).
- Innovation is an idea transformed into something sold or used (Piatier, 1981).
- A set of activities, in a given time and place, that lead to the successful introduction of an idea in the market, for the first time, in the form of new or improved products. Management and organizational services or techniques (Pavón and Goodman, 1987).
- Innovation is the complex process of bringing ideas to the market in the form of new or improved products or services (Cotec, 1988).
- To innovate is to want to create value in a systematic way (Parra, 2002).
- To innovate is to create a new (or improved) product or process - or a combination of both - that differs significantly from previous products or processes and that has been made available to potential users (product) or put into use (process) (Oslo Manual, OECD/Eurostat 2018).

From the Center for Quality and Change Management of the Universitat Politecnica de Valencia (Polytechnic University of Valencia) (CQ/UPV) we have been working for more than 15 years in the field of innovation and we work mainly with the development of 2 conceptual axes about "what is innovation":

The first one talks about the personal attitude to innovate through observation, thinking and execution:

- "It is a unique sensation to see what no one has seen before and to understand what no one knew how

to explain before" (Friedman, 1990).

- "To innovate is to see what everyone else sees, to think what few others think, to do what no one else does..., obtaining a product, a service or a process that does not ruin your organization and that makes you money by commercializing or implementing it." (Montesinos et al., 2020).

The second deals with innovation as a process within an organization's management system that allows the transmission of knowledge in the form of added value:

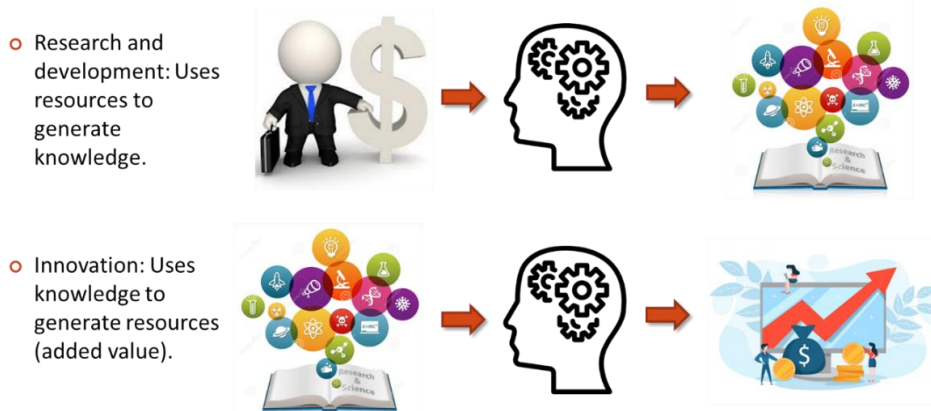
- Research and Development is a process where resources are used to generate knowledge. Innovation (with a capital I) is not necessarily a consequence. It is a different process in which knowledge is used to generate ADDED VALUE (Nieto, 2010).

This point deserves special attention, both from the perspective of public government and University Management. The generation of knowledge (transformation of resources into stock of knowledge) requires a stable investment since obtaining specific results is neither immediate nor occurs as a natural, unforced consequence of the process. Knowledge generation produces results mostly if it is driven by KNOWLEDGE TRANSFER.

We understand knowledge transfer as the actions, structures and personnel dedicated to transform KNOWLEDGE (known, understood and applied) into ADDED VALUE for a THIRD PARTY.

Societies that do not generate knowledge have problems to be a reference in the generation of innovation. And, for these societies, without innovation there is a future imposed by those who do innovate.





**Figure 1.** Difference between innovation and research and development

From the perspective of the spaces where knowledge is generated, it is fundamental to understand that if there are no structures, personnel and/or budget to transfer knowledge, these institutions pass (or remain) in spaces of inconsequence.

### 1.1. Types of innovation

Just as there are countless definitions of the concept of innovation, there are also numerous criteria for classifying innovation. At CQ/UPV we basically work with 5 criteria:

- The area of application.
- The scope of the innovation.
- The knowledge bases on which it is based.
- The functions of the organization where it is applied.
- The organizational dimensions (hexagon for innovation).

According to the application area we consider: Product innovation; Service innovation; Innovation in the process; Innovation in the market; New functionalities of existing products; Innovation in raw materials; Innovation in marketing and distribution and Social innovation, among others

In this taxonomy we subordinate the product and the service to the process that supports it. Innovation occurs with a new product or with modifications to an existing product (additions, changes, simplifications, or improvements). The same happens with the service, with the process or with any of the other categories.

From another perspective, and depending on the scope of innovation, we can distinguish two ways of practicing innovation:

- Incremental innovation: progressive incorporation of improvements in existing products, services, processes (or combinations of the three) in order to improve performance or reduce costs. In this sense, incremental innovation and continuous improvement are very close, sometimes indistinguishable.
- Radical innovation: essential modification of the characteristics and benefits offered to stakeholders of a product or service that generates a new need, meets current needs or fulfills explicit or implicit expectations.

Researchers at CIRCLE (Centre for Innovation, Research and Competence in the Learning Economy, Lund University, Sweden) led by Professor Ashiem (Ashiem

et al 2005) propose to consider the origins of knowledge, the actors and resources involved, the necessary interrelation processes between environments and the consequences of innovation in order to classify it according to the basis and generation of the knowledge that sustains it. They identify three different knowledge bases to produce innovation: Analytical, Synthetic and Symbolic innovation.

Analytical knowledge is based on science and underpins innovations based on formal, deductive tools and processes. It is mostly shared in scientific publications or in licensing. Synthetic knowledge comes from the world of practice and engineering and is achieved by combinations of existing knowledge or improvements in its application. Symbolic knowledge, on the other hand, has its origin in the cultural and artistic practices of a collective to generate new representations and transmission of social, historical, popular or dystopian stories.

Also in this aspect, three major non-hierarchical areas are identified where the innovation activity has an impact: the business configuration, the engineering of what is offered and the customer interaction with the experiential elements of the organization.

The fifth criterion, the organizational dimensions (hexagon for innovation), will be exposed in the next epigraph, as it is especially relevant for our proposal of an Innovation Management Model.

## **2. The organizational dimensions (hexagon for innovation).**

At the Center for Quality and Change Management of the Polytechnic University of Valencia, since 2005 we have been reflecting on the different elements that explain the management of Innovation. As a research center of a public university, our

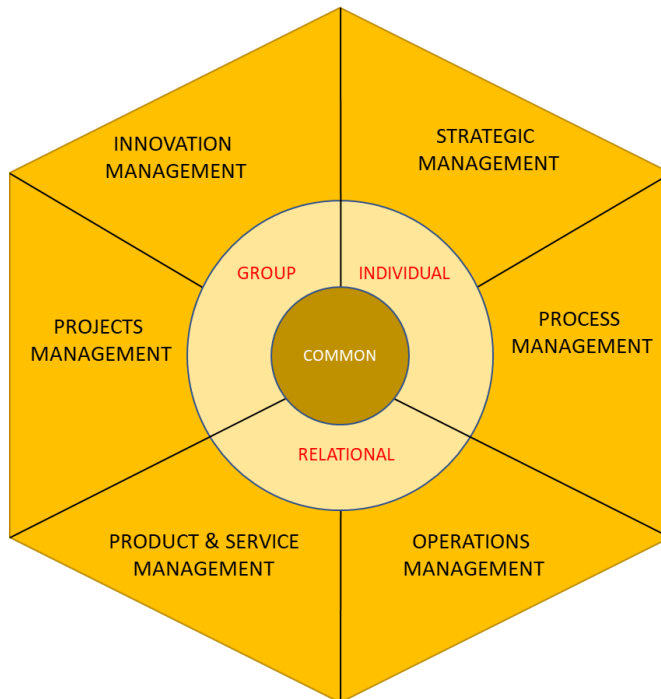
commitment to the generation of knowledge and with lifelong learning has led us to the development of a catalog of tools that allows us to identify not only what tools exist, but also in which dimensions of the organization they should be used.

A first conceptual step was to distinguish that there are some tools that lead to IMPROVEMENT and others that lead to INNOVATION. In both cases, we were able to identify competencies that managers and employees needed to have available to be able to act in one direction or another. The second stage was to distinguish in which dimensions of the organization it was possible to develop a specific innovation (or improvement) using our own tools.

Following this line of thought, we proposed three categories of competencies that would allow us to create a catalog of "competencies for innovation". Take into account that it is more relevant to identify required competencies, than to identify tools to be used: Tools are just the way of operatizing competencies.

In addition to a set of competencies common to all those involved in innovation processes, we identified three categories of competencies to consider. The first category corresponded to individual competencies, defining these competencies as those used individually by executives and managers to support the use of tools conducive to innovation. The second corresponds to group competencies, competencies that must be acquired to work effectively in a group to lead the use of tools to generate innovation. Finally, we identified relational competencies, those that must be acquired to drive innovation with support outside your own department, company or region.

In this process of constructing the model, we confirmed that the improvement-innovation distinction lost significance when we saw the scope of the dimensions and competencies.



**Figure 2.** Organizational dimensions and innovation competencies

In figure 2 we can see the six dimensions and the four categories of competencies. No relationship exists between the position in the figure) of the competencies categories and the organization dimensions: group and relational competencies can be required in each of the dimensions.

The hexagon allows us to represent six organizational dimensions in which innovation takes place and where it is possible, in turn, to identify specific tools that support the development of this innovation. The innovation action may be incremental or radical, based on analytical, synthetic or symbolic knowledge, or have as a consequence an application in any business function. Through this approach it is possible to make innovation appear as a matter of training, discipline and system. Constructive discourse based on the use of tools with the appropriate competencies opens up new spaces, forms and ways of generating

innovation without basing this process exclusively on inspiration.

The selection of innovation tools is outlined in Figure 3. The list of tools should be considered as an example, a list that is not complete nor exclusive.

The more than 40 tools identified by the Quality and Change Management Research Center of the UPV respond to a first need for a basic cataloguing of the methodologies on which organizations should work. Secondly, it is linked to the need to identify where the organization wants to place its investment and implementation efforts in innovation projects.

Innovation is not something ethereal or exclusively inspirational. It responds to specific drivers that force organizations to undergo situations of unstable dynamics and growth or, in the worst case, regression and collapse.



**Figure 3.** Innovation tools and the Hexagon of Innovation

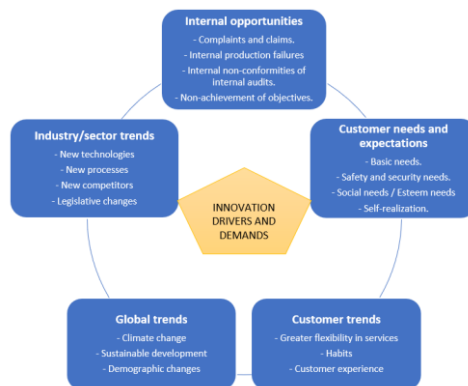
### 3. Innovation drivers and demands

Although much work has been done on the conceptualization of innovation, on tools, methodologies and competencies for excellence in innovation, what companies really need is a process that allows for the effective deployment of innovation at both the strategic and tactical or operational levels.

One of the most common mistakes of organizations in the deployment of their innovation process is to try to jump directly to the implementation of their innovative ideas, without properly defining the innovation challenge and for this we must pay attention to the input to the model. These are the trends, drivers and sources of innovation demands. These sources include the following five great categories:

Global trends  
Industry trends  
and expectations  
Internal Opportunities

Consumer trends  
Customer needs



**Figure 4.** Innovation drivers and demands

It is important to highlight the role of trends in innovation as a basis for defining innovation challenges. Trends allow us to understand change and innovation to act on it. In an innovation process, trends can help to define the user profile, inspire creativity, or future scenarios that help us to think about the evolution of products and services. Because of the relationship that exists around change, trends and innovation are completely connected, and they need each other to be useful.

This tendency analysis can be viewed as the first step of our Innovation Management Model, as it serves as source of innovative ideas and plans, and as input for the rest of the process.

#### 4. The Excellence in the Management of Organizational Innovation (EMOI) model

One of the most important criticisms of management systems defined according to the guidelines of international standards is that they are very generic, very bureaucratic and do not solve many practical problems that organizations usually encounter.

We have also seen that organizations, in many cases...

- Do not have at their disposal all the necessary knowledge to solve the demands that they usually encounter.
- In some cases, although they have the knowledge, they do not know how and when to use it.
- Do not know how to convert these demands into real challenges that really create added value to their products or services.

In order to solve some of these innovation management problems and to comply with the general principles of management excellence, we have developed the EMOI Model. This model is the result of the previous considerations presented in this

paper, and other that the limited space of a conference presentation makes impossible to include here.

It is an innovation management model that...

- Allows to manage in a structured and joint manner the necessary tools and methodologies to plan, deploy and measure innovation at all levels of the organization: strategic, tactical and operational, as well as the temporal sequence of use.

- It provides the necessary methodology to convert the demands and tendencies (social, consumer, internal to the organization...) into real challenges that really create added value to its products or services and that this is perceived as excellent by the stakeholders.

The EMOI Model is a model that manages tools, methodologies, activities and competencies and their application using the global 5F methodology. A methodology that defines which tools and methodologies to use, when and how. It is a model that allows to understand the innovation demands (E), to define innovation (D), to deploy it (D) and to evaluate its results (E).

The EMOI model is structured in 4 criteria (Figure 5):

- Criterion 1. Innovation demand profile.
- Criterion 2. Innovation value proposition.
- Criterion 3. Innovation spaces.
- Criterion 4. Innovation results.

Criterion 1 includes the tools and methodologies for analyzing the demands of stakeholders, the organization itself and its environment and answering questions like these: Who are the customers, and the stakeholders? What do I know about my customers? What are their expectations and needs? What is the organization currently doing to satisfy these needs? Strengths and weaknesses? Who are my competitors and what are they doing? Threats and opportunities?

Criterion 2 includes the tools and methodologies that make it possible to turn the voice of the innovation driver into the voice of the organization's innovation. This is the real heart of the EMOI model. During the deployment of this second criterion, it

will be possible to:

- Identify and define the innovation challenges.
- Identify the innovation space in which the challenge must be solved.

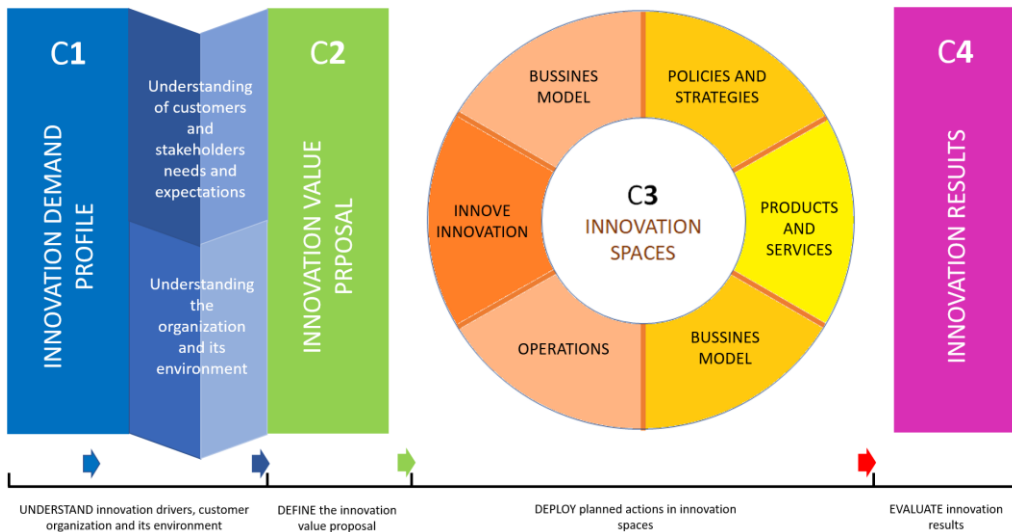


Figure 5. Criteria in the EMOI model

Criterion 3 includes the tools and methodologies that allow the different specialists of the organization to solve the innovation challenge. The different spaces where this innovation can be solved are shown in the Innovation Hexagon.

Finally, criterion 4 includes the tools and methodologies that allow us to answer the following questions: How do we measure the outcome of our innovation? How has the innovation solved the demands? Have we really increased the added value of our products and services and does the customer appreciate it? How are priorities for improvement decided in innovation management?

## 5. Global 5F implementation methodology

In the process of implementing the model, we can speak of 5 phases (the methodology for implementing the EMOI model is known as the 5F Global Methodology).

The methodology phases (Figure 6) cover the following activities:

- F1. The first phase includes the activities necessary to identify the sources of innovation demands.
- F2. The second phase includes the activities necessary to define the innovation demand profile that includes the result of the stakeholder analysis, the internal analysis of the organization itself and the analysis of the environment.

- F3. The third phase includes the activities to build the innovation value proposition, which includes the definition of the innovation strategies to solve the innovation demands and their prioritization, as well as the definition and planning of the innovation challenge that must be solved to satisfy the innovation demands.
- F4. This fourth phase includes the activities carried out by the specialists in each of the innovation spaces and that allow solving the innovation challenge.
- F5. The last phase includes the activities necessary to evaluate the results of the proposed innovation solution measured as the added value that the product or service offers to the different stakeholders.

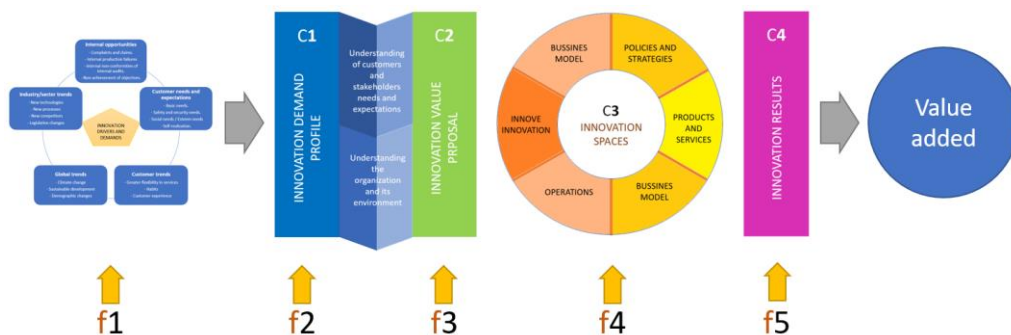


Figure 6. Global 5F methodology

## 6. Final comments and conclusions

EMOI model is not just a theoretical proposal. It has been tested in 130 companies, in different sectors and countries of Latin America (Perú, Colombia, Ecuador, Panamá, Uruguay, Paraguay, Argentina and Costa Rica), including industrial sector companies (chemical, food and agro, manufacture, ...) services (tourism, engineering, finances, assurances, ...) and public sector. Most of the are small and medium enterprises (SME), and their positive experience has shown us that the model, always subject of possible improvements, has helped these organizations to add value for their customers and to face future with better

perspectives. We are preparing a detailed, qualitative and quantitative analysis of the results achieved.

With this experience we are confident that EMOI model can help organizations to take the train of innovation, and continue being active in the markets and profitable. We have special interest in SME, because this is the greatest segment in many countries and, by its limited size, at the same time, they are the least likely to benefit from the use of complex management models with a strong tendency towards bureaucracy.

The model, as presented here, is complemented with a series of operative tools to facilitate the use of the Global 5F methodology, and guides and recommendations on how to use it to create value for customers.

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## SYSTEM THINKING FOR BUSINESS MODEL INNOVATION

**Abstract:** *Management leaders can use systems thinking models to improve comprehension, creativity, and productivity. Systems thinking and business models or business model innovation (BMI) merge. As a complex management endeavour, the creation of BMI may require a significant contribution from the system thinking approach. We have evaluated the literature on systems theory, system thinking models, and business model innovation to demonstrate the promising role of system thinking models in BMI research and identify a system thinking strategy. The systems thinking methodology provides a framework for comprehending complexity, dynamic change, and advanced modelling technologies related to learning settings. This work introduces systems thinking methods, system dynamics (SD) and causal loop diagrams (CLD) to increase BMI complexity. The feedback that might solve issues with the system and innovation project boundaries, specifically the balancing loop, is one of the essential components of innovative management. A negative or balancing loop clarifies the system's behaviour, which empowers management to take creative and long-lasting action. A final CLD shows how to use this system thinking method for BMI. The research findings show that systems thinking concepts and techniques may offer the adaptability needed to better handle innovation, complexity, and uncertainty.*

**Keywords:** *systems thinking models, sustainable management, innovation management*

### 1. Introduction

Peter Senge presents the term systems thinking in his book *The Fifth Discipline* (1990). Systems thinking offers a different view of life and society; it identifies patterns and relationships among system elements and shows how to structure them more effectively. Systems Thinking is a discipline that enables:

- Observing a reality composed of dynamic systems.
- Building descriptive and simulation models.
- Improving the ability to acquire knowledge, i.e. learning.

- Developing intelligence.

Systems thinking, or thinking as a discipline, must be learned gradually through practice and continuous improvement. Peter Senge (Senge, 2006) presents systems thinking as an intuitive way without logical principles behind it.

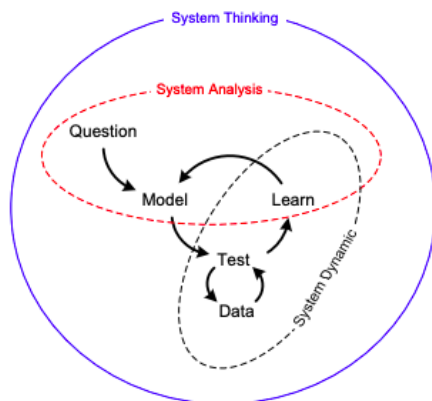
Systems thinking, which has been developing over the last 60 years, is increasingly impacting science and its application in all areas of life. In short, systems thinking is the science of organising logic and integrating disciplines to understand the patterns and relationships of

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complex problems. Systems thinking is also known as principles of organisation or self-organisation theory, which includes 'systems' or 'holistic thinking. It is a science based on understanding the connections and relationships between seemingly isolated things (Haraldsson, 2004).

The logical structure of this discipline can be summarised in five basic rules that the systems thinker must always respect: to understand the world, one must be able to see the "wood from the forest"; one must develop the ability to "zoom in" on parts of the whole, from the whole system to the components; one must not limit one's observation to what appears to be constant, but "look for what changes" (Mella, 2008). Variables - "variations" and feedback loops - are what the systems thinker is interested in—systems thinking is more than just a chain of cause-and-effect relationships. By linking variables, we induce loops between all these variations to transform linear variations in the systemic interactions between variables. At the same time, when we observe the world, we must always define the boundaries of the system we are studying. The systems thinking model introduces two concepts: systems analysis (SA) and systems dynamics (SD)



**Figure 1.** Systems Thinking Model (Source: Haraldsson, 2004).

Systems Analysis (SA) is concerned with uncovering organisational structures in systems and generating insights into the organisation of causality. SA involves breaking down a problem and reassembling it to understand its components and feedback. Systems analysis involves group modelling, where an initial question, problem and mental model structure present the core of a causal loop diagram (CLD). This concept can unlock complex systems, managers and entrepreneurs for sustainability and innovation. The function of the DUP is to map the structure and feedback of a system to understand its feedback mechanisms. DUP serves to understand how behaviour manifests in a system so that strategies can be developed to work on or counteract certain behaviours. Every time we look at a problem, we ask questions, so we can constrain the system to the question asked, and the question becomes the system's boundary around the problem.

The term 'system dynamics' was first presented by Jay Forrester of MIT in the 1960s (Forrester, 1961). System dynamics is about re-creating an understanding of the system and its feedback. It aims to explore dynamic responses to changes within or outside the system. System dynamics create blueprints for interpreting the past and predicting the future. In addition, system dynamics deals with the mathematical representation of our mental models and is a second step after we have developed our mental model. System dynamics is also concerned with numerical analysis and understanding the uncertainty of the realistic representation in the developed mathematical model. All models, whether in the form of a written text, conceptual or mathematical, have an inherent structure of "systems thinking" built into them, as they are constructed according to certain thinking and logic. A model is successful when the thinking behind it is successfully transferred

from the model builder to the observer (Haraldsson & Sverdrup, 2003). A model that does not explain its principles is essentially useless. Therefore, using a common language to convey this understanding is crucial for communication between users and model builders.

Systems thinking provides a language for understanding complexity and dynamic change and offers sophisticated modelling technology and associated learning environments. For this paper, *innovation* is defined as the creation of new knowledge, services, products, and processes using new or existing scientific or technological knowledge that provides a degree of novelty.

Taylor (2017) also defined innovation as "a creative process in which new or improved ideas are successfully developed and applied to produce practical and valuable results". Nidumolu (2015) sees four stages of sustainable innovation-considering: alignment as an opportunity; creating value chains for sustainability; designing sustainable products and services; and developing new business models-describe variations of innovation that require different

levels of effort or change and have different levels of impact in the systems in which they operate.

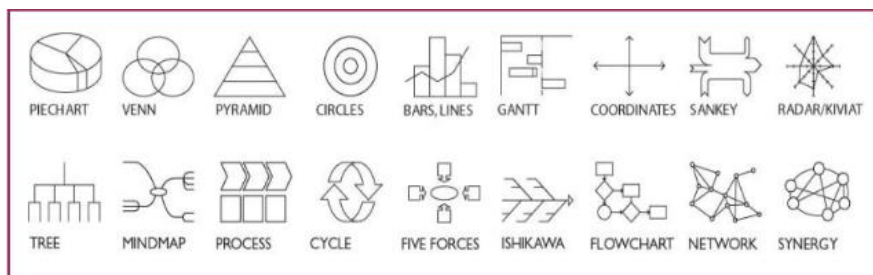
The systems thinking model uses different tools to build holistic perspectives and practices for innovation and sustainable management.

## 2. Methodology

This paper explores different tools and how they can help develop sustainable management and innovative business models. Knowledge visualisation is a central concept with system dynamics (SD) and causal loop diagrams (CLD).

The visual representation of plans, processes, strategies, performance, and many other business entities is a fundamental underpinning of knowledge and practice in business management research (Eppler & Burkhard, 2004).

Figure 2 provides an overview of the most used diagrams in the knowledge visualisation process as ancillary tools in management decision-making.



**Figure 2.** The most used models (Source: Eppler & Burkhard, 2009)

Figure 3 illustrates the complexity of natural systems and the main contributing factors which can meet the requirements for dealing with complex management situations. Figure 3 shows how the above requirements can be met using systems thinking tools, leading to the desired results (Eppler & Burkhard, 2007).

System Dynamics (SD) has been established as a powerful approach to understanding, simulating, analysing, and predicting fluid, complex and dynamic business processes. One of the critical ways to translate human language into machine-readable language is the flowchart.

A causal loop diagram (CDU) is a system thinking tool that could be used to illustrate sustainable and innovative systems. CDUs consider sustainability and innovation as

focal points and expose new concepts that simplify complex webs of management, business, socio-economic and environmental subsystems (Haraldsson, 2004).



**Figure 3.** A framework of systems thinking tools to help achieve the desired outcomes contributing to sustainable management (Source: Ammirato & al., 2021).

### 3. The Complex Systems Modelling Paradigm

The complexity of individual systems is reflected in the ability to identify the best solution among many other solutions. The complexity dynamics increase over time depending on the interactions between subsystems or agents. Dynamic complexity increases as systems: (Serman, 2020)

- **Dynamic:** Heraclitus said, "Everything changes". Systemic changes occur at different times and sometimes influence each other. A star evolves for over a million years before burning through its hydrogen fuel and then exploding as a supernova in seconds. An evolving square can grow for years and then collapse in hours. After a long time,

what seems to be unchanging seems to change.

- **Highly interconnected:** System elements are highly interconnected, interacting with each other and with the natural world. Everything is connected to something else.
- **Feedback loop,** where feedback is the driving force: because the elements are so closely connected, our actions receive feedback about them. The dynamics arise from this feedback. Our decisions change the state of the world by causing changes in nature and by causing other changes, marking new situations that influence our future decisions.
- **Non-linear:** the effect is rarely proportional to the cause, and local developments often do not affect

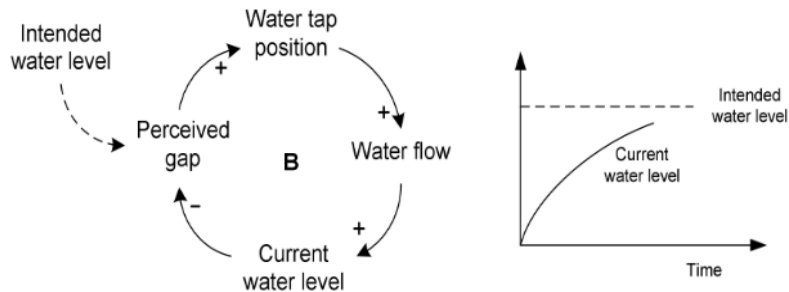
distant areas. Non-linearity often arises from fundamental physical laws and several factors in decision-making - the pressure to achieve more increases motivation and effort, but only to the point where it becomes clear that the goal is unattainable.

- Historically dependent: Taking one path often precludes taking another and determines the end of the path (path dependency). Many actions are irreversible. A broken egg cannot be made whole (second law of thermodynamics). Stocks and flows (accumulation) and long-time lags often mean that action and inaction have different time constants.
- Self-organised: the dynamics of a system arise spontaneously from its internal structures. Frozen patterns, heartbeats, consistent real estate market targets and structures such as shells and markets arise spontaneously from feedback between factors and elements of the system. Often minor random disturbances, reinforced and shaped by feedback structures, form patterns in time and space and create path dependencies.
- Adaptability: The decision-making capabilities and rules of agents in complex systems change over time. Growth leads to selection and introduction; some agents while others disappear. Adaptation also occurs when people learn through experience, especially when they learn new ways to achieve their

goals in the face of obstacles. In any case, such learning is not always welcome.

- Intuitive control: In complex systems, causes and effects are distant in time and space, and we want to see the causes when the events we want to explain occur. High-impact policies are often not visible here. We are trying to draw attention to the symptoms of problems, not their causes.
- Political resilience: the complexity of the systems we are embedded in exceeds our capacity to understand them. The result: more apparent solutions to the problem fail or make the situation worse.
- Defined by substitution: Time lags in the feedback loop represent the long-term response of the system to an intervention, which is often different from the short-term response. High-impact policies often worsen situations in the short term and improve them in the long term. The opposite is true for low-impact policies, which often improve temporarily before the problem worsens.

Effective modelling involves constant iteration between experimenting and learning in the virtual world and experimenting and learning in the real world. Modelling is embedded in system dynamics. The figure below illustrates the embeddedness of modelling in the natural and virtual worlds by explaining the causal loop.



**Figure 4.** Explanation of the Causal Loop Diagram (CLD) (Source: Haraldsson, 2004)

When we use the DUP language, we use feedback to explain a process. We always start with an initial question: "What do I need to do to ensure he fills the water glass and understands how the water flows in the lesson?". Instead of seeing the action from the individual's point of view, where 'I am the doer and the centre of focus, we shift our perception, where 'I am' becomes part of the feedback process rather than separate from it. Suddenly we have turned our attention to the structure of the behaviour, and we can see that the structure causes the behaviour. The CLD follows the details, and the 'feedback' in the model can be read as a story. Since we want a certain amount of water in a glass, we start by turning the water tap (Senge, 1990);

The main objective is to understand how managers can use systems thinking to achieve the desired results.

#### 4. Results

The data sources in Figure 3 were used to generate CLDs to demonstrate an effective decision support technique, the qualitative cause and effect diagram, which led to

sustainable and innovative management.

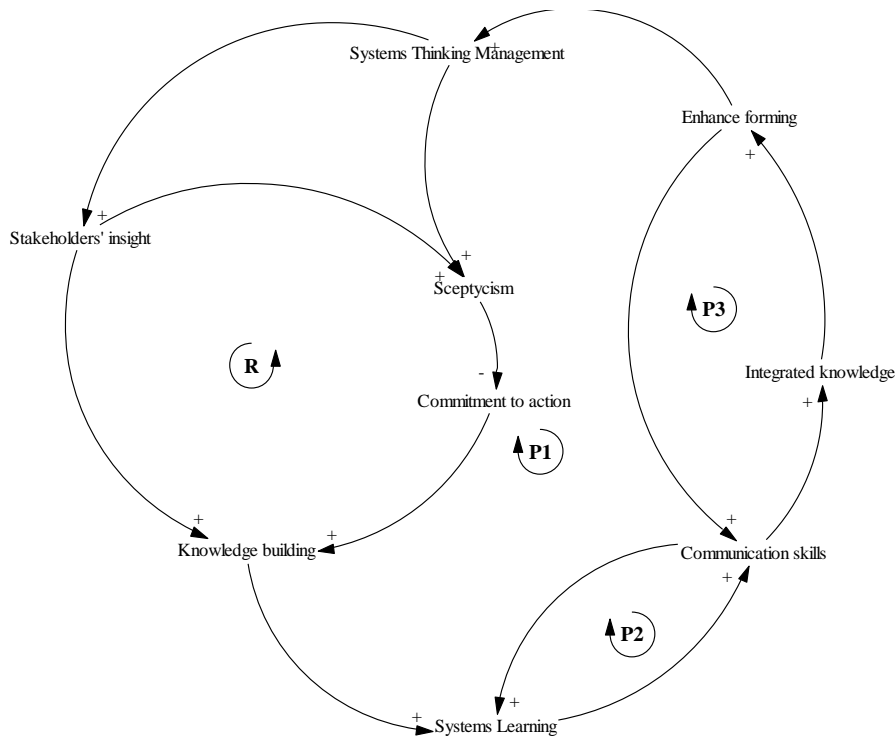
One of the well-known simulation modelling techniques is conceptual diagrams, which can unlock the decision-making process in a sustainable direction.

Business model innovation processes show that SD diagrams are a valuable tool for decision-making, improving managerial communication, strategies, knowledge integration, creative thinking, and evaluation of new business models.

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**Figure 5.** Dynamic diagram of a qualitative cause-and-effect system (Source: (authors, 2022))

Figure 5 shows the CLD model and the cause and effect of the imported facts, creating visible circular causality (loops), highlighted by a loop identifier, positive (reinforcing) or negative (balanced) feedback. The CLD does not show what is happening but what will happen if the variables change. The loops in the CLD are essential as they determine the system's behaviour. According to this model, managers can predict sustainable outcomes based on the interaction of cause-and-effect facts. An interpretation of the causal loop diagram (CLD) in Figure 5 would be as follows: Management with systems thinking influences (+) stakeholders' insights into systems increasingly, and they increasingly build knowledge about it (+). Knowledge increases (+) systems learning, which increases (+) communication skills and increases (+) integrated knowledge. Integrated knowledge has a positive effect

(+), and enhanced design affects the growth of systems thinking management (+). This description explains the reinforcement cycle, denoted by the symbol P. On the other hand, we have also anticipated the scepticism that is always present when change occurs. Systems thinking management increases (+) scepticism, but stakeholder insights also increase it (+), commitment to action decreases (-), and commitment to action has a positive effect on knowledge (+).

This description is represented by the equilibrium circle, denoted by the R. The causal loop model offers two more reinforcement circles, denoted by the symbols R2 and R3. Systems thinking increases (+) communication skills, and there is a growing return to systems thinking (+), which is becoming more and more understandable. Communication skills increase (+) integrated knowledge, which

has a positive impact on (+) enhanced modelling, which increases (+) communication skills. This qualitative description makes it possible to build a quantitative model in system dynamics. It can be said that the qualitative causal loop diagram forms the basis for a simulation model that can demonstrate the suitability of system modelling for sustainable innovation management. At once, it helps to bring about the desired systemic changes that are the key to individual and collective power of accountability (Zabukovec Baruca&Brezovec, 2014).

## 5. Conclusion

According to some authors (Košmrlj et al., 2015), the obstacles entrepreneurs meet when they try to solve problems of innovations are incorrect assessment of circumstances, insufficient data, information and analyses, and the importance of focusing

on the future. We can present and solve the problems by knowing a causal loop diagramming in a frame of system dynamics (CLD) since one of the most critical factors for sustainable management is feedback, especially the so-called balance loop. A negative or balancing loop, which emphasises system behaviour and enables management to make sustainable decisions, has the power to free complex systems, managers, and entrepreneurs to be sustainable and innovative.

Further research will address quantitative cause and effect diagrams by simulating the models developed. Thanks to visual diagrams acting as a knowledge interface between humans and machines, simulation software can implement system behaviour, test and evaluate the designed service of organisations and make sustainable decisions.

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## **PRELIMINARY ASSESSMENT OF THE TECHNICAL CONSEQUENCES OF THE INCIDENTS ON THE NORD STREAM 1 AND 2 GAS PIPELINES. POSSIBLE WAYS OF SOLVING THE PROBLEMS**

***Abstract:** The incident on the Nord Stream pipeline system at the bottom of the Baltic Sea in 2022 caused a significant release of natural gas into the atmosphere and made it impossible to transport gas further through three of the four pipelines. Before the pipeline system was inspected and the results of the technical commission were available, a preliminary assessment of the volume of natural gas released was carried out, the possible technical consequences of the incident were evaluated and a preliminary assessment of the possibility of carrying out repair and restoration work was carried out. The existing technical solutions and alternative technologies to restore the pipeline system integrity have been analyzed. The feasibility of applying the technologies taking into account the specific conditions of the Baltic Sea has been evaluated. A preliminary assessment of the scope of repair works has been carried out and repair technologies have been considered.*

***Keywords:** offshore pipeline, calculation of gas leakage volume, offshore pipeline repair, offshore pipeline incident, Baltic Sea oil and gas infrastructure*

### **1. Introduction**

The Nord Stream pipelines are complex technical facilities designed and built in 2006-2012 and 2014-2021. They are the longest uncompressed gas pipelines in Europe. The length of these pipelines is about 1,224 km of each of the strings. The internal diameter is Ø 1,153 mm. Each of the four pipelines previously had an annual capacity of 27.5 billion cubic meters of gas. The design pressure varied from 220 bar at the Russian onshore compressor station exit to 106 bar at the Greifswald onshore exit in Germany: Kostianov A. G., Ermakov P. N.,

Soloviev D. M. (2008). The September 2022 accident resulted in the shutdown of natural gas from Russia to Europe via the Nord Stream pipeline system. Pipeline ruptures resulted in complete depressurization of the system, loss of a number of pipeline fragments as a result of explosions, destruction of the base and backfill of the pipeline sections. The works to establish the causes of the accident and assess the technical condition of the pipeline system will continue for an indefinite period of time. At the same time the technical specialists face a number of nontrivial problems which require additional research, analysis,

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discussion and development of the concept of repair-rehabilitation work at these objects. Such works and actions are rare in the world practice and are of significant interest both in terms of offshore oil and gas technologies, engineering, mechanics, and in terms of ecology, economics, and organization of technological processes in general.

The raised problems are extremely extensive and surely will be widely discussed in scientific journals in the nearest future, especially taking into account new data and results of researches. The uncertainty of available information, the difficulty of organizing pipeline inspection processes, analyzing the data obtained and the importance of developing the concept of equipment rehabilitation, made the authors to summarize the technical data on the gas transportation systems of Nord Stream as of the beginning of 2023, as well as the task of assessing the possible consequences of the emergency situation and, as a result, developing recommendations for the maintenance of these pipeline systems. It should be noted that, in fact, each realized project of offshore hydrocarbon transportation system is individual, because it is necessary to take into account not only specifics of equipment materials, but also depths, winds, currents and characteristics of the bottom of the water area (Rosicki R., Rosicki G. *Znaczenie*, 2012). Therefore, the experience of emergency situations, their consequences and peculiarities of the approaches related to offshore pipeline systems repair can be used only partially. Among the most remarkable incidents of this kind are pipeline ruptures in the North Sea at the Dutch and British gas fields in the 1980s (Catherine Mitchell JimSweet TimJackson, 1990), gas pipeline ruptures in the Kara Sea (Bovanenkovo-Ukhta in 2018), gas pipeline ruptures in the Gulf of Mexico (the latest case in 2021 with the inflammation of gas released from the destroyed offshore pipeline of Petr6leos Mexicanos). In the scientific

and technical literature, the incident rate of the offshore oil and gas pipelines varies depending on the pipeline diameter and operating conditions in the range of  $1 \cdot 10^{-5}$  to  $1 \cdot 10^{-3}$  (events/year) /km.

In order to conduct a detailed analysis of the technical condition of the pipeline system after the incident and assess the repair options, we first consider the characteristics of the pipes and coatings used in the project, the specifics of the technology used during the construction of laying and placement of pipelines on the seabed, which will give a clearer picture of the original technical and hydrological characteristics of the strings of Nord Stream 1 and 2 gas pipelines.

## **2. Linear part of the Nord Stream pipeline system. Technical characteristics and breakdown points.**

When designing the Nord Stream pipeline route, a number of parameters were taken into account. They include not only the minimum distances along the pipeline route, but also the depths of the sea in the area of the pipeline route, the underwater relief, the presence of debris, shells, chemical weapons dumped since World War II, benthic communities, etc. (Värk J., Nutt M., Martin J., 2011). To improve safety and reliability of the system before design and construction, we collected geotechnical, environmental, bathymetric, and other baseline data with the participation of the Shirshov Institute of Oceanology of the Russian Academy of Sciences (IO RAS) and the Russian Federal Research Institute of Fisheries and Oceanography. The environmental feasibility study, risk assessment and quality management were carried out with the participation of Marin Mätteknik, Rambøll, DoF, PeterGaz, ERM, DNV, etc.

The bottom of the Baltic Sea is composed of different types of rock, it has prominent

ridges, hollows, crevices, quicksands and muds and it is not always possible to lower the pipeline directly onto these soils. Technically, if there is a big sag of the gas pipeline string between two natural supports, its construction can collapse over time (Dadonov Yu.A., 2008). That is why after the route was finally chosen the bottom relief in the laying zone was corrected artificially, by means of creating stable foundations preventing sagging, rolling and siltation of pipes. During the construction of each of the pipeline strings, a special vessel loaded with gravel and small stones, using a pipe, the lower end of which was equipped with nozzles, filled the bottom cavities, giving it a more suitable profile (Dantsevich I. M., Kosolap Y. G., Cherkasov A. V., 2021). Sometimes concrete slabs were lowered down instead of stones, to strengthen the base of the pipeline. In a number of sections, the buried location of the pipeline strings was preferred. Thus, along the entire route the bottom structure was checked and strengthening works were carried out. Different layouts were used depending on the type of seabed. In the northern part of the pipelines (Gulf of Finland area), due to the rocky ground, the pipelines were placed through bunding on the seabed as well as via a bunding scheme with a reinforced block base; in the central area of the Baltic Sea, a simple bottom placement with an additional weight coating was used more frequently as well as bunding in some places. In areas with heavy shipping traffic, on fairways and main port traverses (where soils allowed), the buried pipeline option was used. Considering the damage points of the gas pipeline strings, we can state that the emergency situation is localized in the areas where the laying was carried out in areas where the pipeline was simply placed on the bottom with an additional weighting coating. Special pipes with an outside diameter of 1220 mm and an inside diameter of up to 1153 mm were used in the linear part of the Nord Stream

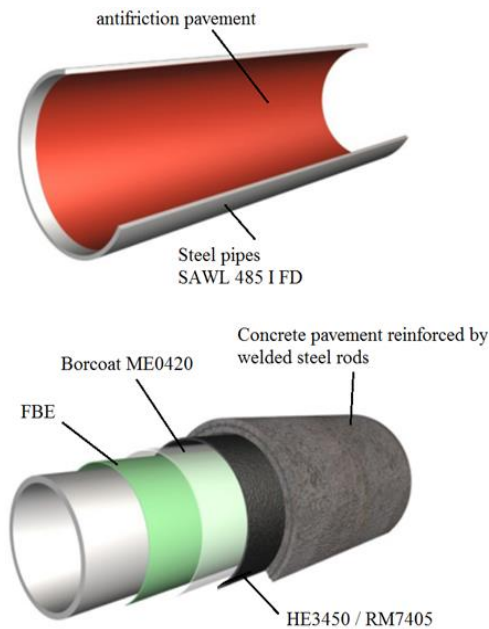
pipeline. The pipe wall thickness varied depending on the depth of the pipeline installation and the pressure of the pumped gas. The pipe was designed to withstand a pressure of 220 bar in the first 300 km, 200 bar in the next 500 km, and 170 bar thereafter. On each of these sections the pipeline wall thickness varies from 34 to 27 millimeters.

**Table 1.** Key data on pipe manufacturers used in the Nord Stream 1A, B and Nord Stream 2A projects

Gas pipeline	Nord Stream 1 A	Nord Stream 1 B	Nord Stream 2 A
Pipe manufacturers	Europipe - 75% Vyksa Steel Works - 25%	Europipe - 65% OMK - 25% Sumitomo - 10%	Europipe - 40% OMK - 33% CHTPZ - 27%
Manufacturers of related materials - coating, cement, reinforcement	Saipem; Allseas; Van Oord; Boskalis Tideway; Rohde Nielsen		

This segmentation made it possible to save on the production costs of the pipes while maintaining their reliability. The maximum sea depth at the pipeline strings was 210 meters. The pipelaying was carried out in accordance with DNV OS-F-101 Submarine pipeline systems. The materials (steel pipes) used for construction of the pipelines were made by a number of companies (Table 1) in accordance with the international standard - ISO3183-3 Petroleum and natural gas industries - Steel for pipelines. The grade of steel used for main pipelines - SAWL 485 I FD - has three-layer external and internal antifriction coating (thickness from 90 to 150 microns), pipe length 12.2m with minimum yield strength of 485 MPa, submerged arc welding with one longitudinal seam capable of bearing a load of 570-605 MPa was carried out. The steel used in pipe

production is unique, and during its manufacture special importance is given to metal desulfurization process, which is carried out in three stages, which allows to obtain a material having very low sulfur content (not more than 0,0015%), the content of other impurities is also within narrow limits (Dantsevich I. M. et al., 2021). The outer surface of the pipes has an anti-corrosion component consisting of a three-layer polyethylene coating (3LPE) including epoxy resin (inner layer), adhesive layer and high-density polyethylene (outer layer), then there is a concrete coating over the anti-corrosion coating on the main pipes, whose task is to weight the pipeline for a stable position on the seabed (Lohmann S., 2019) (Figure 1).



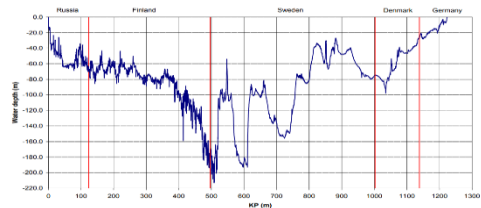
**Figure 1.** Structure of internal and external pipe coating of the Nord Stream pipeline system.

Source: North Stream AG

In addition to cement, water and standard aggregates (gravel, crushed stone, sand), aggregate containing iron ore is added to the concrete mixture to increase its density; the concrete coating is also reinforced by a framework having welded steel rods (the minimum diameter of the rod is 6 mm). After welding the concrete coated pipes, the joints are protected with a heat shrink sleeve and highdensity polyethylene, then, as a frame, a sheet of carbon steel or polyethylene formwork is installed around the joints; after installing the frame, the voids formed between the heat shrink sleeve and the frame are filled with two-component polyurethane foam, which has a density of 160 kg/m<sup>3</sup> after hardening.

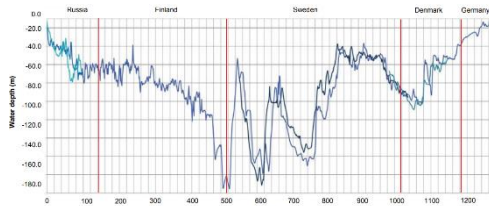
The chosen system combines a base layer of fusion-bonded epoxy coating (FBE) 0.15-0.30 mm thick, which is slightly less than the thickness of a standard base layer of three layers of polyethylene. A 0.2-0.4 mm thick Borcoat ME0420 (a binder made of polyethylene modified with maleic anhydride) from Borealis and an outer layer of Borcoat HE3450 (black, bimodal, copolymer high density polyethylene), also from Borealis, was applied over the base layer. RM7405 (so called coarse coating) of black polyethylene from Borealis was used as a cover layer. This coarse polyethylene layer, applied on the still hot outer layer, is designed to increase the adhesion to the subsequent concrete layer with a thickness of 60-110 mm.

The total thickness of the polymer coating is about 4.2 mm.



**Figure 2.** Depth of Nord Stream 1A and 1B.  
 Source: North Stream AG

The pipeline sections passing in the deepest areas are equipped with bend protectors, so-called deformation dampers, directly welded into the pipe and made of the same alloy, steel as the main pipes, but with a thicker wall and more delicate machining at the ends in order to match the main pipes.

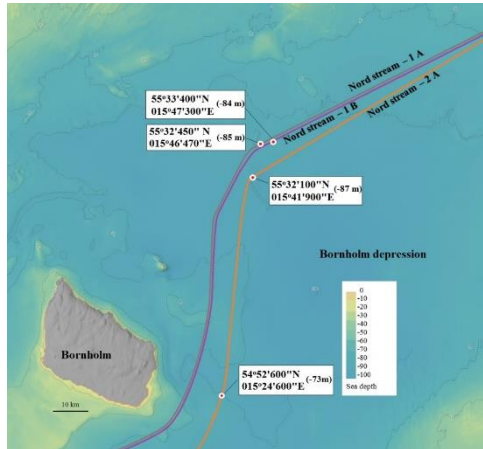


**Figure 3.** Depth of Nord Stream 2A.  
Source: North Stream AG

Let's consider the bathymetric characteristics of the position of the Nord Stream 1 and 2 pipes (Figures 2 - 4). The total thickness of the polymer coating is about 4.2 mm. The pipeline sections passing in the deepest areas are equipped with bend protectors, so-called deformation dampers, directly welded into the pipe and made of the same alloy, steel as the main pipes, but with a thicker wall and more delicate machining at the ends in order to match the main pipes. Let's consider the bathymetric characteristics of the position of the Nord Stream 1 and 2 pipes (Figures 2 - 4). Given the coordinates of the incident points, we can say that in the case of the North Stream 1 string A, the pipeline failure occurred at a depth of -85 m. In the case of string B, the pipeline rupture occurred at a depth of -84 m. In the case of Nord Stream 2 A, the pipeline breakdown occurred at a depth of -87 m and -73 m.

As for the peculiarities of Nord Stream pipeline design, it should be noted that apart from primary corrosion protection, it has secondary protection, which is provided by anodes made of galvanic material (Chen B. Q., Zhang X., Soares C. G., 2022). This protection represents a separate (independent) system, the effect of which is

aimed at pipeline protection in case of damage of external pipe coating.



**Figure 4.** Breakdown points on gas pipelines and depths  
Source: Authors

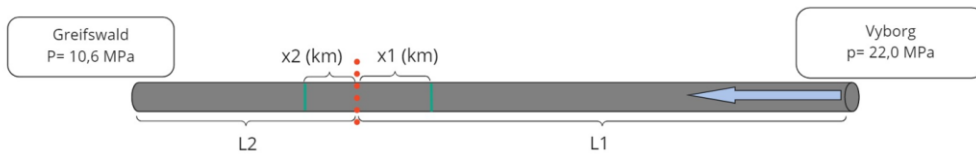
Anode alloys for preserving pipeline integrity for the calculated operation time have been determined by tests, the results of which showed that zinc alloy is appropriate for the sections with low and medium mineralization, for the remaining sections the use of indium-activated aluminum has been declared (Aulia R., Tan H., Sriramula S., 2021).

Taking into account the technical characteristics of the Nord Stream pipeline system, as well as the location of failure points, sea depths, peculiarities of the location of pipelines on the bottom, we will make two types of calculations. First, we preliminarily estimate the volume of natural gas release from each of the pipeline strings, and second, we consider the issue of repair and restoration work volumes by calculating the lengths of destroyed and flooded sections.

### 3. Preliminary assessment of the consequences of the gas pipeline system destruction

To make the calculations, we consolidate the materials on the technical parameters of the pipeline and the external environment in all damaged sections. Then we calculate the

leakage volume from section to section and make a preliminary assessment of the length of flooding of each of the pipeline strings - both by sections from the gas supply point and by sections adjacent to the receiving point (Maksimov A. O., Polovinka Y. A., 2015; Podvalny S., Kutsova E., Vasiljev E., 2021), (Figure 5).



**Figure 5.** Example of the location of sections of the Nord Stream-1A pipeline, in relation to the incident point.

Source: Authors

The distance from the place of the gas pipeline rupture to the nearest emergency valves is marked  $x_1$  and  $x_2$ .  $L_1$  and  $L_2$  are distances from the place of rupture to compressor stations.

At the first stage let us determine the initial critical gas flow rate (STO Gazprom 2-3.5-051-2006; Kóczy L. Á., Cserssik D., Sziklai B. R., 2022) (1):

$$G_0 = \frac{P_0 \cdot \pi \cdot d_0^2 \cdot \sqrt{k}}{4 \cdot \sqrt{R \cdot Z_k \cdot T_0^m}} \cdot \left[ \frac{2}{k+1} \right]^{\frac{k+1}{2 \cdot (k-1)}}, \#(1)$$

Where:  $P_0$  - pressure at the moment of the incident at the point of gas pipeline rupture (Pa);  $d_0^2$  - pipe inner diameter (m);  $k$  - gas adiabatic index (b/r);  $R$  - gas constant (J/(kg·K));  $Z_k$  - gas compressibility factor in the critical section;  $T_0^m$  - average temperature (K).

Thus, the gas flow rate for the first damaged section with the length  $L_1$  will be determined by the expression:

$$G_1(t \leq t_l) = \frac{M_n}{\eta_L^2 \cdot \varepsilon_L} \cdot \exp \left[ -\frac{1}{\eta_L^2 \cdot \varepsilon_L} \right] + \frac{[M_g - M_n]}{\varepsilon_L} \cdot \exp \left[ -\frac{t}{\varepsilon_L} \right], \#(2)$$

Where:  $t_l$  we assume more than 0.1s;  $M_n$  - mass of gas flowing in adiabatic mode (kg);  $M_g$  - mass of gas in the damaged section of the pipeline (kg).

The value of  $\eta_L$  is determined according to the expression (3):

$$\eta_L = \frac{2 \cdot M_g}{\varepsilon_L \cdot G_0}, \#(3)$$

Where:  $\varepsilon_L$  - time constant, s.

In this case, depending on the section, it is determined by the following ratio:

$$\varepsilon_L = \frac{2}{a_0} \cdot \frac{L_1}{d_0} \cdot \sqrt{\frac{k \cdot \lambda \cdot L_1}{d_0}}, \#(4)$$

Where:  $a_0$  - speed of sound in the gas before the incident;  $\lambda$  - hydraulic resistance coefficient.





**Figure 6.** Destruction of the Nord Stream-1 pipeline section, initial inspection results  
Source: Nord Stream AG

Further in the calculation it is necessary to take into account the mass of gas at the point before the incident (kg):

$$M_g = \frac{L_1 \cdot \pi \cdot d_0^2 \cdot P_1^m}{4 \cdot R \cdot Z_0^m \cdot T_1^m} \pm M_{ks}, \#(5)$$

Where:  $Z_0^m$  – the compressibility factor of the gas before the incident at the parameters  $P_1^m$  and  $T_1^m$ ;  $M_{ks}$  – mass of gas (kg) pumped into the first section of the pipeline by the compressor station until the cut-off of the damaged section, kg. The sign "+" is used in calculations for the first damaged section, the sign "-" in calculations for the second damaged section.

$$M_{ks} = G_{ks} \cdot t_i, \#(6)$$

Where:  $G_{ks}$  – the pipeline capacity in normal operating mode (kg/s);  $t_i$  – time from the moment of the incident till the stationary

emergency valve is completely closed (s).

Then using formula (7) it is necessary to determine the mass of gas flowing in adiabatic mode:

$$M_n = \frac{2 \cdot M_g \cdot d_0}{\lambda \cdot L_1 \cdot \sqrt{k}} \cdot \left\{ \left[ \frac{1}{k} \cdot \left( \frac{k+1}{2} \right)^{\frac{k+1}{k-1}} + \frac{\lambda \cdot L_1}{d_0} \right]^{\frac{1}{2}} - \left[ \frac{1}{k} \cdot \left( \frac{k+1}{2} \right)^{\frac{k+1}{k-1}} \right]^{\frac{1}{2}} \right\}, \#(7)$$

To determine the mass of gas at the gas release from the first section until the line valve is closed, we use the expression (8):

$$M_{11} = M_n \cdot \left( 1 - \exp \left( -\frac{t_l}{\eta_L^2 - \varepsilon_L} \right) \right) + (M_g - M_n) \cdot \left( 1 - \exp \left( -\frac{t_l}{\varepsilon_L} \right) \right), \#(8)$$

Next, to determine the total volume of gas leakage it is necessary to establish the value of its flow at the time of closing the damaged section, which can be done by the following formula (9):

$$G_1(t_l) = \frac{M_n}{\eta_L^2 \cdot \varepsilon_L} \cdot \exp \left( -\frac{t_l}{\eta_L^2 \cdot \varepsilon_L} \right) + \frac{(M_g - M_n)}{\varepsilon_L} \cdot \exp \left( -\frac{t_l}{\varepsilon_L} \right), \#(9)$$

Since the emergency shutdown system is triggered when the gas pipeline is damaged, it is necessary to calculate the gas flow rate for the damaged section 1 after closing the valve:

$$G_1(t > t_l) = G_1(t_l) \cdot \exp \left( -\frac{t - t_l}{\varepsilon_x} \right), \#(10)$$

Where:  $\varepsilon_x$  – time constant

$$\varepsilon_x = \frac{2 \cdot x_1}{3 \cdot a_x} \cdot \sqrt{\frac{k \cdot \lambda \cdot x_1}{d_0}}, \#(11)$$

Where:  $a_x$  – sound velocity in the cut-off section at the time  $t_{ij}$ :

$$a_x = \sqrt{k \cdot R \cdot Z_0^m \cdot T_{ch}^m}, \#(12)$$

Where:  $T_{ch}^m$  – average temperature in the cut-off section after closing the line valve (K).

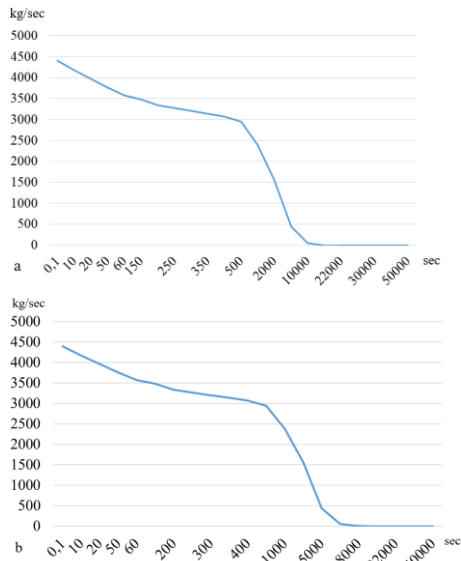
The mass of gas in the second phase of the flow after closing the line valve is calculated by the formula (13):

$$M_{12} = \varepsilon_x \cdot G_1(t_l), \#(13)$$

Total mass of gas on the first incident section (14):

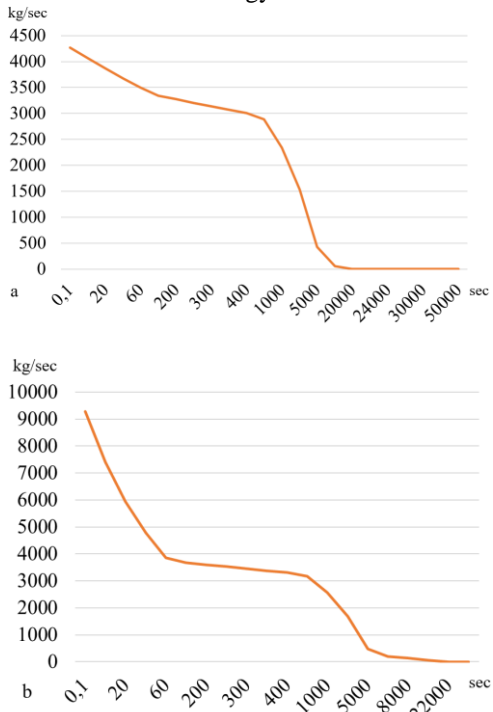
$$M_1 = M_{11} + M_{12}, \#(14)$$

For the second cutoff section, we perform the same calculation. The intensity of gas outflow in each of the strings during the incidents on the North Stream 1 and 2 are shown in the graphs (Figures 7 - 9). We assume that the time passed from the moment of the incident to the moment of complete closure of the line valves at both sections of the pipeline is 40 sec. For the second section of length x2 the calculations are made in the same way (Lurie M. V., Musailov I. T., Lysenko N. O., 2020).



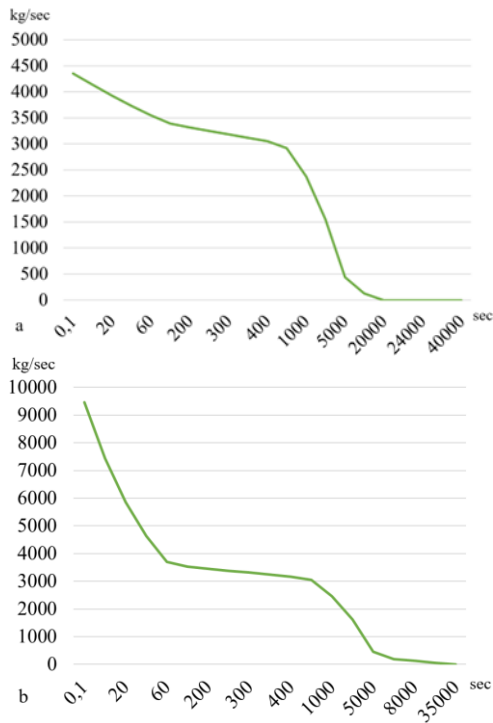
**Figure 7.** Graphs of natural gas leakages from the damaged pipeline segments of the Nord Stream 1A pipeline: a - section of the pipeline from the gas compressor station in Russia to the rupture place; b - section from the rupture place to Greifswald. Source: Authors

Certainly, it should be noted that the indicated volumes based on the results of calculations are based on open data and were obtained considering the above-mentioned calculation methodology.



**Figure 8.** Graphs of natural gas leakages from the damaged pipeline segments of Nord Stream 1B: a - section of the pipeline from the gas compressor station in Russia to the rupture point; b - section from the rupture point to Greifswald). Source: Authors

Results may differ significantly in case of other technical characteristics or other methods (STO Gazprom 2-3.5-051-2006). The final results will be obtained by visual inspection and inspection. Data obtained using the above mentioned, methodology for natural gas leakage volumes and the length of pipeline strings flooding were summarized in the following table (Table 2).



**Figure 9.** Diagrams of natural gas leakages from the damaged pipeline segments of Nord Stream-2A: a - section of the pipeline from the gas pumping station in Russia to the rupture point; b - section from the rupture point to Greifswald).

Source: Authors

**Table 2.** Preliminary volume of natural gas leakage from damaged strings of the Nord Stream system. Estimated volume of repair and rehabilitation work.

Pipeline string	NS-1A	NS-1B	NS-2A
mass of the gas during the total time of outflow (in mega tons)	0,018217	0,017851	0,044246
mass of the gas during the total outflow time (in mega tons)	0,0803		

Using the results of calculations we can preliminarily assert that the volume of methane emission caused by all incidents was about 0,0803 mega tons, emissions of different intensity took place over a period of 4-6 days. At the same time, no more than 10% of the gases dissolved in the sea water, and the main mass was released into the atmosphere.

In general, the total volume of leakages corresponds to the volumes of emissions assumed by different expert organizations (Mehrafrooz B., Edalat P., Dyanati M., 2019). Thus, according to the calculations made by: Stéphane Orjollet in his publication dated October 5, 2022 "Nord Stream leaked less methane than feared: atmospheric monitoring" - the leakage volume in all pipeline sections was about 0.07 meg tons; according to the article "Improved estimates of Nord Stream leaks" by Christine Forsetlund Solbakken dated October 12, 2022: the leakage volume from all damaged sections was 0.056 - 0.155 meg tons. Interested results of gas leakage was shown by Katharine Sanderson, they are also confirming presented calculations (Sanderson, Katharine, 2022).

#### 4. Analysis of the application of different methods for gas pipeline restoration on the bottom of the Baltic Sea

The investigated emergency situations require decision-making on carrying out repair-rehabilitation works on the gas pipelines of the Nord Stream system. At the same time we can state that after direct visual inspection of pipelines, their sonar sounding, metal sampling and establishing the actual length of flooded sections, a number of obligatory operations will be required at the transition stage before repair works:

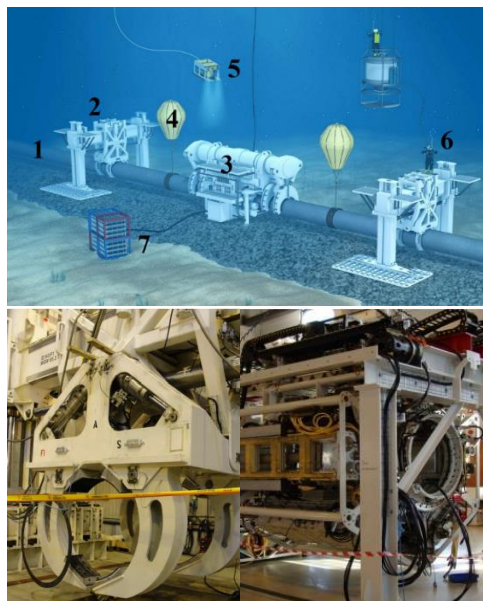
1. Restoration of at least 100-150 meters of embankments under pipeline strings in emergency areas;
2. Dismantling of destroyed and flooded sections of pipelines;
3. Preparation of pipeline sections for repair works;
4. Carrying out works on connection of broken sections (installation of new section of pipes instead of lost ones);
5. Carrying out of external and internal diagnostics of gas pipeline strings, testing;
6. Obtaining of the special permission documents for putting into operation after the execution of the repair-restoration works and registration of the insurance.

It should be noted that, in fact, each of these stages requires a separate investigation, as it is connected with the solution of a large number of technical, technological, organizational, managerial and political problems. Nevertheless, the technical and technological aspect of the problem results in choosing the optimal method of repairing the damaged pipeline strings. At the same time it is obvious that the repair works on the Nord Stream-2A pipeline is unreasonable due to the high length of the flooded section (over 105 km), as well as the absence of permits for putting the pipeline into operation (insurance). In the case of Nord Stream-1A, B pipelines the repair is possible by applying such technologies as Heier E., Mellem T. (2007):

1. Underwater welding operations with cut-in points and hyperbaric chambers (e.g. application of PRSI - Pipeline Repair and Subsea Intervention or Eni/Saipem SiRCoS - Sistema Riparazione Condotte Sottomarine)
2. Lifting and welding of the pipeline strings on the surface, with subsequent laying

Now let's analyze the application of these methods, their strong and weak points, as well as the risks associated with the repair process of the gas transportation system. We should note that some of the presented technologies have already been used during the pipeline construction.

For example, hyperbaric welding was performed at three points along the route of each of the pipeline strings. The welding works were remotely monitored by the Skandi Arctic, while divers performed the monitoring and control of the welding of the sections themselves. These cases (for any of the pipeline strings) allow this type of work to be carried out because the depth of the incident does not exceed 180 m. (depth limitation for divers, according to DNV-RP-F113 Pipeline subsea repair).



**Figure 10.** a - North stream pipeline bracing by hyperbaric welding; b - PHF; c - PRS.

- 1 - Pipeline string; 2 - Supporting mechanisms (PHF); 3 - Hyperbaric welding chamber (PRS); 4 - Inflatable diving lifting bag; 5 - Underwater inspection apparatus; 6 - Diver; 7 - Gas cylinders.

Source: a- Nord Stream AG, b, c – Authors

In technological terms, the process is as follows. A specialized welding equipment is lowered on the sea floor, to the area containing the retained section, which has been cleaned and prepared by the divers; this is where the old section and the new section lowered from the ship can be welded (Amaechi C. V., Hosie G., Reda A., 2023).

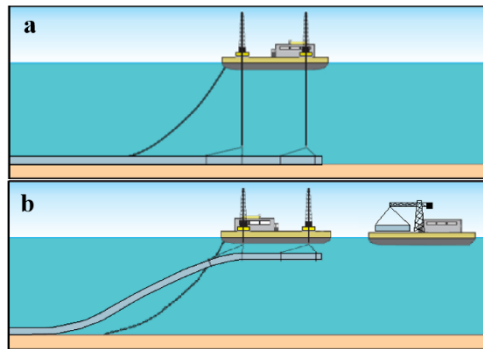
The specialized dry-welding system used during construction of the Nord Stream pipelines was previously supplied by Statoil. It is a dry zone (PRS), where divers work without diving equipment to set up the automatic welding machine. At the same time, the welding process is fully controlled from the support vessel. At the same time, two specialized supporting mechanisms (PHFs) are lowered onto the same seabed area, which provide support and alignment of the welded pipeline strings (this is necessary to ensure the quality of the welded joint).

There are different modifications of such technological scheme of repair performed by companies. Thus, the repair can be carried out with or without the use of divers - for example, with the use of special robots, with the involvement of various support and alignment systems and with special telemetry systems. In general, we can distinguish three large groups of companies that provide such technologies - Norwegian, Italian and American companies. Whether it is possible to carry out such repair and restoration work under current conditions with the involvement of partners from these countries is an open-ended question.

Another method of repairing damaged sections of gas pipelines is surface repair, using specialized vessels (Sharifi S. M. H., Kaveh M., Bolfakeh M., 2022). Considering the process of welding area preparation, welding operations and subsequent flaw detection, as well as pipeline coating operations - this method allows to achieve higher quality and reliability and fully meets the requirements of DNV-OS-F101:

Submarine Pipeline Systems. However, we should mention some specific aspects that may complicate this technological process. Initially, after inspection, clearing and elimination of the damaged pipeline section, cleaning and fastening of the repaired pipeline to the hoists is performed (Figure 11 a).

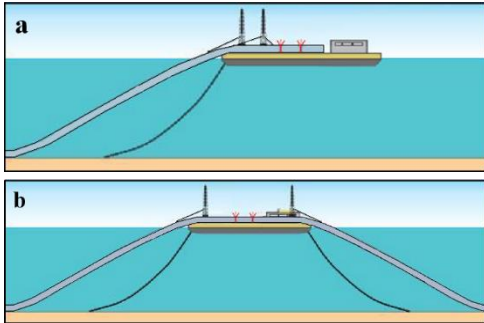
During this operation, the integrity of the lifted pipe string, the uniformity of fastening and distribution of loads during the lifting of the pipeline section are of great importance. Then, additional pipes are delivered to extend the pipeline (Figure 11 b).



**Figure 11.** a. Lifting the flooded pipeline from the seabed; b. Bringing in additional pipes for welding on the surface

Source: Authors

At the same time the lifted pipe section is gradually filled with gas to be lifted aboard the ship. Next step is onboard inspection and inspection of the welded-on string, removal of protective coating on the end section, and subsequent onboard welding and joint assembling of the sections on the ship (Figure 12 a). This ensures their alignment, quality of edge stripping, quality of welded joints and protective coating.



**Figure 12.** a. Emptying of the pipeline, inspection, preparation for welding, welding of new sections; b. Connection of the expanded section and the second end of the gas pipeline  
 Source: Authors

At the final stage, welding is performed with the opposite old section, which is also lifted from the bottom, with the performance of the whole complex of measures for its examination and preparation for joining (Figure 12 b). After that, the final welding, weld quality control, coating with external protective coatings, lowering and laying on the bottom, with subsequent tests take place. In fact, this work was already performed during the construction of the Nord Stream pipeline, involving specialized vessels: Castoro Sei, Far Samson, Allseas' Solitaire, as well as many other tugs, supply vessels, and soil preparation vessels. Of course, arrangement of works using this technology will also require consolidation of efforts at the international level. At the moment, unfortunately, the Russian Federation doesn't have a fleet capable of handling the whole range of operations. However, there are plenty of contractors (as compared to underwater hyperbaric welding) in this case - a number of firms and companies in East Asia, South America and, of course, in Europe.

In this regard, it is more rational to repair and restore the damaged sections of the Nord Stream pipeline by repairing it on the surface (due to the complexity of contracting,

organization of the technological process, and the quality of the work itself).

A preliminary analysis of the scope of work shows the necessity of forming a group of vessels to provide not only lifting and welding of the strings, but also clearing and strengthening the bottom in the emergency areas (for the strings of Nord Stream 1, this will be about 2 km). Strengthening and restoration of the embankment - about 120 km, with clearing of flooded pipes. In addition, material support is required - production and delivery of the proper amount of pipes, fittings, concrete, gravel and electrodes. So, according to preliminary assessment (excluding a direct underwater inspection), the restoration of both strings of Nord Stream-1 will require at least 9837 pipes

## 5. Conclusion

Initial analysis suggests that about 0,0803 meg tons of natural gas was released into the atmosphere as a result of the incident on the three strings of the Nord Stream pipelines. Preliminary modeling shows that gas release from the breakdown points continued for up to 6 days. If the valves in the pipeline sections had operated normally, after the shutdown the volume of flooding was about 60 km in the pipeline sections Nord Stream 1A and B, and about 110 km in the pipeline section Nord Stream 2A. (taking into account the pipe section between the two incident points).

If the pipeline valves were not closed, the gas release could last longer and be larger in volume, and the flooding process of the pipeline strings took place up to the hydrostatic pressure level - between the sea water and the gas remaining in the system. Considering the relatively shallowness of the seabed in the area of the Bornholm basin - based on data from bathymetric maps, it is impossible to establish these hydrostatic pressure levels in an analytical way. More

precise results can only be obtained by direct underwater inspection of the pipeline strings. Taking into account the complexity and high cost of repair and restoration of pipelines, it seems rational to repair only the Nord Stream-1A and B gas pipeline strings. In this case, the most affordable and at the same time controllable and qualitative way of repair will be lifting of flooded strings on a ship, its inspection, repair, extension, welding and lowering onto a prepared ground. To perform these works a wide

range of contractors can be involved. It should also be noted that application of this technology will provide a full range of tests of the system after welding works in accordance with the requirements of DNV-RP-F113 Pipeline subsea repair.

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## THE BIDIRECTIONAL RELATIONSHIP BETWEEN HIGHER EDUCATION AND INNOVATION: EMPIRICAL EVIDENCE FROM MENA REGION

**Abstract:** *The purpose of this paper is to examine the bidirectional relationship between two sets of variables, higher education and training (eight indicators) and innovation (seven indicators), using the canonical correlation analysis (CCA). The study utilises data published by the World Economic Forum Reports for seven years (2012-2018) for a sample of 12 countries in the MENA area. CCA is used to analyse the relationship between the two sets of variables. It helps in the evaluation of the interchangeable relationships between the two sets of multiple variates. More in-depth analysis of the nature of such a relationship between the two sets of variables is provided through redundancy analysis to identify the percentage of the variance in each set that is interpreted by the other set, and the commonality analysis to determine the variance of canonical function that is due to unique or standard variables. Canonical analysis shows the causality between the two endogenous sets of variables. Also, the findings suggest that technology alone is not an antidote, while other factors might have a significant impact on innovation. Commonality analysis shows that the role of quality of management school in explaining the variation in canonical function of innovation in common with “quality of education system”, “quality of math and science”, “internet access”, “training availability and “staff training produce”.*

**Keywords:** *Higher Education and Training, Innovation, Canonical Correlation Analysis, Emerging Markets*

### 1. Introduction

Higher education plays an essential role in the economic development of countries worldwide. It is a fundamental and reliable axis to achieve prosperity and progress. Higher education institutions need help with many problems, including adherence to tradition, which is one of the obstacles to universities benefiting from innovation and technology. For example, innovation is likely to make a massive difference in our world as it can help to develop and

overcome any new risks the world may face (Bates, 2009). According to Arima (2002), the needs of societies are continuously changing. Consequently, there is need to rethink university education's purpose education. Although higher education has evolved over the centuries to keep pace with changes in societies, it still needs to be improved for some curricula in addition to the development of new curricula where universities must adopt technology-based innovation in many educational materials to fill some gaps in higher education.

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Wildavsky et al. (2012, p. 1) pointed out that “higher education has to change. It needs more innovation”. The integration of modern information technology-based innovation in educational processes helps to acquire knowledge easily. Therefore, educational institutions can meet the needs of the labour market with qualified graduates (Cai et al., 2019). In this regard, Gourova et al. (2014) concluded that higher education institutions play an exclusive role to their customers including public and private firms through the transfer of knowledge. Such knowledge is essential for countries tilling to achieve advanced economies and prosperity for their people. This requires the availability of well-educated and well-trained workers to perform complicated tasks using advanced technology-based innovation that is rapidly adapted to their changing environment and evolving labour market needs. Several studies have addressed the relationship between higher education and innovation from one direction (Goddard & Vallance, 2013; Etzkowitz, 2013; Buasuwan, 2018; Cai et al., 2019; Cai et al., 2020).

The current study investigates the bidirectional relationship between higher education and innovation, in addition, it provides a deep analysis of the nature of such relationships using unique analyses namely, the canonical correlation, redundancy, and commonality analyses. In this regard, we considered the main ideas for both social cognitive theory and constructivist theory by selecting eight indicators for higher education & training factors. The nature of these indicators is related to the external environment and personal aspects such as “quality of the education system”, “quality of math and science education”, “quality of management schools”, “Internet access in schools”, “local availability of specialized training services” and “extent of staff training”. The above-mentioned indicators have been suggested by the World Economic Forum (WEF) to reflect

the competitive characteristics of countries. Furthermore, the study calls to apply technology-based innovation to improve higher education as a new stream for the future. Such a stream can affect the ability to innovate because it reflects the extent to which professional researchers can benefit from technology in creating new ideas, ways, or new products and moreover, its effects on labour market efficiency (Billon et al., 2017; Yunis et al., 2018).

Our study has unique characteristics over previous studies. First, it provides evidence of the bidirectional relationship between higher education & training set and innovation set. Whereas, previous studies, (Thor, 2011, Cai and Liu, 2015; Cai et al., 2020) on higher education and innovation, have examined the relationship between the two sets of variables from one direction. Second, this study uses a sample of 12 Middle Eastern countries that suffer from the lack of studies in this area of research, therefore, it provides a valuable contribution to the field of higher education & innovation. Third, the study uses a set of distinct measures to estimate higher education & innovation by adopting eight variables for the higher education & training set and seven variables for the innovation set. These two sets of variables have been suggested by the WEF to reflect the competitive advantages of each country which makes a clear difference between the current study and previous studies. Moreover, the data related to these variables have been collected by international organizations with a distinguished global reputation such as International Monetary Fund (IMF); the World Bank; and various United Nations’ specialized agencies which provide a high level of accuracy for such data. Fourth, the current study employs the canonical correlation analysis, as a unique statistical method to explore the bidirectional relationship between higher education & training set and innovation set in a sample of

12 the Middle East and North African countries (MEAN), and to determine the most common factors in each set and the percentage of the variance explained in each variable over the other. Moreover, it the redundancy, and commonality analyses to identify the percentage of variance and such variance is due to unique or common variables. Fifth, the results of our study may provide some avenues for regulators in MEAN countries to support both education and innovation in educational institutions, which has the greatest impact on the economic development of these countries and the achievement of a higher level of well-being for their people.

We are motivated to focus on MEAN by using a sample of 12 countries namely, Bahrain, Cyprus, Egypt, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Turkey, United Arab Emirates and Yemen. for several reasons. First, these countries have a common heritage of history, culture, trade relations and economic conditions, which makes the study sample is coherent and consistent. Secondly, these countries suffer from a shortage in the number of studies related to higher education and innovation, unlike most developed countries. Third, MEAN countries are a model for both developing countries and emerging markets as well. Since these countries are characterized by being attractive to foreign investment, the results of this study may be of interest to many different parties inside and outside these countries. The structure of the current study is as follows. Section 2 presents a literature review and hypotheses development. Section 3 offers details on the research methodology. The section shows data analysis and results. Section 5 concludes the study.

## 2. Literature Review and Hypotheses Development

### 2.1. The Impact of Higher Education & Training on Innovation

The topic of the university's role in creating innovation within societies is receiving a great and increasing attention, as the education reform process requires the interaction and integration of universities in their society with industry and other actors to enhance innovation (Mowery & Sampat, 2005; Etzkowitz, 2013). The educational system is one of the most important elements of the innovation system in any country. The effectiveness of the educational system depends on a range of factors including human resources and linking the adequacy of the education system with the requirements of the economy, nationally in particular and globally in general. For example, in China, Cai and Liu (2015) examined the effect of universities' role in innovation systems by considering universities' engagement with society to promote innovation systems. Magno and Sembrano (2007) argued that innovation is the ideas or methods conceived by innovators, then turned these ideas into new practices in recent years. Therefore, innovation is a tool that can be used by higher education institutions to adopt the requirements of societies and students to bring new changes in educational practices through the adoption of modern technology. There are different forms of educational innovations including innovative models of education; new textbooks and programs; new or improved learning technologies (such as distance or online learning and Internet technology); updating the content of the curriculum; new teaching technologies; ideological innovation; scientific and methodological innovation; managerial innovation and others. (Zhu, 2015; Buasuwan, 2018).

Universities are facing pressure from many external parties including the government and the public to change their strategy and adopt new policies that can enhance innovation in university education (Cai, 2017). Thus, to understand the innovation process in universities, Musselin (2007, p. 317) reported that “one has to take ‘two speeds’ of change into account”. Lundvall (2013, p. 33) pointed out that “as one that starts with combining elements of existing knowledge and ends with new knowledge as an important output”. This process is linked with the knowledge that can be gained by educational organisations therefore innovative ideas need educational interaction and good implementation of these ideas needs a learning process carried out by scientific bodies with accumulative experience in the field of innovations (Cai, 2017). Finally, Armstrong and Taylor (2000) identified several effects of the universities in their societies related to economic development in both the short and long term such as improving the quality of labour by providing quality skilled graduates and skilled workers to labour markets; and skilled staff to provide expert advice to regulators and agencies; enhancing the cultural and economic developments. Based on the above discussion, the first hypothesis is suggested as follows:

**H1:** Higher education & training has a significant impact on innovation.

## **2.2. The Impact of Innovation on Higher Education & Training**

According to Rogers (2003, p. 22), innovation is “the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system”. Braak (2001, p.144) also described innovativeness as “a relatively stable, socially-constructed, innovation-dependent characteristic that indicates an individual’s willingness to

change his or her familiar practices”. However, Goddard & Vallance (2013) argued that innovation in higher education is part of an intertwined and connected social system, and universities of course are part of this system, then innovation in higher education is seen as a response to changes in society and the economic system where universities play a vital through managing and transferring the knowledge economy. In this avenue, Billon et al. (2017) argued that innovations are the result of interactions between a range of socio-economic factors as well as research and development activities. Therefore, the economic and social development of societies affects the innovation process in higher education (Goddard & Vallance, 2013). Etzkowitz and Leydesdorff (1997) determined three main elements of the innovation system. Such elements are industry, university, and government. Innovations in higher education aim to have long-term effects. For example, universities are becoming increasingly intertwined with and supportive of industrial innovation ((Etzkowitz, 2003) similar argument was provided by Wang (2014).

Furthermore, Makori et al. (2013) reported that technology-based innovation is one of the most influential factors in societies and institutions, including educational institutions, especially in the twenty-first century with the knowledge-based economy. The concept of technology-based innovation reflects programs and services related to the circulation of information over the Internet, simulations and others. The process of integrating technology-based innovation with the educational process aims to take advantage of different technologies in transferring educational experiences through social networks, distance education, blogs and e-learning. Integrating technology with education increases innovation opportunities (Baer and McCormick, 2012). Technology-based innovation is the main driver of economic growth, social development of

people and good performance of business enterprises (Yunis et al., 2018). Such an argument is consistent with the European Commission (2010) which pointed out that the economic prosperity of the people of the European Union is fundamentally dependent on innovation and technology. Because they are sources of competitive advantage associated with local knowledge creation and knowledge diffusion that may increase competitiveness and economic growth at the regional level (European Commission, 2010). Innovations and technology services are commodities whose demand is positively affected by a combination of economic factors such as household income, gross domestic product (GDP) and unemployment (Vicente and López, 2011; Neokosmidis et al., 2015).

Furthermore, Zhu (2015) conducted survey research among six Chinese universities to examine the association between organisational culture and technology as well as, the implementation of innovation factors. The major finding of Zhu's study is that organisational culture has a significant impact on using technology in higher education, including online learning. Isleem (2003) investigated the use of technology-based innovation for educational purposes in "Ohio public schools" focusing on several factors such as the level of technology used by teachers, attitude, and the characteristics of teachers. The main finding of Isleem's study is that the greater the experience of the teacher with the computer, the greater his or her appetite for using the computer over teachers who lack the experience to deal with computers. Makori et al. (2013) examined the use of technology-based innovation in higher education, in two Kenyan universities, using different research methods such as a survey, interviews and document analysis. They revealed that where graduates lack the relevant technology knowledge and skills, there is an urgent need for technology-based innovation to be

integrated with higher education to meet the demands of the job market. According to above discussion, the second hypothesis is established as follows:

**H2:** Innovation has a significant impact on higher education & training.

### 3. Research Methodology

#### 3.1. Canonical Correlation Analysis (CCA)

CCA can be used "when you wish to analyse the relationship between two sets of variables" (Pallant, 2013, p. 102). It helps in the evaluation of the interchangeable relationship between two sets of multiple variates. It is a method of giving meaning of cross-covariance matrices (Hair et al., 2010). The main objective of CCA is to identify the best linear combination between the two sets of data that maximizes the linear correlation between them. One is a linear combination of the variates of the first set, and the other is a linear combination of the variates in the second set. Such that, If there are two sets of variates with each set consisting of two or more variates " $X=(x_1, \dots, x_i)$ " and " $Y=(y_1, \dots, y_j)$ ",  $i$  and  $j$  the numbers of variates in each set, the CCA can find the orthogonal linear transformation of  $X$  and  $Y$  that have the highest correlation coefficients with each other, if we have " $U=a'X$ " and " $V=b'Y$ ". The highest number of canonical functions that can be found equals the minimum variates in any set  $\min_{i,j} \{f_0\}$  (Stevens, 1996; Hair et al., 2010; Warner, 2008).

In the present study, CCA is used to identify the inter-relation between the two sets of variables. First set is "higher education & training" that includes eight variates namely, "secondary education enrolment rate gross % (SEER)"; "tertiary education enrolment rate gross % (TEER)"; "quality of the education system (QOES)"; "quality of math and science education (QMSE)"; "quality of

management schools (QOMS)”; “internet access in schools (IAIS)”; “local availability of specialized training services (LAST)” and “extent of staff training (EOST)”. The second set is “innovation” that includes seven variates namely, “capacity for innovation” (CFIN); “quality of scientific research institutions” (QSRI); “company spending on research and development (R&D)” (CSR D); “university-industry collaboration in R&D” (UCRD); “Gov’t procurement of advanced technology products” (GPAT); “availability of scientists and engineers” (ASAE); and “patent applications” (PATA). Since the present study has two sets of variates where the first set has seven variates and the second with eight variates, therefore the number of canonical functions is equal to the number of variates in the smaller set ( $\min\{7,8\}=7$ ). All the analyses in the present study were done using the package CCA in R-software (<http://cran.r-project.org/>).

**3.2. Data Collection and Sample Size**

Our sample includes 12 countries from MEAN area namely, Bahrain, Cyprus, Egypt, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Turkey, United Arab Emirates and Yemen. Data needed for variables of the study (set 1: “higher education and training” and set 2: “innovation”) were collected from WEF Reports covering the period from 2012 to 2018. These variables are pillars of the Global Competitiveness Index (GCI) that was established by WEF.

**3.3. Measurement of the variables of the study**

The measurement of two sets of variables used in this study is based on the data collected from “Global Competitiveness Reports” related to seven years (from 2012 until 2018) that established by WEF through GCI. Details on these sets and their variables are shown in Tables 1 & 2 below.

**Table 1. Higher education & training (the first set)**

The first set: Higher education & training (“X”)			
No.	Variable	Notation	Description
1	“Secondary education enrolment rate gross percentage” (hard data)	SEER “X1”	“According to the World Bank’s World Development Indicators, this corresponds to the ratio of total enrolment, regardless of age, to the population of the age set that officially corresponds to the secondary education level.”
2	“Tertiary education enrolment rate gross percentage” (hard data)	TEER “X2”	“According to the World Bank’s World Development Indicators, this corresponds to the ratio of total enrolment, regardless of age, to the population of the age set that officially corresponds to the tertiary education level”
3	“Quality of the education system”	QOES “X3”	“How well does the educational system in your country meet the needs of a competitive economy? [1 = not well at all; 7 = very well]”
4	“Quality of math and science education”	QMSE “X4”	“How would you assess the quality of math and science education in your country’s schools? [1 = poor; 7 = excellent – among the best in the world]”
5	“Quality of management schools”	QOMS “X5”	“How would you assess the quality of management or business schools in your country? [1 = poor; 7 = excellent – among the best in the world]”
6	“Internet access in schools”	IAIS “X6”	“How would you rate the level of access to the Internet in schools in your country? [1 = very limited; 7 = extensive]”
7	“Local availability of specialized training services”	LAST “X7”	“In your country, to what extent are high-quality, specialized training services available? [1 = not available; 7 = widely available]”
8	“Extent of staff training”	MOST “X8”	“To what extent do companies in your country invest in training and employee development? [1 = hardly at all; 7 = to a great extent]”

Source: “Global Competitiveness Report (from 2012 to 2018). “World Economic Forum”; available at: <https://www.weforum.org>”

**Table 2.** Innovation (the second set)

The second set: Innovation (“Y”)			
No.	Variable	Notation	Description
1	“Capacity for innovation”	CFIN“Y1”	“In your country, companies obtain technology (1 = exclusively from licensing or imitating foreign companies, 7 = by conducting formal research and pioneering their own new products and processes)”
2	“Quality of scientific research institutions”	QSRI“Y2”	“Scientific research institutions in your country (e.g., university laboratories, government laboratories) are (1 = nonexistent, 7 = the best in their fields internationally)”
3	“Company spending on R&D”	CSR“Y3”	“Companies in your country (1 = do not spend money on research and development, 7 = spend heavily on research and development relative to international peers)”
4	“University-industry collaboration in R&D”	UCRD“Y4”	“In the area of R&D, collaboration between the business community and local universities is (1 = minimal or nonexistent, 7 = intensive and ongoing)”
	“Government procurement of advanced technology products”	GPAT“Y5”	“In your country, government procurement decisions result in technological innovation (1 = strongly disagree, 7 = strongly agree)”
6	“Availability of scientists and engineers”	ASAE“Y6”	“Scientists and engineers in your country are (1 = nonexistent or rare, 7 = widely available)”
7	“Patent applications” (hard data)	PATA“Y7”	“Number of utility patents (i.e., patents for invention) granted between Beginning of year, January 1, to end of year, December 31, per million population”

Source: “Global Competitiveness Report (from 2012 to 2018). “World Economic Forum”; available at: <https://www.weforum.org>”

## 4. Data Analysis and Results

### 4.1. Descriptive analysis

Descriptive statistics are given in Table 3 below. The average, median, standard deviation (SD) and skewness and kurtosis for all variables in both sets (“Education” and “innovation”) are provided. The highest mean score is for SEER (89.514) and TEER (35.624) while the mean score for other variables is almost the same and with low score. Also, most variables’ distribution is nearly symmetric where the value of skewness near zero except for SEER (-1.212) and PATA (1.458).

**Table 3.** Descriptive statistics for the two sets of the study

Variables	Mean	Median	SD	Skewness
SEER	89.514	92.30	16.813	-1.212
TEER	35.624	33.15	17.477	0.580
QOES	4.027	4.20	1.138	-0.413
QMSE	4.171	4.20	1.142	-0.275
QMOS	4.250	4.30	1.002	-0.207
IAIS	4.358	4.40	1.205	-0.702
LAST	4.230	4.30	0.774	-0.471
EOST	4.048	4.00	0.687	0.109
CFIN	3.817	3.80	0.720	0.124
QSRI	3.617	3.60	0.920	0.109
CSR	3.258	3.10	0.797	0.771
UCRD	3.560	3.60	0.838	0.182
GPAT	3.754	3.70	0.989	0.315
ASAE	4.432	4.40	0.688	-0.376
PATA	4.168	1.70	4.977	1.458

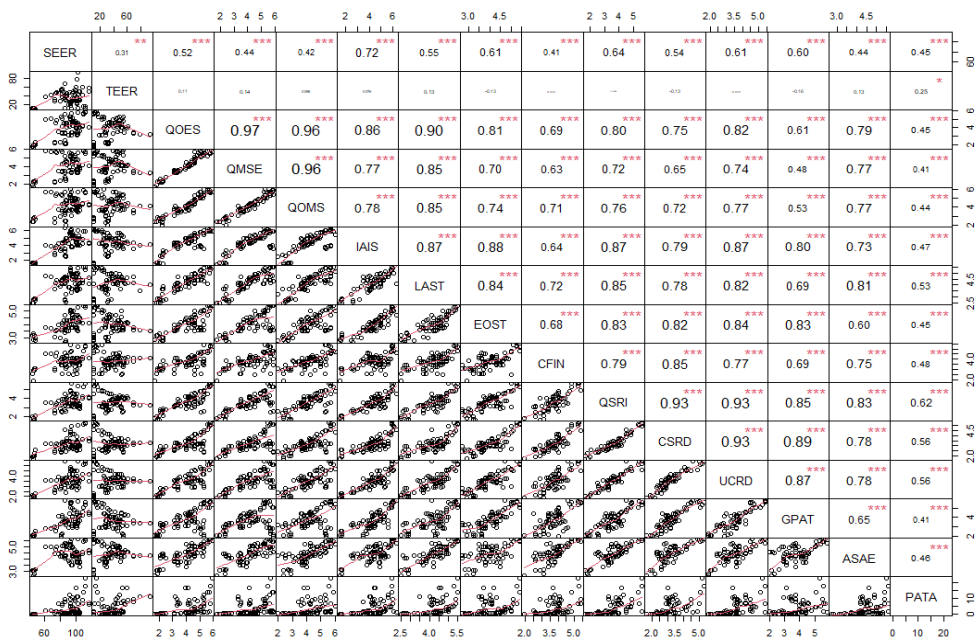
### 4.2. The Correlation Analysis

Figure 1 shows a visualisation of correlation matrix between the two sets, ‘higher education & training’ and ‘innovation’. In the bottom part, it shows the pair scatter plot

with a fitted line, while it shows the (absolute) value of the correlation adding the result of correlation test as stars in the top part. There are strong and significant correlations between the two sets except for one, TEER, which has a weak and insignificance correlation with other variables. The highest correlation is 0.97 (QOES and QMSE), followed by 0.96 (QOES and QMSE and QMSE and QMOS).

This high correlation between the two sets supports making further CCA analysis to find out the interaction between “higher education & training” and “innovation”.

Correlation between the two sets supports making further CCA analysis to find out any interaction between “higher education & training” and “innovation”.



Note: \*\*\*significant at 0.001, \*\*significance at 0.01, \*significance at 0.05  
 Figure 1: Correlation matrix between “higher education & training” and “Innovation”

Figure 1. A visualization of correlation matrix between the two sets

### 4.3. Measuring statistical significance of the CCA

Table 4 shows the canonical correlation (CanR) between the two sets and the p-value (Pr>F) to test if the canonical correlations in the current row and all that follow are zero (Dattalo, 2014). The results of p-values confirm that there are significant four canonical correlations where the p-value is

less than 0.05, therefore, the null hypothesis is rejected. Moreover, the first column, which shows the strength of the relationships, indicates that the strength of the relationship between first pair of canonicals (X<sub>1</sub>,Y<sub>1</sub>) is 0.93, the second pair of canonicals (X<sub>2</sub>,Y<sub>2</sub>) is 0.86, the third pair canonicals (X<sub>3</sub>,Y<sub>3</sub>) is 0.71 and it is 0.50 for the last significant pair of canonicals, (X<sub>4</sub>,Y<sub>4</sub>).



**Table 4.** Assessment of the overall model fit

CanR	LR test stat	approx F	numDF	denDF	(Pr>F)
0.93	0.01	8.82	56	376.89	0.00
0.86	0.08	5.71	42	331.78	0.00
0.71	0.31	3.28	30	286.00	0.00
0.50	0.61	1.93	20	239.75	0.01
0.37	0.81	1.35	12	193.43	0.19
0.25	0.93	0.88	06	148.00	0.51
0.06	1	-	02	-	-

Findings on Table 4 show that there are four significant canonical correlation (p-value < 0.01). Therefore, H 1 and H 2 can be accepted. These results suggest that both sets impact each other and a bidirectional relationship exists. Therefore, the development or change in any set must be seen through the other set. Further analyses have been conducted in the next section to provide more explanations on the nature of the relationship between the two sets and to identify the main players in each set.

#### 4.4. Standardized and Loading Values

To determine the importance of individual variables within each set, we computed the canonical correlation functions as shown in Table V. Then, standardized and loading values were estimated in Tables 6 and 7 as presented below. Table 5 illustrates the estimates of CanR, square of canonical

correlation (CanRSQ), eigen, percent and cumulative of CCA. It is found that the first canonical correlation is about 0.93 that representing 85.9% (canRSQ) of the amount of variance in the first canonical function for the first set accounted for through the first canonical function. In the second set, the estimates of canonical correlation are about 0.86. There is 74.6% of the amount of variance in the second canonical function for the first set accounted for through the second canonical function in the second set and so on. The eigen value represents the shared variance between two canonical functions. There are 57.61% of shared variance for the first canonical functions while it is 27.77% for the second function the shared variance and so on. In total, the first four canonical functions have shared variance of 97.85% (Cumulative).

**Table 5.** The estimate of the canonical correlation functions

No. of functions	CanR	CanRSQ	Eigen	Percent	Cumulative
1	0.927	0.859	6.083	57.61	57.62
2	0.863	0.746	2.931	27.77	85.38
3	0.706	0.498	0.992	09.39	94.78
4	0.495	0.245	0.325	03.08	97.86
5	0.365	0.133	0.154	01.45	99.31
6	0.253	0.064	0.068	00.65	99.96
7	0.062	0.004	0.004	00.04	100.00

The standardized canonical coefficients, which can be used to reflect the relative importance of the original variates in each canonical function (Chew and Dillon, 2014), are presented in Table 6 below. Regardless the sign of the first canonical function

(Xcan1), it can be considered the most important variables in the first set, IAIS (-0.525), followed by QMSE (0.522), then QOES (-0.457), LAST (-0.383), QOMS (-0.186), SEER (-0.146), TEER (0.142) and EOST (0.122).

**Table 6.** Standardized Coefficients for Higher Education & Training (First Set)

Variables	Xcan1	Xcan2	Xcan3	Xcan4
SEER	-0.146	0.143	0.282	-0.081
TEER	0.142	-0.160	-0.326	-0.995
QOES	-0.457	-0.132	0.814	0.021
QMSE	0.522	-0.800	-2.139	1.117
QOMS	-0.186	-0.066	2.621	-0.707
IAIS	-0.525	0.139	-1.609	1.106
LAST	-0.383	-0.582	-0.117	-0.330
EOST	0.122	1.212	0.360	-1.148

Regardless the sign of the first canonical function (Ycan1), it can be considered the most important variable in the second set, QSRI (-0.753), followed by CSRD (0.437),

then UCRD (-0.432), GPAT (-0.218), ASAE (0.066), PATA (0.066) and CFIN (-0.017) as shown in Table 7.

**Table 7.** Standardized coefficients for innovation (second set)

Variables	Ycan1	Ycan2	Ycan3	Ycan4
CFIN	-0.017	-0.139	0.514	-1.259
QSRI	-0.753	0.194	-0.804	0.764
CSRD	0.437	0.482	2.642	1.772
UCRD	-0.432	-0.710	-0.075	-0.434
GPAT	-0.218	1.222	-1.390	-0.737
ASAE	-0.088	-1.098	-0.666	0.297
PATA	0.066	-0.022	-0.280	-1.074

In Table 8, the canonical loadings have been increasingly used to interpret CCA (Härdle and Simar, 2007). They measure the linear correlations between observed variate the h or k sets and the set's canonical function. The square of loading coefficients reflects the variance of the original variate shares with the canonical function. The loading coefficients identify the important contribution of any variate to each canonical function (Huang et al., 2009).

The highest the coefficient, the more important it has in obtaining the canonical function. From Table IIX, regardless the sign of loading coefficients, it can be concluded the most important variables in the first set are IAIS (-0.978), followed by LAST (-0.923), then EOST (-0.912), QOES (-0.884), QOMS (-0.813), QMSE (-0.793), SEER (-0.706) and TEER (-0.003). Results of Table IIX suggest that the most important factors in higher education & training set are the

availability of both the Internet and specialized training centers and the quality of the education system.

**Table 8.** Loading coefficients of higher education & training (first set)

Variables	Xcan1	Xcan2	Xcan3	Xcan4
SEER	-0.706	0.158	-0.239	-0.264
TEER	-0.003	-0.472	-0.380	-0.743
QOES	-0.884	-0.341	0.161	0.013
QMSE	-0.793	-0.494	0.163	0.059
QOMS	-0.813	-0.411	0.343	-0.009
IAIS	-0.978	0.010	-0.131	0.006
LAST	-0.923	-0.239	0.044	-0.145
EOST	-0.912	0.242	0.158	-0.098

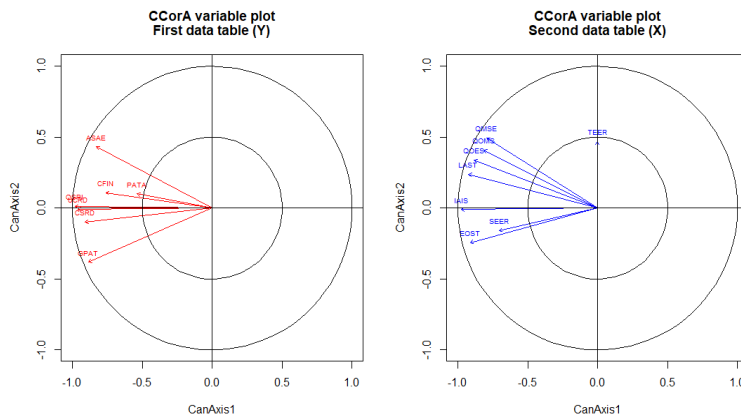
Regardless the sign of loading coefficients in the second set, it can be concluded from Table 8 that the most important variables in the second set are QSRI (-0.979), followed by UCRD (-0.962), CSRD (-0.910), GPAT (-0.886), ASAE (-0.829), CFIN (-0.761) and PATA (-0.538). Results of Table 9 suggest

that the most important factors in innovation set are the availability of both specialized scientific research centres and the company's spending on research and development of products, as well as the reliance of scientific research on joint cooperation between the university and industry.

**Table 9.** Loading coefficients of innovation (second set)

Variables	Ycan1	Ycan2	Ycan3	Ycan4
CFIN	-0.761	-0.110	0.458	-0.285
QSRI	-0.979	-0.012	0.095	-0.035
CSRD	-0.910	0.099	0.342	-0.012
UCRD	-0.962	0.006	0.152	-0.038
GPAT	-0.886	0.381	0.017	-0.009
ASAE	-0.829	-0.433	0.029	0.052
PATA	-0.538	-0.101	0.030	-0.605

Figure 2 shows the biplot for the two canonical functions and their variables in terms of loading values. The furthest away these loading values or arrows from origin (0,0), the more impact the variable has on its canonical function. Also, Figure II shows that the impact of the two sets is in the same direction. For the education set ("X"), IAIS has the highest impact followed by EOST while, there is no impact for TEER variable. For the second set, the QSRI has the highest impact followed by UCRD, while PATA has the least impact. One of the most important implications of Figure II is all variables of higher education & training set have a high correlation with first canonical function except for TEER variable. In addition, all variables in innovation set have a high correlation with first canonical function. Such finding supports the impact of each set on the other.



**Figure 2.** Biplot of the two canonical functions and their variables

### 4.5. Cross-loading

To identify the importance of one canonical correlation on another, first, we computed cross-loading in each set (higher education and innovation) in Tables 10 and 11. Second, we measured loading coefficients of each set with the other set canonical function in Tables 10 and 11 as follows. In Table X,

regarding the sign of loading coefficients, it can be considered the most important variables in the first set that have correlated with second set (first canonical function) are IAIS (-0.906), followed by LAST (-0.855), then EOST (-0.845), QOES (-0.820), QOMS (-0.753), QMSE (-0.735), SEER (-0.654) and TEER (-0.003).

**Table 10.** Cross Loading coefficients of the first set with second set canonical function

Variables	Ycan1	Ycan2	Ycan3	Ycan4
SEER	-0.654	0.137	-0.169	-0.131
TEER	-0.003	-0.407	-0.268	-0.368
QOES	-0.820	-0.294	0.113	0.006
QMSE	-0.735	-0.427	0.115	0.029
QOMS	-0.753	-0.355	0.242	-0.005
IAIS	-0.906	0.009	-0.092	0.003
LAST	-0.855	-0.207	0.031	-0.072
EOST	-0.845	0.209	0.111	-0.048

**Table 11.** Cross Loading coefficients for the second set with first set canonical function

Variables	Xcan1	Xcan2	Xcan3	Xcan4
CFIN	-0.705	-0.095	0.323	-0.141
QSRI	-0.908	-0.010	0.067	-0.017
CSRD	-0.843	0.085	0.242	-0.006
UCRD	-0.892	0.005	0.108	-0.019
GPAT	-0.821	0.329	0.012	-0.004
ASAE	-0.768	-0.374	0.021	0.026
PATA	-0.498	-0.087	0.021	-0.300

Regardless the sign of loading coefficients, Table 11 leads to consider that the most

**Table 12.** Redundancy index of the two sets (education & innovation)

	Xcan1	Xcan2	Xcan3	Xcan4	Xcan5	Xcan6	Xcan7	Total
Redundancy index	0.559	0.083	0.025	0.020	0.004	0.002	0	0.695
	Ycan1	Ycan2	Ycan3	Ycan4	Ycan5	Ycan6	Ycan7	
Redundancy index	0.619	0.039	0.026	0.016	0.003	0.002	0	0.706

Table 12 illustrates the redundancy index for the two sets. It can be concluded that the canonical variates for the first set (higher education and training) can explain 69.5% of variance in the original variables for the second set (innovation), especially, the Xcan1 contributes 55.9%. Moreover, the canonical variates for the second set (innovation) explains 70.6% of variance in the original variables for the first set (higher education and training), especially, Ycan1 contributes 61.9%.

#### 4.7. Commonality Analysis

Commonality analysis clarifies the canonical impacts made by using the signals in each

important variables in the second set that correlated with first set (first canonical function) are QSRI (-0.908), followed by UCRD (-0.892), then CSRD (-0.843), GPAT (-0.821), ASAE (-0.768), CFIN (-0.705) and PATA (-0.498).

#### 4.6. Redundancy Analysis

According to Dattalo (2014) and Jendoubi and stimmer (2018), when using the CCA, the redundancy index is used to do the same function of the R-square in regression analysis. This index is the percentage of variance in the original variates of one set that is interpreted by the canonical function of the other set. High redundancy index proposes a high ability to forecast. If there is a clear definition for independent and dependent sets, the researcher may use the redundancy index for independent canonical function in forecasting the variance in the set of original variates in the dependent set.

canonical set to split the variance of canonical functions produced from the other canonical set. These canonical variates can be divided to unique and common impacts. "A canonical commonality unique effect is computed as a squared correlation between the canonical variate for a given canonical set and a variable of interest in the other canonical set. A canonical commonality common effect is computed as a squared correlation between the canonical variate for a given canonical set and the set of variables of interest from the other canonical set after subtracting all unique effects and the variance explained by any other sets of variables" (Nimon et al., 2010).

Table 13 below provides the splitting of higher education & training canonical first function by the variables in the innovation and the splitting of innovation canonical first function by the variables in the higher education & training indicators. The values point out “how much variance can be explained as unique or common by the variables” and the “% total” points out “the percentage of variance that can be illustrated out of the observed canonical impact”. It exposes that the higher education & training variables are explained by variance common to CFIN, QSRI, CSRD, UCRD, GPAT and ASAE (27.63%) of canonical impact, followed by CFIN, QSRI, CSRD, UCRD,

GPAT, ASAE and PATA (21.92%). However, the unique support of these variables is very low. For example, the highest support is attributed to QSRI (0.0339), followed by UCRD (0.0152). Furthermore, it indicates that the innovation variate is explained by variance common to SEER, QOES, QMSE, QOES, QMSE, QOMS, IAIS, LAST, EOST (35.74%) of canonical impact, followed by QOES, QMSE, QOES, QMSE, QOMS, IAIS, LAST, EOST (24.39%) while, the unique support of these variables is very low. For example, the highest support is attributed to IAIS (0.0247), followed by LAST (0.0165).

**Table 13.** Commonality Analysis of education & innovation sets

Splitting of X canonical function				Splitting of Y canonical function				
	Unique	Common	% Total		Unique	Common	% Total	
CFIN (y1)	0.0001	0.4973	0.4974	SEER (x1)	0.0061	0.4215	0.4276	
QSRI (y2)	0.0339	0.7898	0.8237	TEER (x2)	0.0100	-0.100	0.0000	
CSRD (y3)	0.0097	0.7008	0.7105	QOES (x3)	0.0032	0.8885	0.6717	
UCRD (y4)	0.0152	0.77999	0.7951	QMSE (x4)	0.0055	0.5344	0.5399	
GPAT (y5)	0.0067	0.6676	0.6743	QOMS (x5)	0.0018	0.5658	0.5676	
ASAE (y6)	0.0118	0.5883	0.5901	IAIS (x6)	0.0247	0.7966	0.8213	
PATA (y7)	0.0020	0.2462	0.2482	LAST (x7)	0.0165	0.7151	0.7316	
				EOST (x8)	0.0014	0.7128	0.7142	
Highest three commons			% Total	Highest three commons			% Total	
y1, y2, y3, y4, y5 & y6			0.2373	27.63	x1, x3, x4, x5, x6, x7 & x8			0.3069
y1, y2, y3, y4, y5, y6 & y7			0.1882	21.92	x3, x4, x5, x6, x7 & x8			0.2095
y2, y3, y4 & y5			0.1024	11.93	x1, x3, x6, x7 & x8			0.0835

One of the interesting results is obtained by commonality analysis is the explained variance in innovation set is related to common variables instead of one unique variable while, the explained variance in higher education & training set is linked to common variables not a unique variable.

## 5. Conclusion

The study examines the bidirectional relationship between two sets of variables namely, higher education & training with eight indicators and innovation with seven indicators using the canonical correlation analysis through a sample of 12 MEAN

countries. The main result of our study indicates that the canonical variates for the first set (higher education & training) explains 69.5% of variance in the original variables in the second set (innovation). The canonical variates for the second set (innovation) interprets 70.6% of variance in the original variables in the first set (higher education and training). The most important variables in the first set that correlates with second set in the first canonical function are “internet access in schools”, followed by “local availability of specialized training services”, then “extent of staff training, “quality of the education system, “quality of management schools, “quality of math and science education, “secondary education

enrolment rate gross percentage and “Tertiary education enrolment rate gross percentage. The most important variables in the second set that correlates with first set in the first canonical function are “quality of scientific research institutions”, followed by “University-industry collaboration in R&D”, then “company spending on research and development”, “government procurement of advanced technology products”, “availability of scientists and engineers”, “capacity for innovation” and “patent applications”. All variables in higher education & training set have a high correlation with first canonical function except for “tertiary education enrolment rate gross percentage” variable. Further, all variables in innovation set have a high correlation with first canonical function. Our results have confirmed on the bidirectional relationship between higher education & training and innovation. Consequently, H 1 and H 2 are accepted.

Based on the redundancy analysis, the first canonical variate (Xcan1) for the first set (higher education & training) explains 55.5% of variance in the original variables

for the second set (innovation), while all canonical variates explain 69.5%. Also, the canonical variate (Ycan1) for the second set (innovation) explains 61.9% of variance in the original variables for the first set (higher education and training), and in total, all canonicals explain 70.6%. Findings of the commonality analysis shows that the role of quality of management school in explaining the variation in canonical function of innovation (about 36%) in common with “quality of education system”, “quality of math and science”, “internet access”, “training availability and staff training produce”.

The current study, like other studies, have some limitations such as it considers only 12 MEAN countries. Therefore, it is recommended to extend it in a future study through the inclusion of other MENA countries which are ignored in the current study. In addition, the measurement of the variables is based on GCI that is established by WEF. Different measures and other variables can be used in future studies.

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## ROAD TO INDUSTRY 5.0: CHALLENGES AND OPPORTUNITIES

**Abstract:** *The application of advanced digital technologies has the greatest potential for innovation in the industry, as demonstrated by Industry 4.0. However, Industry 4.0's technology-centered approach neglects the importance of human impact in its implementation, since this transformation requires new knowledge and skills for engineers and workers alike. The European Commission has introduced the concept of Industry 5.0, which emphasizes the sustainability and resilience of smart manufacturing systems through human-centric production. Thus, Industry 5.0 represents a shift from Industry 4.0, focusing on bringing humans back to the forefront while maintaining the digital agenda to develop human-cyber-physical systems. However, as a new strategy, Industry 5.0 faces a great challenge, where the lack of human resources represents the largest gap. Thus, the present research provides a methodology that supports this strategy shift. In addition, this research addresses the main challenges of Industry 5.0 and provides opportunities for overcoming them based on the developed methodology.*

**Keywords:** *Smart Manufacturing, Industry 5.0, Human-Cyber-Physical Systems (HCPS), Upskilling*

### 1. Introduction

In the last decade, the global hype around digital transformation in the industry was focused on creating smart, connected manufacturing systems based on Industry 4.0 concept, emphasizing the role of Cyber-Physical Systems (CPS) (Qiao, Liu, Ma, & Liu, 2021). However, the CPS environments, in which physical objects and software are closely integrated via the Industrial Internet of Things (IIoT) empowered by Artificial Intelligence (AI), constrict the human impact on manufacturing (Pacaux-Lemoine, Berdal, Enjalbert, & Trentesaux, 2018). Moreover, recently the European Commission (EC) pointed out that humans are still the most valuable asset of every company: they are dexterous, intelligent, flexible, and creative,

and outperform most machines or robots (European Commission, 2019). Thus, it seems that the technology-centered approach of Industry 4.0 has proved improper since the lack of a human impact in the application of Industry 4.0 has been reported (Bajic, Rikalovic, Suzic, & Piuri, 2021; Rikalovic, Suzic, Bajic, & Piuri, 2022). Therefore, it becomes evident that the overall change in the industry has effects that go far beyond technological transformation.

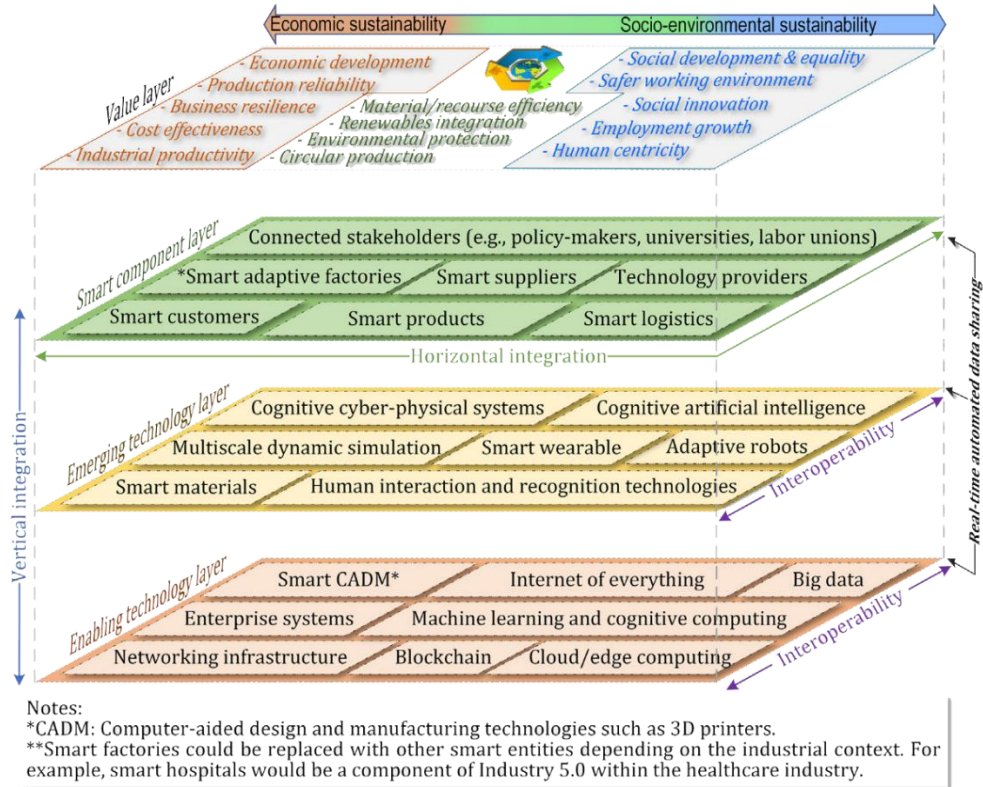
In reply to the paradigm shift, the EC adopted an official document introducing the concept of Industry 5.0 which emphasizes the main role of the research and innovation sector in support of the industry through three core pillars, namely: human-centricity, sustainability, and resilience (European Commission, 2021, 2022). Thus, Industry

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5.0 puts the human aspect back in the center of manufacturing processes proposing the

development of Human Cyber-Physical Systems (HCPS) (Bajic et al., 2023).



**Figure 1.** The reference model of Industry 5.0 was developed by Ghobakhloo et al., 2022

As a part of the Industry 5.0 concept, the HCPS represents an advanced intelligent system composed of humans— experienced engineers, skilled shop floor workers, and data researchers — implementing the expert domain knowledge in the CPS to achieve a smart manufacturing system by assessing manufacturing data based on AI applications(Bajic et al., 2023; Jabrane & Bousmah, 2021; Maddikunta et al., 2021; Nahavandi, 2019; Zhou, Zhou, Wang, & Zang, 2019).However, this future form of the industry requires new knowledge and skills from both engineers and workers.

Thus, the present research tries to fill the gap and contributes to the existing literature in two ways:1) addresses the main challenges that Industry 5.0 faces and, 2) provides opportunities for overcoming them through the proposed academia–industry collaboration methodology.

The rest of the article is organized as follows. Section 2 provides a theoretical background of Industry 5.0 and HCPS. Section 3 presents the addressed challenges in Industry 5.0, while Section 4proposes the opportunities through developed academia–industry collaboration methodology for overcomingaddressed challenges. Finally, Section 5 derives some conclusions.

## 2. Industry 5.0 and HCPS

The first academic research on the concept of Industry 5.0 dates back to 2016 (Sachsenmeier, 2016) when discussions about the essence of humanity's existence, physical integrity, and relationship with nature were initiated through the emerging field of bionics. After that, many human-oriented initiatives were launched (Demir, Döven, & Sezen, 2019; Nahavandi, 2019; Scanlon, 2018). However, in 2021, the EC adopted an official document presenting Industry 5.0 and emphasizing the main role of the research and innovation sector in supporting industry in its long-term service to humanity (European Commission, 2021).

However, Industry 5.0 is not a new paradigm, but the natural continuation of Industry 4.0. Thus, the transition from Industry 4.0 concept to Industry 5.0 represents a combination of the advantages of a CPS, intelligent machines, and human knowledge, which have a focus on increased productivity, manufacturing resilience, and sustainability (Pizon & Gola, 2023).

Additionally, authors (Ghobakhloo et al., 2022) developed the reference model of Industry 5.0, presented in Figure 1. The reference model describes this phenomenon, explaining its underlying technologies, techno-functional principles, smart components, and values.

Moreover, the official definitions of Industry 5.0 are still abstract ideas generalized from the practices and shortcomings of Industry 4.0, focusing primarily on human aspects (Bajic et al., 2021; Nahavandi, 2019; Rikalovic et al., 2022; Sachsenmeier, 2016), and sustainable and resilient manufacturing processes (European Commission, 2021; Humayun, 2021). Thus, definitions of Industry 5.0 depend on the field of research. In particular, the definition of Industry 5.0, accepted in this research is adapted from (Bajic et al., 2023), and reads as

follows:

"Industry 5.0 represents the concept of transition to sustainable and resilient manufacturing systems focused on human resources (European Commission, 2021, 2022) and driven by advanced technologies, grouped into categories (adapted from (European Commission, 2020)) for:

- individualized human-machine interaction (including robotics with AI and augmented and virtual reality);
- simulation of the production system (including CPS, digital-twins of products, processes, and entire systems); and
- data transmission, storage, and analysis technologies (including IIoT, cybersecurity, big data analytics (BDA), and Edge computing),

to enable the development of HCPS". The Industry 5.0 ecosystem is presented in Figure 2.



Figure 2. Industry 5.0 ecosystem with three main pillars: human-centricity, resilience, and sustainability (adapted from European Commission, 2020)

Human Cyber-Physical Systems are composed of human experts, cyber systems, and physical components to achieve specific manufacturing goals, i.e. flexibility, resilience, and sustainability (Ji et al., 2018; Kim et al., 2022). Noticeably, we were unable to locate a precise definition for HCPS in the relevant literature, nor did we encounter accurate information concerning the term "human". According to some authors (Coronado et al., 2022; Garrido-Hidalgo et al., 2018), "human" in HCPS denotes a shop floor worker who collaborates with machines, i.e., collaborative robots (cobots) (Jabrane & Bousmah, 2021), whereas other authors (Ji et al., 2018; Pathak, Pal, Shrivastava, & Ora, 2019; Zhou et al., 2019) believe that it refers to human knowledge that is implemented within CPS. Nevertheless, no research was found that highlighted the significance of data researchers as a vital connection between CPS and human domain expert knowledge, empowered by AI. To address this inadequacy in the current definitions, we define HCPS as an advanced intelligent system that encompasses humans, such as experienced engineers, skilled shop floor workers, and data researchers, who implement expert knowledge in CPS to achieve intelligent manufacturing systems based on AI and manufacturing big data (Jabrane & Bousmah, 2021; Maddikunta et al., 2021; Nahavandi, 2019; Zhou et al., 2019) presented in Figure 3.

### 3. Industry 5.0 Challenges

As Industry 4.0 failed to fulfill the industry expectation due to managerial and technological challenges (Bajic et al., 2021; Rikalovic et al., 2022), it is considered that Industry 5.0 will overcome those gaps. However, the majority of unsurpassed challenges from Industry 4.0 present issues in Industry 5.0 as well. Thus, the main challenges can be grouped into three

categories referring to the Industry 5.0 pillars, namely: human-centricity, resilience, and sustainability.

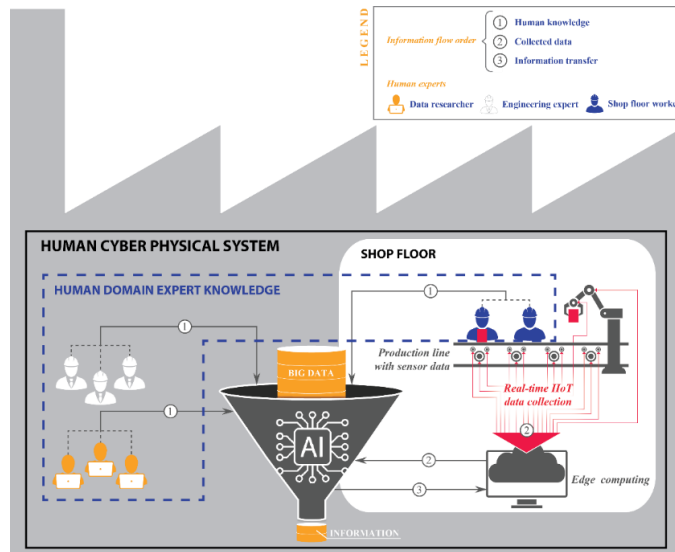
**Human-Centricity.** To achieve human-centric manufacturing, it is essential for every participant in the factory, including both humans and machines, to consistently learn and acquire new knowledge. (Adel, 2022; Gürdür Broo, Kaynak, & Sait, 2022; Lu et al., 2022). Thus, the fundamental prerequisites to Industry 5.0 implementation are related to reskilling and upskilling of experienced engineers and workers. However, the reluctance of workers to embrace change and improve their skills can impede a company's progress in commencing or advancing with the Industry 5.0 implementation (Bajic et al., 2021; Kumar, Bhamu, & Sangwan, 2021).

**Resilience.** To achieve the resilience of manufacturing systems, the most important is to establish trust within HCPS where security presents a challenge in this regard (Adel, 2022; Bajic et al., 2021). The HCPS incorporates a diverse range of cyber technologies (e.g., AI, IIoT, Cloud, Fog and Edge computing, BDA, etc.) that generate, transmit, and handle significant amounts of security and privacy-sensitive data in manufacturing systems, making it susceptible to numerous potential cyber-attacks in the realm of cybersecurity (Wang, Zheng, Yin, Shih, & Wang, 2022). Thus, the integration of AI, IIoT, and automation into HCPS creates security threats, necessitating trusted security measures to protect businesses. The focus of Industry 5.0 applications on information and communication systems leads to stringent security requirements to address security challenges.

**Sustainability.** On the one hand, sustainable development of manufacturing systems seeks the protection of the environment through sustainable products and logistics to approach the zero-waste objective (European Commission, 2022). In addition to waste

prevention, the manufacturing processes must be environmentally friendly (Bajic et al., 2021)—for example, by using renewable resources and digital technologies (Bajic et al., 2023). On the other hand, considering human capital sustainability is essential in the realm of smart manufacturing because

humans possess a considerable amount of knowledge. Moreover, how stakeholders choose to leverage this knowledge can have a profound effect on transitioning the company from CPS into HCPS (Wang et al., 2022).



**Figure 3.** HCPS in Industry 5.0 ecosystem empowered by human domain expert knowledge, AI, and advanced technologies (adapted from Bajic et al., 2023)

## 4. Industry 5.0 Opportunities

In the present section, upon the Industry 5.0 challenges, we derived the opportunities to overcome them. These opportunities are obtained based on the approach of connecting academia and industry to respond to the real needs of manufacturing companies. In addition to the need for digitization to technologically improve companies, a major challenge is also the lack of human resources with adequate skills (Adel, 2022; Bajic et al., 2021; Gürdür Broo et al., 2022; Lu et al., 2022; Wang et al., 2022). Based on these state-of-the-art research papers, the Industry 5.0 opportunities are presented via developed academia-industry collaboration

methodology (Figure 3) consisting of the following phases:

**Phase 1: Industry needs analysis** – represents the collection of relevant information related to Industry 5.0 challenges according to the following steps:

- the industry must determine its specific needs regarding the implementation challenges of the Industry 5.0 concept;
- academia has to do research in the field of implementation challenges of Industry 5.0 that companies have in practice.

The output of this phase will be the aggregate results of all the challenges noted by the industry during the implementation of Industry 5.0. These results are the starting

point for addressing the challenges related to the lack of human resources.

**Phase 2: University/LLL course definition**—represents a response to defined needs based on industry needs. Thus, the response to industry needs will be developed in a two-way direction:

- academia has to develop and improve university courses in accordance to industry needs to teach the next generation of young engineers who will have the skills necessary to develop and implement AI in an HCPS environment of Industry 5.0.
- academia has to develop lifelong learning (LLL) training course for upskilling and reskilling of existing engineers and shop floor workers with AI digital skills and AI-based knowledge to improve:
- lack of Industry 5.0 skilled engineers with a clear vision of digital skills benefits to industry (Bajic et al., 2021),
- engineers' resistance to knowledge upgrades (Kumar et al., 2021),
- engineer acceptance of AI in manufacturing processes (Angulo, Chacón, & Ponsa, 2023; Nahavandi, 2019).

The results of this phase will be developed courses for students/engineers based on theoretical and practical AI knowledge for implementation of HCPS in Industry 5.0.

**Phase 3: Industry 5.0 engineers**—represents the implementation of developed University/LLL courses and attendance of students/engineers/shop floor workers in relevant courses for the practical application of AI HCPS. Thus, the upskilling should be done based on academia and industry collaboration to design the Industry 5.0 labs for practical education and simulation of AI-based manufacturing for both students and engineers.

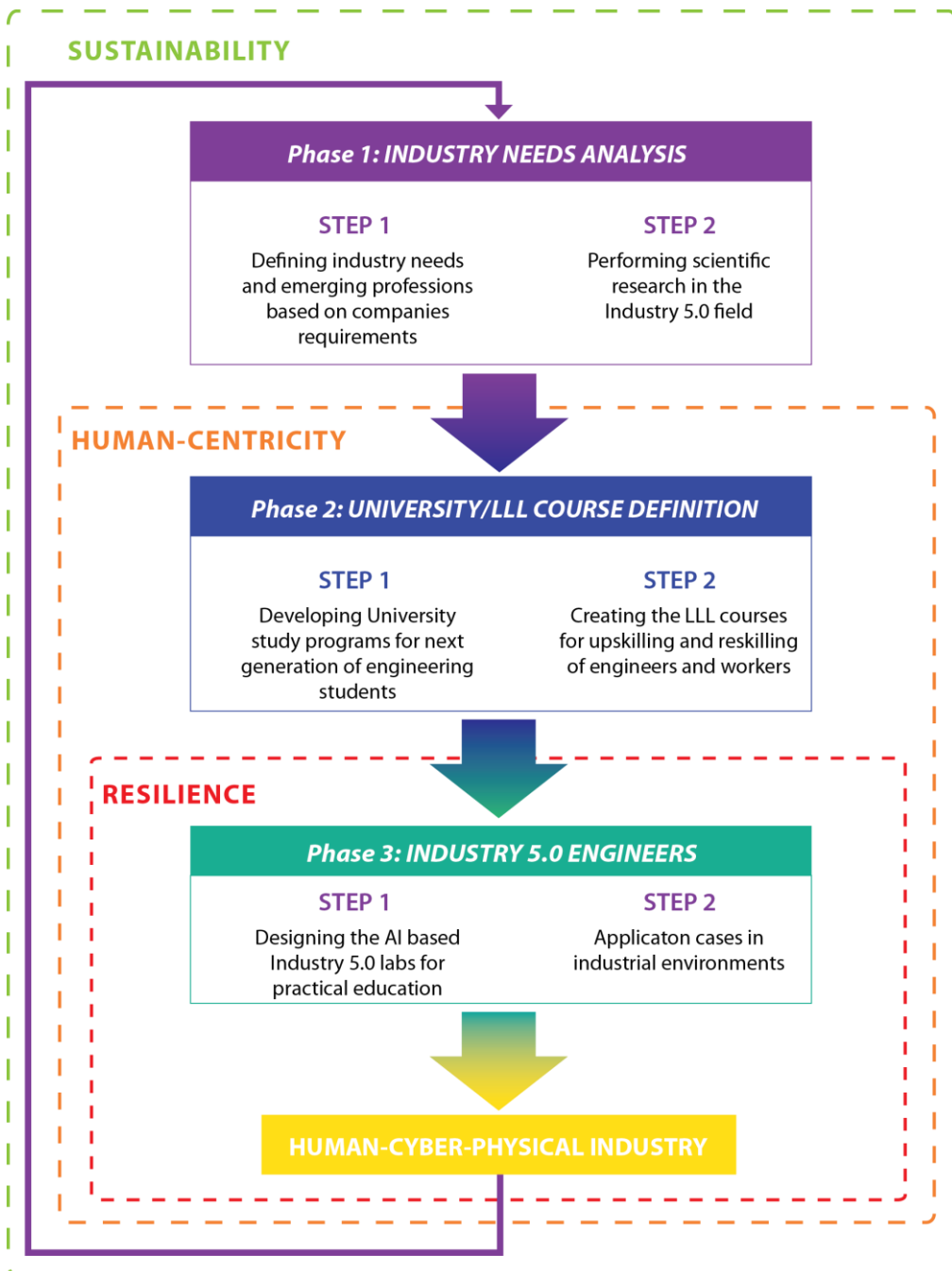
The results of this phase will be trained students and engineers with AI knowledge for practical application of Industry 5.0. The first goal of this phase will be training students in the development and use of AI to improve the industry in the direction of HCPS in Industry 5.0. The second goal will be the training of engineers and shop floor workers employed in the industry in the direction of Industry 5.0 so that they can practically and independently apply AI tools to solve manufacturing problems.

The proposed methodology represents a resilient, human-oriented, and sustainable concept for overcoming Industry 5.0 challenges, whereby:

- human-centricity is reflected in the cooperation between academia and industry to transfer and implement state-of-the-art knowledge in the field of AI with a focus on Industry 5.0, where AI will enable increased levels of automation and human interaction in HCPS environments,
- resilience is reflected in the generation of knowledge within the industry itself, where a new generation of engineers would be able to independently apply and develop AI models,
- sustainability is reflected in the circular process of continuous improvement of the industry by applying AI skills.

The developed methodology provides opportunities for future academia and industry collaborations. This collaboration will ensure the adaptation of existing needs, both in the industry and academia, for providing knowledge and skills to existing engineers working or students that can work in the future in the companies, able to sustain industry to obtain and apply AI-based to the HCPS solutions.





**Figure 3.** HCPS inIndustry 5.0 ecosystem empowered by human domain expert knowledge, AI, and advanced technologies (adapted from Bajic et al., 2023)

## 5. Conclusion

Industry 5.0 represents a shift towards a more human-centric, sustainable, and resilient approach to achieving HCPS production. However, achieving these goals presents several challenges that must be overcome. One major challenge is the need to ensure that human engineers and workers remain at the center of the manufacturing process, with advanced technologies, such as AI, IIoT, BDA, and automation, being used to augment rather than replace workers. This will require a focus on upskilling and reskilling workers, with an accent on designing workplaces that prioritize workers' safety and well-being.

Another challenge is the need to design a resilient manufacturing system in Industry 5.0 with a focus on cybersecurity. Cybersecurity refers to a company's ability to anticipate, withstand, and recover from cyberattacks. It requires a comprehensive strategy of continuous improvement that includes proactive measures, and incident response plans. The goal of minimizing the

impact of security incidents on a company can be achieved by using advanced technology (e.g., Edge computing) to ensure that knowledge and data flow will stay within the manufacturing company limiting external intrusions into the system.

Finally, achieving sustainability in the manufacturing industry, with a focus on reducing environmental impacts such as greenhouse gas emissions, waste, and resource depletion. This will require the use of new green technologies, e.g., AI and BDA, that are more efficient. The use of AI and BDA can minimize waste and maximize productivity.

Thus, to solve all of these Industry 5.0 challenges in HPS environments, this research provides the methodology for establishing the collaboration between academia and industry, to develop strategies (i.e., focusing on knowledge upgrading) that can ensure the long-term viability of industrial manufacturing in an uncertain and rapidly changing world.

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# **14. International Quality Conference**



**SCIENTIFIC FOCUS 1**

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Slavko Arsovski<sup>1</sup>

## QUALITY 5.0: FROM CHALLENGES TO REALITY

**Abstract:** A world is in process of rapid changing in all areas of living. In all of them exists old and new problems with urgent needs for solving. Transition from Industry 3.0 to Industry 4.0 changed view on industry in 21st century and also there are answers on challenges based on Quality 3.0 and Quality 4.0 concept. In last ten years is developed concept of Japan's „Society 5.0“ which needs Quality 5.0 concept. This is main motive for researching possibility for transition quality into Quality 5.0.

In the paper are presented basic information about Industry 4.0 and Quality 4.0 based on new challenges in 21st century. Based on literature and own research is defined concept of Quality 5.0 and ways of transition to Quality 5.0, especially in transition countries as Serbia in next 30 years. The first analysis pointed out that it is possible with using smart technologies, smart leadership, smart people and other smart „things“ for achieving smart/integrated quality, quality of life, resilience and all human-centric activities.

**Keywords:** Society 5.0, Quality 5.0, Quality of Life, Resilience, Serbia.

### 1. Introduction

The trend in 21st century is to establish smart society in which is included more than 27 smart components. For this research are interesting smart industry (Industry 4.0) and smart quality (Quality 4.0). This process is located in all technology advanced states, but also in some states with big Intellectual Capital (IC). These concepts are defined for each components of smart society. There is problem of integration and including human being and problems of sustainability, quality of life, resilience etc. These are challenges for developing concept of Quality 5.0 dedicated to „Society 5.0“ development ed in Japan. It is great transition with for fundamental themes (CSTI, 2019):

- creating new values for industry development in future and social transformation,
- reorganising economic and social challenges,
- higher support for science,
- technology and innovation (STI), and
- establishing sistem cycles of human resurces, knowledge and capacity for innovation.

For its realization is necessary investment in R&D minimum 4% of GDP from private and public sector, from state government minimum 1 percent. With introduction „Society 5.0“ in Japan expect enhancing GDP circa 3.3%. The goal of „Society 5.0“ is to achieve economic rise/wellbeing and in

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same time overlapping social challenges and in total prosperity of global society.

According Tompston N. (2014) are recognised four waves of changes until year 2050., i.e. :

1. first wave (2010-2020) with slow development of technologies and first introduction of smart solutions,
2. second wave (2020-2030) with development strategy innovation related to RFID, telemetrics, integration, etc.,
3. third wave (2030-2040) with self-assembly, masive 3D printing, self purchasing, etc.,
4. fourth wave (2040-2050) with paradigm of confidence, supported by advanced robotic and AI, autonomuos vehices, sensing material

In smart society is higher role of ethical and well-being aspects. Etical government realizes through: (1) impact of regulatives, (2) regulation of collective actions, (3) building/modernising existing regulation, (4) anticipating strenght of transformation of collective adaptive systems (ACS), (5) balancing government decisions, (6) decising adaptive government, etc. Based on Deloitte (2018) are emphasized challenges in smart cities which need quality answers in following areas:

- smart economy,
- smart environment,
- smart living,
- smart mobility,
- smart quality and safety and
- smart education.

Transition of concept Industry 4.0 to Society 5.0 has impact on planning big social transformation in Japan with destroying five walls related to:

- ministries/agencies,
- legal system,
- technology,
- human resurces and

- social acceptance.

A transition from Industry 4.0 to Industry 5.0 is practicaly transformation of digital manufacturing to digital society (Skobelev P.O., Borovik S.Y., 2017) with convergence of science and technologies in society 5.0 from technology to society.

A concept of enterprise value management defined for smart enterprise in Industry 4.0 could be make broader for Society 5.0 and Quality 5.0 (Fujitsu Consalting, 2002).

According Kearney A.T. (2017) value dimensions from converging technologicis have levels:

1. value for the factory,
2. value to the firm (enterprise),
3. value to the industry,
4. value to society, and
5. value to the individual.

In all of the levels are included elements of Quality 4.0 (level 1, 2 and 3) and Quality 5.0 (level 4 and 5).

Kueper D. et al. (2019) analyzed Quality 4.0 and concluded that cca 63% companies had not decision or plan for it, but only 16% had some form of implementation. The challenges of implementation were: (1) cost of quality check, (2) first-pass yeald, (3) defect rate, (4) rework rate, (5) on-time delivery, (6) customer satisfaction, (7) waranty claims, and (8) product-related complaints. All challenges are base for Quality 4.0 and Quality 5.0, also on levels 1 and 2 in value creation.

A Quality 5.0 concept is connected with Industry 5.0 (Nahavandi S., 2019) with advanced technologies: (1) networked sensor data interoperability, (2) multiscale dynamic modeling and simulation: digital twins, (3) shopflor trackers, (4) virtual training, (5) intelligent autonomous systems, and (6) advances in sensing technologies and machine cognition.



In Industry 5.0 is appropriate to use concept of Lean Innovation because is based on value management (Ozkeser B., 2018). Relations among Quality management in the 21st Century and Industry 4.0 are analyzed in Gunasekaran A., Subramanian N., Ngai E. (2018).

In this research are emphasized following quality topics for Industry 4.0:

1. economic aspects,
2. decision models in quality,
3. business models,
4. human aspects in quality (including leadership),
5. technological aspects in quality.

Authors conclude that is necessary to make alignment between human aspects and technology revolution in quality management.

A concept of Quality 5.0 is connected with concept Society 5.0. According CSTI (2019); Filip, D. et al. (2014); Nakićević N. et al. (2019) and Smith J. et al. (2018) are defined fundament goals:

- goal 1: Leave N<sub>0</sub> Person Behind,
- goal 2: Empower Users through Good Digital Identities,
- goal 3: Make Business Work for People,
- goal 4: Keep Everyone Safe and Secure,
- goal 5: Build new rules for a new game,
- goal 6: Broke through the data barriere

Author concluded that start is beginning.

## 2. Challenges in 21<sup>st</sup> century

In 21st century are expecting a lot of challenges (Klein F., Bansal M., Wohlers J., 2017). In this study are emphasized the megatrends of tomorrow's world divided into five categories:

- society,
- technology,

- environment,
- economy, and
- politics.

For Society 5.0 and Quality 5.0 are specially highlined:

- artificial intelligence,
- augmented reality,
- digitalization,
- IoT,
- climate change,
- concentration on wealth,
- demand for customization,
- environmental awareness,
- focus on transparency,
- globalization,
- partnership models,
- resource scarcity,
- sharing economy,
- social media,
- industry consolidation,
- urbanization,
- geospatial technology,
- terrorism defence, etc.

A way from Industry 4.0 to Society 5.0 and Quality 5.0 needs a big societal transformation, with challenges to avoid or override barriers related to:

- ministries and agencies,
- legal system,
- technologies,
- human resources,
- aging of populations, etc.

The challenges are related to:

- data availability, security and accuracy,
- technology,
- competences,
- openness,
- ecosystem,
- project solutions,
- security of realized system.

A big challenge is related to citizen, i.e. happiness or quality of life in modern society (Kanazawa S., Li N., 2015). It is now element of concept Quality 5.0.

In Gladden M. (2019) is analyzed „Society 5.0“ from aspect of antropological posthumanized societies in future. In this study is asked answer on questions:

1. how different types of human and non-human members can collaborate, besides difference among them,
2. how can make concept dynamics of members of „Society 5.0“, and
3. in which aspects are different members of „Society 5.0“ from societies 1.0 to 4.0.

At the end are stated three questions:

1. does exists samting real new in concept 5.0? Answer: is positive.
2. does the paradigm Society 5.0 could be apploed aut from Japan? Could with some adaptations.
3. How have to collaborate all stakeholders in purpose of realization of Society 5.0? Answer:

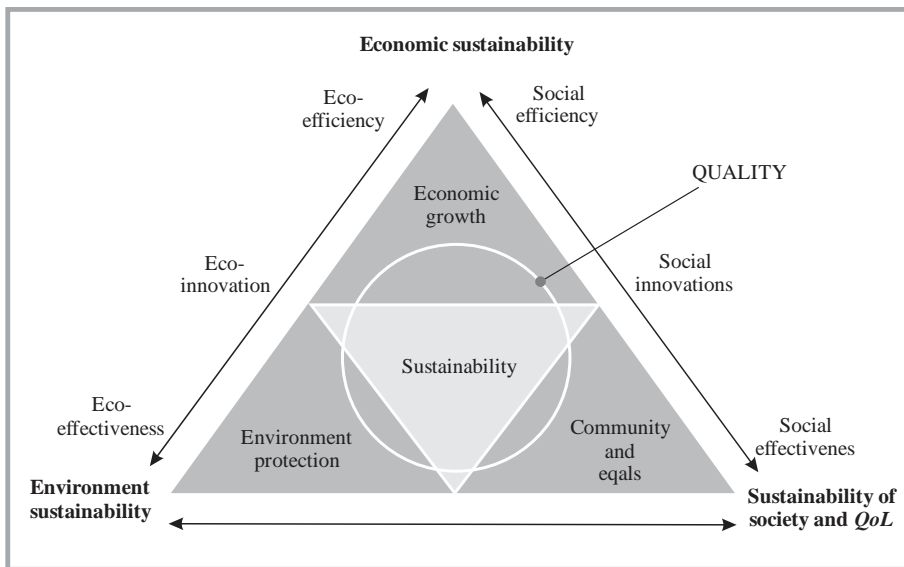
on theoretical and organizational level.

As extension of Society 5.0 is developed concept „Living Laboratories“ and „Living Services“ (Fjord, 2015) based on IoT in broad applying and close relations among people, machines and environment.

In Society 5.0 a quality has higher impact and „glue“ role. A complexity of these reguests, challenges, needs to develop a new paradigm: Quality 5.0, what is explained in next chapters.

### 3. Concept of quality 5.0

Quality 5.0 concept in Society 5.0 is directly related with sustainability, sustainable digital innovation, digital culture, social innovations, quality of life. In figure 1 is presuted quality in context of sustainability.



**Figure 1.** Quality in context of sustainability

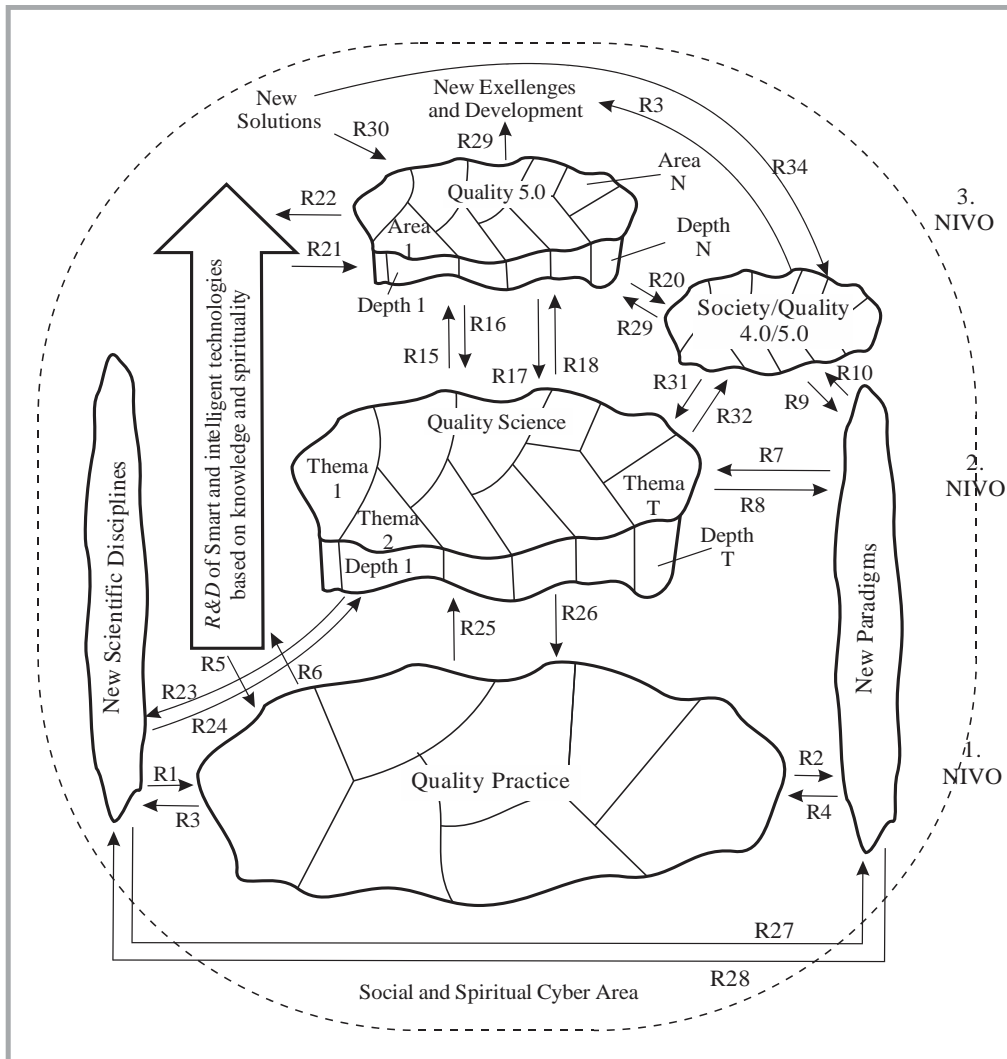
In this model quality is incorporated in all elements of Society 5.0. It is enabler of economic growth, sustainability,

environment protection, community and equals of peoples, and sustainability of society and quality of life (QoL).

It is defined for extension of existing situation (Quality 3.0/Quality 4.0 in first phase) and creating new reality in future (second phase). On figure 2 is presented structure of concept Quality 5.0 and relations with environment.

This concept started from a quality practice (on the bottom) divided with different areas, as industry, education, food, etc. On higher

level is quality science with different themas. Each thema has different depth of development and introduction in practice. On higher levels are Quality 4.0 and Quality 5.0 connects with mutual relationships, and also relationship with presented entities in social and spiritual cyber area (environment).



**Figure 2.** Levels to achieving a Quality 5.0

A Quality 5.0 consists from different areas (1 – N). Each area of quality has own depth. Through relation R19 and R20 is performed correspondence with socially 4.0/5.0 as present level of development. On the highest level in the model is Quality 5.0 which has inputs through relations:

- R3: new technological, social and other solutions,
- R21: research and development of intelligent technologies based on knowledge and spirituality,
- R19: common elements from Society 4.0/5.0, and
- R15, R18: new themas from paradigm „Quality Science“ (on second level).

On second level is emphasized:

- Quality science and
- Society /quality 4.0/5.0.

Each relation in this level with elements in other levels has own content, related entities and in total own antology. An egsample, R24 represent impact and results of research of concios fields on innovativeness or a.e. sustomer decision.

According Jacob D. (2017) LNS research a Quality 4.0 has 11axes, i.e.:

1. data,
2. analitics,
3. connectivity,
4. collaboration,
5. application development,
6. scalability,
7. management systems,
8. compliance,
9. culture,
10. leadership, and
11. competency.

Each axis has own sub-elements.

She highlined scientific method versus data science. On this approach Quality 4.0 is defined as CIA:

- C (Connectedness),
- I (Intelligence) and
- A (Automation).

in appropriate Quality 4.0 Ecosystem. In center of this system are Neural Networks and Deep Learning. Some elements of her model of Quality 4.0 are oriented to excitement (drive out fear, build safety and quality culture, and find meaning and purpose) and on this way is connected with Quality 5.0 concept.

Mourtzis D. et al. (2019) emphasized aspects of internal complexity and ICT based relations in digitalized manufacturing system (Cyber-Physical Systems) of Industry 4.0.

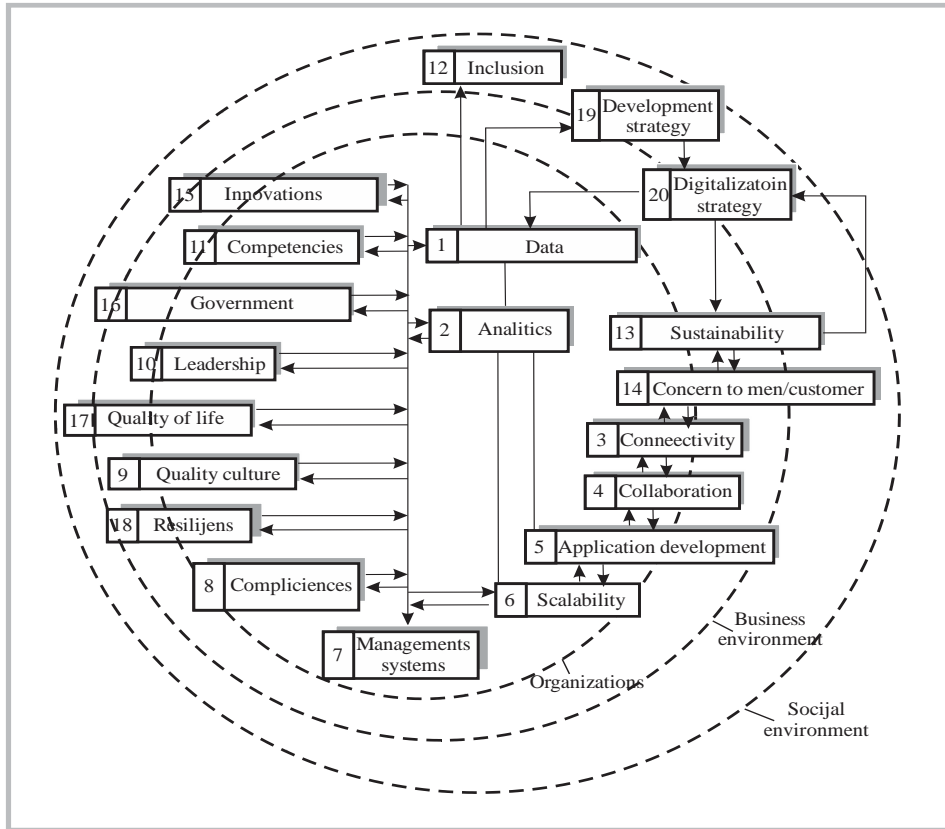
Integration of Quality 4.0 and Quality 5.0 concepts are presented in figure 3.

In purpose to make concept Quaality 5.0 is necessary to integrate Quality 4.0 with external entities. Besides previos described variables (1-11) in Quality 4.0 model and (12-18) in Quality model, in integrated Quality 5.0 (figure 4) are included variables (Arsovski S., 2019):

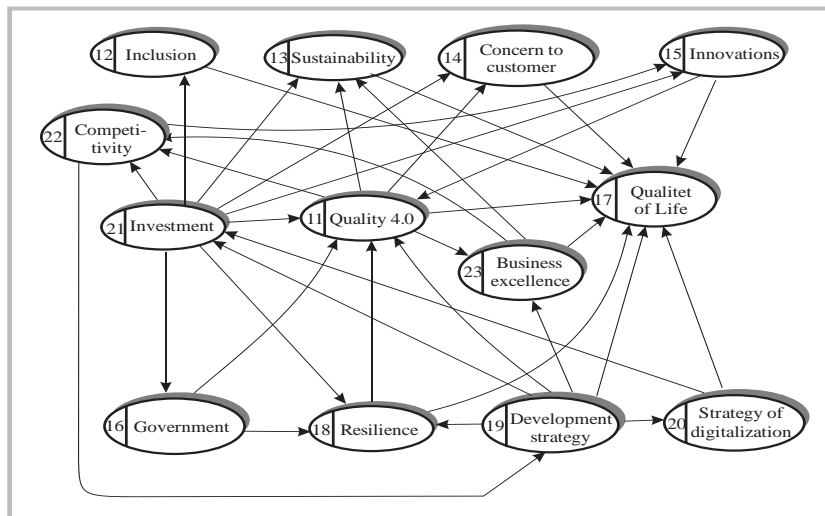
- V19 – strategy of development,
- V20 – strategy of digitalization,
- V21 – level of investment in Quality 5.0,
- V22 – competitiveness level, and
- V23 – level of business excellence.

There are a lot of relations and problem in model testing are data (present low level), its reliability in future and appropriate methods. Proposed solution is to concept national project „Quality 5.0“ to find optimal strategy to transit from existing Quality 2.0/3.0 to Quality 4.0/5.0.

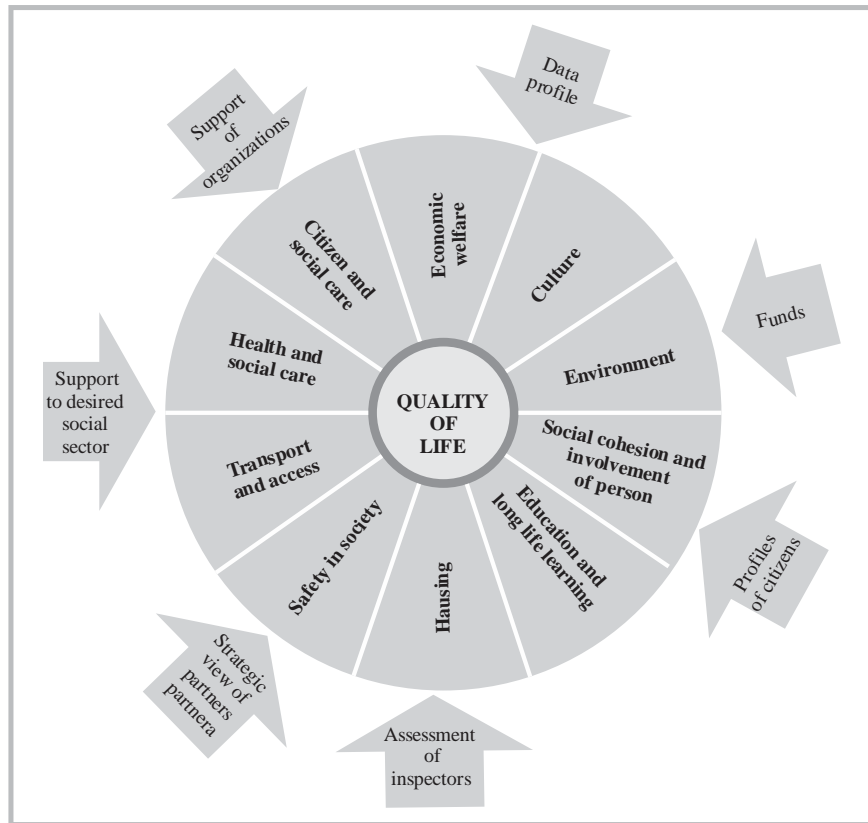
Quality 5.0 is very closely connected to Quality of Life (figure 5).



**Figure 3.** Integration Quality 4.0/Quality 5.0



**Figure 4.** Integrated Quality 5.0 model



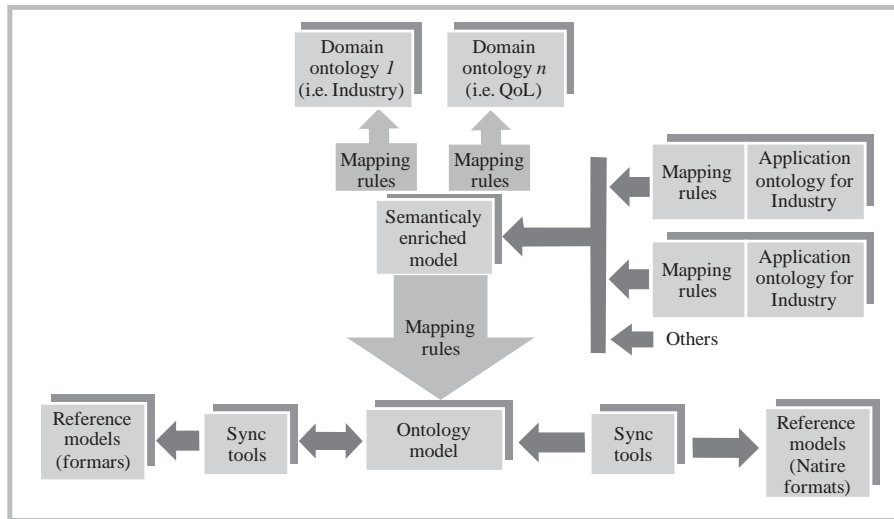
**Figure 5.** Impacts on Quality of Life (QoL)

After analysis elements of Quality 5.0 concept is possible to define appropriate ontology (figure 6), based on Zdravković M. et al. (2011). Each of impacts has different mutual collision. Because that on level of local community is necessary to develop strategy of sustainable community (Arsovski S., 2019).

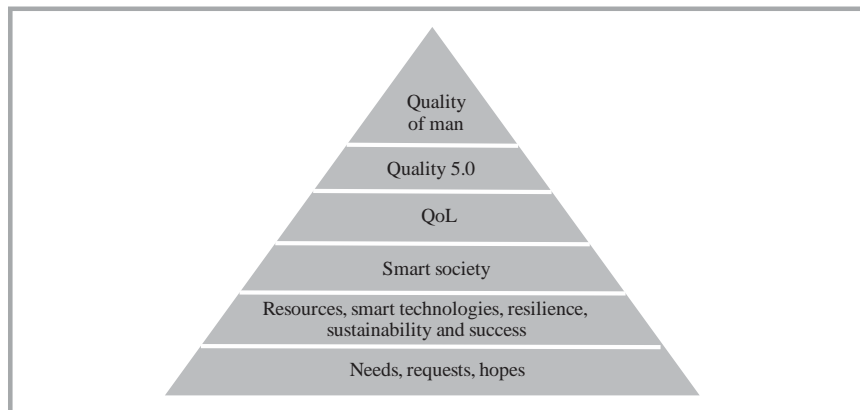
For this framework are crucial domain ontologies and mapping rules, tools and application ontologies for different elements of Quality 5.0, presented through hierarchical model (figure 7).

On the top of pyramid is quality of person, as highest goal of our civilisation. A Quality 5.0 is enabler together with QoL. On lower level is smart society (platinum Society 5.0) based on resources, smart technologies, resilience, sustainability and success of each component of smart society. A base for all are needs, requests and hopes of people.

On this way, this pyramidal model with quality of men is similar with Japan's pyramid of Total Quality Management with men on the top.



**Figure 6.** Framework for semantic environment of reference models for Quality 5.0



**Figure 7.** From human needs to Quality 5.0 and Quality of men

#### 4. Ways to realization of quality 5.0 in Serbia

According to figure 8 the level of quality in Serbia is between low and middle.

This assessment is provided using Delphy method with 15 experts. The average level in Serbia is approximately cca 30% i.e. mixed Quality 2.0, Quality 3.0 and in some cases Quality 4.0. Based on Japan's vision 2050 the process to „Platinum Society“ 2050 with Quality 5.0 consumes a lot of time (cca 30

years) and it is very expensive.

Each component of smart society needs very high investment in purpose to achieve level near assessment 10. For transition society to „Platinum Society 2050“ and Quality 5.0 is necessary in first step to develop vision and strategy for this giga projects which need more than billions of dollars, depend on priorities and constraints for each state. In this moment with respecting cost/benefit analysis is possible to find priorities with best ratio and invest in it (figure 9).

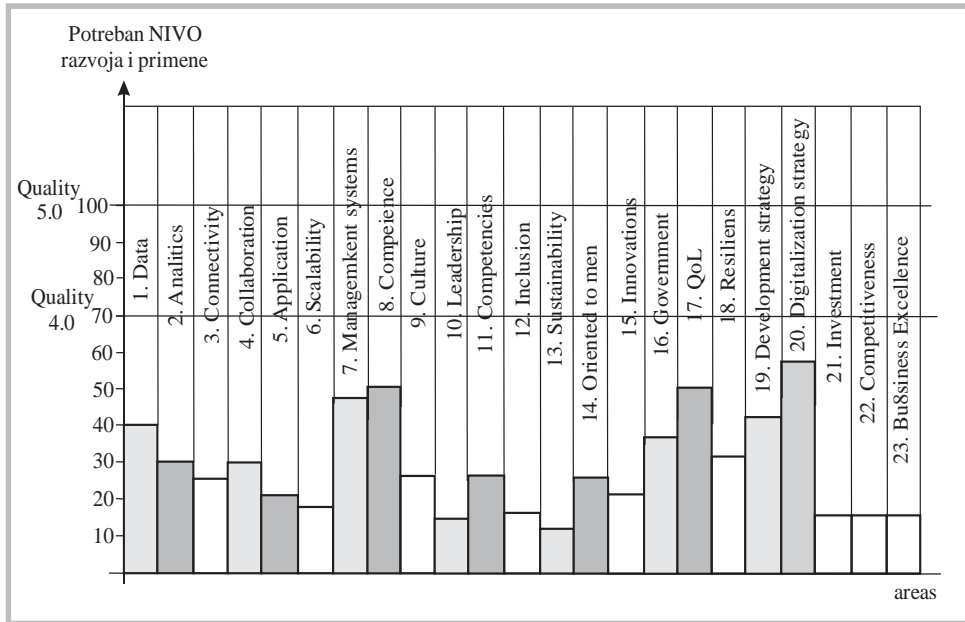


Figure 8. Level of development and introducing elements of Quality 4.0/5.0 in Serbia

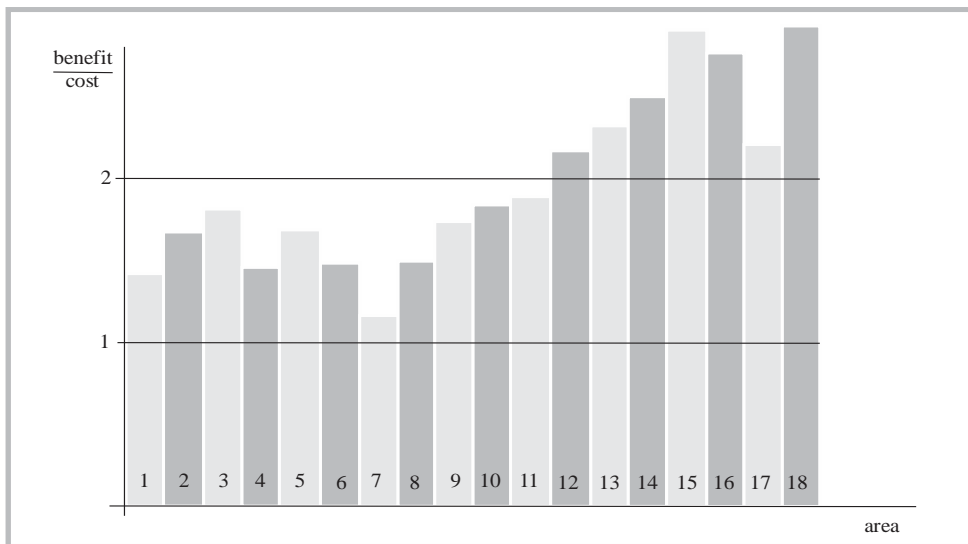
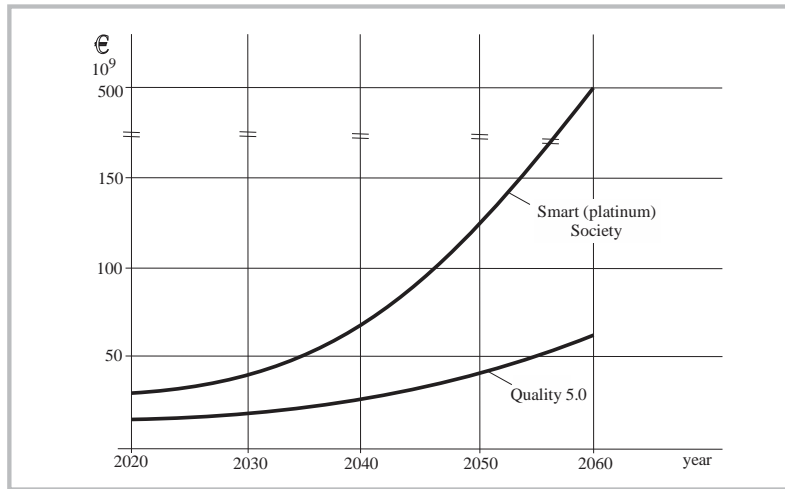


Figure 9. Results of benefit/cost analysis (CBA)

The Quality 5.0 concept is closed with Smart Society (Platinum Society) which also needs huge investment in all 27 areas (Arsovski S., 2020, Smart region of Eastern Serbia, ALPEN TEKIJ, Kragujevac, in Serbia).

Dinamics of introducing new development solutions related to Quality 5.0 and Platinum Society in Serbia is presented in figure 10, as first approximation.





**Figure 10.** Investment in Quality 5.0 and Platinum Society in Serbia

In this approximation for Quality 5.0 according priorities is needs to invest in quality in all 27 components of smart society in Serbia. For this study is not included risks in this long period, especially related to natural, ecological, political, health, and other hazards.

## 5. Conclusion

A Quality 5.0 concept is now reality but it is

partly developed and introduced. Specially for Serbia, it is problem because relative small level of quality and constraints in investments, knowledge and generally human factor. Author proposes strategy according Japan's long range strategy, with close collaboration all stakeholders, especially government, investors, local government, business sector, universities et others.

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## A CONCEPTUAL REVIEW OF DIGITAL TWIN-BASED BUSINESS ECOSYSTEMS IN SUPPLY CHAIN PLANNING

**Abstract:** *In Today's fickle environment, supply chain management has become increasingly delicate and complex. In this context, a well-performed supply chain requires incorporating digitalization into supply chain networks. To fill this gap, the proposed paper aims to provide a better comprehension of prerequisites required when developing a digital twin in manufacturing supply chains, as well as the benefits and service business growth opportunities that are created for different companies by participating in a digital twin business ecosystem, and further the expected benefits for the entire ecosystem. Findings revealed that digital twins in the manufacturing supply chains are changing the way they do business. They offer a range of opportunities to facilitate collaborative environments, data-driven decisions and make business processes more robust. Finally, the paper aims to help academicians and practitioners to have good insight and overview of digital twins into supply chain planning activities and also it can provide insights for businesses regarding the use of digital twins in supply chain planning, helping them to improve their operations and gain a competitive advantage.*

**Keywords:** *Digital twin business- innovation ecosystem- supply chain planning- manufacturing supply chain*

### 1. Introduction

Computerized twins give a few modern openings for item and benefit advancements for fabricating companies, and hence, this innovation is anticipated to alter the product-service offerings of fabricating companies (Tao et al., 2019). Besides, computerized twins are gathered to form modern commerce opportunities for a few companies inside the whole fabricating environment (Oubrahim, Sefiani, & Happonen, 2023). In expansion to the expanded product-service offerings of fabricating companies, modern databased benefit businesses are assumed to seem in, for illustration, arranging, extend

administration, reenactment modeling, visualization, control frameworks, robotization, and information analytics administrations. However, the application ranges and benefit trade concepts related to advanced twins are still within the investigation stage (Ivanov & Dolgui, 2021; Oubrahim, Sefiani, & Happonen, 2022). The later writing surveys on advanced trade biological systems within the fabricating industry, (Huikkola, Kohtamäki, & Ylimäki, 2022) have examined that there exists a require for more empirical-level understanding around the operations of advanced commerce biological systems such that they can dodge both the benefit and digitalization catch 22s. In expansion to

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advanced commerce biological systems, the benefit trade and servitization among the fabricating organizations have been investigated as of late. Indeed, in spite of the fact that there exists an understanding on both advanced trade biological systems and benefit commerce in a computerized trade environment, (Jovanovic, Sjödin, & Parida, 2022) have stated that the inquire about on industrial digital stages is still early. Since all the understanding from B2C setting isn't transferrable to B2B setting and to mechanical advanced stages. (Park et al., 2019) have argued that, for this reason, scholars should pay more consideration to exploring the early stages of the advancement of stage biological systems, for illustration, to get it how stage administration components advance. Concurring to (Huikkola et al., 2022), there's, for occasion, a got to get it how the parts of administrators alter when a conventional advanced arrangement utilizer needs to gotten to be a framework supplier and bad habit versa.

## **2. Background**

### **2.1. Digital twin**

An advanced twin may be a virtual show and comprehensive portrayal of the framework utilized to get it the execution parameters, improve forms, and viably improve value-added activities (Park et al., 2019).

An advanced twin may be a computerized partner of the physical frameworks based on a reenactment that bargains with plan frameworks and optimizes them for moved forward productivity (Guo, Zhao, Sun, & Zhang, 2019). Computerized twin improvement has significant potential in feasible fabricating operations since of its data-rich environment that encourage real-time checking, recreation, and forecast of fabricating forms (Cheng, Zhang, Tao, & Juang, 2020; Oubrahim, Sefiani,

Quattrociochi, & Savastano, 2022). Numerous fabricating organizations have mechanized their generation lines utilizing mechanical frameworks and IoT-based innovations, producing advanced data.

The computerized twin mimics the fabricating environment based on the collected data and makes a difference the proprietor choose between the accessible activities for expanded productivity, superior precision, and economies of scale (Alam & El Saddik, 2017). Cyber physical frameworks have played a basic part in numerous up and coming advances with the improvement of real-time detecting, progressed control, counterfeit insights, and service-oriented fabricating. Savvy fabricating, combined with cyber physical framework improvement, has cleared the street for advanced twin innovation to supply sufficient determination to arrange between the physical world and the virtual world (Alam & El Saddik, 2017; Oubrahim, Sefiani, Happonen, & Savastano, 2022). The interoperability between these developing advances comes about in critical potential for the improvement of compelling stages and applications to screen and control the fabricating frameworks, changing them into maintainable fabricating frameworks (Ahidar, Sarsri, & Sefiani, 2019; Cai, Starly, Cohen, & Lee, 2017).

The existing writing demonstrated that organizations are considered fruitful on the off chance that they can deliver high-quality items assembly client needs and desires with moo fabricating and supply chain costs (Leng et al., 2020). An advanced twin can control generation forms in reaction to the changing showcase needs with tall precision and nimbleness. Computerized twin systems have considered one or more fabricating offices with the center of creating free customized applications, but they need a center on creating a advanced twin as a center mechanical component of the whole framework (Leng et al., 2020). The

computerized change plan of numerous organizations requires overhauls in existing fabricating frameworks to shrewd and brilliantly maintainable fabricating frameworks. A digital supply chain twin is utilized for progressed supply chain modeling based on prescriptive analytics that works in real-time and can decide the correct remedial activity supporting supply chain optimization. The potential of the advanced twin within the supply chains and later advancements in rising advances, such as added substance fabricating, BDA, and IoT, request a survey of existing writing to get it computerized twin components, applications, and challenges.

The advanced twin, combined with the control of huge information analytics, fake insights, and interconnected IoT frameworks, has the potential to open covered up esteem for organizational decision-making (Lu & Xu, 2019). Computerized twin proprietors can foresee operational disappointments, make strides item quality, and diminish downtime (Tao et al., 2018a). The innovation effectively employs nonstop optimization frameworks, which bolsters consolidating the framework and handle parameters amid the generation cycle [15].

Advanced twin innovation offers three noteworthy points of interest. To begin with, it permits existing generation frameworks, forms, and components to be coordinates and made congruous utilizing little gadgets like sensors and application program. Moment, it makes a difference increment efficiency by diminishing blunders and applying predictive maintenance to diminish breaking down. At long last, the generation information of computerized twins is put away within the framework and are utilized for handle optimizations. Simchenko et al. (2020) recommended utilizing computerized twins to map exercises over the whole supply chain. As before long as client orders are entered into the framework, the arrange

points of interest and related exchanges can be captured by the advanced supply chain twin, empowering real-time simulation and decision-making. For case, in case any delays happen within the supply chain due to machine breakdown or supply delays, this data can be sent to the advanced supply chain twin utilizing developing advances such as mechanical IoT gadgets, cloud computing, and enormous information analytics. In this manner, it is fundamental to survey how distinctive Industry 4.0 advances can meet supply chain needs when considering the arrangement of advanced supply chain twin.

The literature uncovered the utilize of different Industry 4.0 advances that are utilized within the computerized supply chain twin design. We recognized IoT, recreation modeling, cyber physical frameworks, machine learning, and fake insights as up-and-coming innovations that can play a noteworthy part in creating advanced supply chain twins.

## 2.2. Digital twin business ecosystems in manufacturing

In later ponders, the part of advanced twins in shrewdly fabricating and related stages has produced a extraordinary bargain of intrigued. He and Bai (2020) [16] propose a nitty gritty system for computerized twin-driven feasible fabricating. They highlight the preferences of advanced twins for expanding insights and maintainability at diverse layers of the generation stage, such as fabricating gear, frameworks, and administrations (He and Bai, Li et al, 2020) contend that advanced twins can successfully interface the gadget layer and arrange layer in fabricating frameworks, hence they play a more successful part in all esteem joins. By coordination divided advanced data, companies can be given with a comprehensive see on, for illustration, items, fabricating, supply chain, client encounter,

and productivity. Be that as it may, fair utilizing computerized twins to upgrade trade victory in fabricating stages isn't sufficient. It is similarly vital to coordinate these empowering advances with the real needs of clients and clients Hannola et al. 2021. Li et al. 2020) have also recommended that companies ought to change from company-centered to user-centered substances to move forward their productivity and adequacy and client involvement. This change is as of now on its way in numerous fabricating companies, which are moving center from a product-centric approach to combined item and benefit offerings, called servitization. Adjusting between the benefit needs of clients and income goals has ended up a central source of competitiveness within the fabricating division. (Cenamor, Rönnerberg Sjödin, & Parida, 2017) have recommended that a stage approach may encourage both customization and operational proficiency by leveraging the esteem of advanced advances to overcome the so-called benefit conundrum. One striking contention in their think about is that a stage approach requests that companies distinguish and characterize modern parts. They too contend that the engineering and stage parts of servitized manufacturers to reinforce understanding of how to form fruitful environments within the fabricating division; all performing artists included ought to know their part and have a unflinching commitment to work collaboratively to use the esteem of shared data (Tao et al., 2019). The selection of modern sorts of parts and endeavors for esteem cocreation and shared interface are among the key prerequisites for an ecosystem-based trade (Oubrahim, Sefiani, Happonen, et al., 2022). (Meierhofer, West, Rapaccini, & Barbieri, 2020) have come to comparable conclusions after analyzing shrewdly mechanical administrations from the angle of their esteem recommendation. They state that producers got to forsake the

part of esteem maker and instep adopt the considering demonstrate of esteem cocreation through client interaction. As famous, advanced twins are a momentous enabler for the development of a benefit trade within the fabricating sector. However, each participating on-screen character will have different jobs and encounter distinctive torments and picks up, each of which is subordinate on the circumstance in address. The so-called commerce system, that's, the requirements of the performing artists within the biological system and the esteem in utilize, ought to be modeled to begin with. As it were at that point will applying an advanced twin arrangement to supply the esteem in utilize be considered as a way of coordinating with 'the actor's problem'. This cultivates cocreation of esteem between distinctive on-screen characters, such as suppliers and clients (Meierhofer et al., 2020). Be that as it may, since ecosystem-based considering is still or maybe a modern marvel in companies, they regularly battle with embracing the prerequisites of an ecosystem-based commerce. A ponder by (Kokkonen et al., 2022) on DBEs found that companies regularly recognize the potential of unused shapes of esteem cocreation, but they as a rule endure from finding ways to arrange participation, and hence, they battle at adapting with interconnectivity, interoperability, and competing interface. In this paper, it is contended that the complementarity of distinctive companies' offerings isn't a prerequisite but or maybe ought to be developed in a shared advancement handle between environment members.

### **3. Findings and discussions**

#### **3.1. Supply chain digital twin**

Conventional supply chains may now not be sufficient within the computerized age. Cutting edge markets advantage not as it

were from supply chain productivity, but too from its nimbleness and adaptability. Nowadays, the supply chain is advancing from a conventional show of straight, person, and no concurrent connections to a more associated and facilitated organize of commerce accomplices. The supply chain is expected to be restored, computerized and able to supply the desired administrations. Subsequently, it must advance through interconnected advanced gadgets and complex systems. This computerized supply chain interfaces distinctive partners (counting clients) more successfully and empowers them to reply speedier and adjust to a quickly changing advertise. Capgemini Counseling clarifies the five measurements of alter as takes after (Ageron, Bentahar, & Gunasekaran, 2020; Oubrahim & Sefiani, 2022).

- 1) Computerized supply chain methodology: The objective is to coordinated computerized developments within the in general supply chain methodology.
- 2) Supply Chain Administration and Operational Show: A particular computerized working demonstrate in which information now not depends on location. Large enterprises working all-inclusive will consider inside coordination committees in more detail.
- 3) Coordinates execution: Executing diverse supply chain capacities is exceptionally imperative. The most objective is to supply forms that give all the data required by representatives.
- 4) Coordinates supply chain execution estimation: This highlight makes it conceivable to track any arrange or exchange through a computerized working demonstrate. When utilizing barcodes or RFID labels, the utilize of labeling advances opens the way to getting real-time

data on physical relocation. A digital twin can be characterized as an energetic virtual representation of a protest or physical framework, utilizing real-time data to get it, learn, and reason. In spite of the fact that its definition changes from source to source, the most thought is to supply an advanced representation of a resource (unmistakable [presence] or intangible [framework]), which employments the Web of Things to get significant information in genuine time. And based on the created demonstrate, how it worked within the past and how it works presently, comes to the conclusion.

### **3.2. The importance of digital twin in supply chain planning**

The advanced twin was created with three fundamental components counting physical item (PP), virtual item (VP) and information trade. Advanced Twin has three vital highlights: synchronization between physical item and virtual item, comprehensive and energetic information collection, and high-quality virtual modeling. These three characteristics play a critical part in managing with arranging challenges. By synchronizing between the physical item and the virtual item, the computerized twin makes strides the speed of operation and responsiveness to decrease obtainment time. Arranging is based on data recovered from chronicled things and each unit within the supply chain. As a rule, there's a noteworthy time slack between target distinguishing proof, information collection, information trade, and execution. Synchronization between the physical item and the virtual item permits data to be shared between each unit and each design within the supply chain in genuine time, which essentially diminishes obtainment time. In expansion,

synchronization between the physical item and the virtual item upgrades the human-machine interaction between the supply chain and engineers. So, engineers can rapidly oversee the supply chain by changing virtual items. By powerfully and comprehensively collecting information, Computerized Twin altogether makes strides estimate exactness. As a rule, information collected from authentic cases are frequently not comprehensive sufficient to completely portray the situations they incorporate and the status of supply chain units or products. In differentiate, Advanced Twin powerfully collects information from different sources. Within the physical product, the advanced twin records real-time information of physical items, situations, comparable items, and administrators. Within the virtual item, the computerized twin extricates information from virtual models and reenactments. Chronicled case information is additionally put away. In expansion, distinctive advanced twins can have connected and trade information with each other, permitting the advanced twin to recover information from other frameworks. Subsequently, this tremendous information makes determining and arranging more exact over a longer period. With tall quality modeling, Computerized Twin improves arranging approval. A key approach to confirming arranging is simulation. Conventional computer program and instruments frequently incorporate insufficient natural components, rules, instruments, and behaviors. In differentiate, the computerized twin models all of this within the virtual item. Hence, the reenactment quality will be made strides, and the arranging confirmation will have less deviations.

### **3.3. Digital Twin-benefits in manufacturing**

Manufacturing is becoming smart at all levels from the physical device, through

factory management, to production networks, gaining abilities to learn, configure and execute with cognitive intelligence. Smart manufacturing is coined by several agencies, such as the Department of Energy (DoE) and the National Institute of Standards and Technology (NIST) in the United States. According to Davis et al., smart manufacturing is the dramatically intensified application of manufacturing intelligence' throughout the manufacturing and supply chain enterprise (Davis, Edgar, Porter, Bernaden, & Sarli, 2012; Iqbal et al., 2021). It comprises the real-time understanding, reasoning, planning and management of all aspects of manufacturing processes, facilitated by the pervasive use of advanced sensor-based data analytics, modeling, and simulation. NIST defines smart manufacturing systems as "fully-integrated, collaborative manufacturing systems that respond in real time to meet changing demands and conditions in the factory, in the supply network, and customer needs" In smart manufacturing, a physical 'thing' in a factory is connected to the Industrial Internet via standard cyber gateways and abstracted as a Digital Twin in the cyberspace. Each Digital Twin in the cyberspace is an abstraction of its counterpart in the physical world by reflecting its physical status. The cyberspace stores and processes the streamed data from connected physical objects. These data are used to model, simulate and predict the status of each physical thing under dynamic working conditions. The pervasive use of smart technologies, such as Big Data Processing and Artificial Intelligence enables the extraction of manufacturing intelligence at every single moment of manufacturing activities. The collective intelligence in locally connected factories and the cyberspace paves the way for some dramatic changes from the aspects of intra-business operation, inter-business collaboration and production model,



- **Smart Production:** Manufacturing systems augmented with cognitive intelligence (Amjad, Rafique, & Khan, 2021; Oubrahim et al., 2023) can take over more and more production jobs. Connected and self-organizing manufacturing systems will tackle new manufacturing tasks with high efficiency and flexibility. The relationship between humans and machines will also change; one direction is a factory will become fully-immersed human-machine collaboration space (Oubrahim, Sefiani, Quattrociochi, et al., 2022).
- **Smart Production Network:** Connected cyber-physical production systems will form a global production network that can respond in almost real-time to dynamic changes in local production systems and external supply chain (Bauer, Wollherr, & Buss, 2008). A production network of adaptive and self-optimizing production systems can enable autonomous configuration and planning of production activities for production jobs at changing scales to achieve sound economic, environmental and social impacts.
- **Mass Personalization:** Production model will move from a push type mass production model to pull-type mass personalization (Alfaro-Saiz, Bas, Giner-Bosch, Rodríguez-Rodríguez, & Verdecho, 2020; Li & Mathiyazhagan, 2018).

Smart factories that are fully responsive to changes and demands from the factory, supply chain, and customer side can achieve batchsize-of-1 production with high efficiency and flexibility. The ubiquitous manufacturing intelligence in distributed factories and production systems can sense,

configure and collaborate by themselves based on near real-time production status and demands, which therefore provides the required agility for producing highly personalized products.

#### 4. Conclusion

In conclusion, the paper emphasizes the importance of digitalization in the context of supply chain management and highlights the benefits of incorporating digital twins in manufacturing supply chains. The study identifies key prerequisites required for the successful development of digital twins, including data quality, system integration, and effective communication among stakeholders. By enabling companies to monitor and analyze their operations in real-time, digital twins can facilitate data-driven decision-making, improve efficiency, reduce costs, and enhance supply chain resilience. Moreover, the study shows that digital twins can create significant growth opportunities for companies through increased collaboration and the development of new service business models. The paper also emphasizes the importance of building a digital twin ecosystem to maximize the benefits of this technology. A digital twin ecosystem involves a network of companies and stakeholders that work together to develop and implement digital twins in their operations. This approach allows companies to share data and collaborate more effectively, leading to improved supply chain visibility, better decision-making, and increased efficiency. Furthermore, the study identifies several benefits of a digital twin ecosystem, including reduced risk, improved innovation, and the development of new business opportunities.

Overall, the paper provides valuable insights for academicians, practitioners, and businesses seeking to improve their supply chain operations through the use of digital twins. By highlighting the prerequisites for

successful digital twin development, the study helps companies to better understand the challenges and opportunities associated with this technology. Additionally, the paper emphasizes the benefits of a digital twin ecosystem and provides guidance on how to develop such an ecosystem. Ultimately, the

study demonstrates that digital twins are a powerful tool for improving supply chain efficiency, reducing costs, and enhancing competitiveness, and that companies that embrace this technology can gain a significant advantage in today's fickle and complex business environment.

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Miloš Jelić

## STRATEGIC DECISION-MAKING OF ORGANIZATION IN VOLATILE BUSINESS ENVIRONMENT

**Abstract:** *Organizational strategy provides the road map for every organization and ensures that decisions concerning the future are taken in a systematic and purposeful way. Strategic decisions are never simple to make. On one hand, biases in company decisions cannot be avoided since they are inherent to human nature which is mainly resistant to feedback. On the other hand, uncertain environment requires an organization to develop mechanisms to understand future scenarios and manage strategic risk. The paper deals with hazards and threats exerted on nowadays organizations that may generate their vulnerability. To mitigate vulnerability some strategic approaches are proposed as a response to challenges for World crisis that will perpetuate in coming years.*

**Keywords:** *strategy, management, uncertainty, quality, business excellence*

### 1. Introduction

Strategy has been dealt with by military people since Middle Ages thus first prescriptions concerning business strategy originate with military tests. However, in most contemporary business schools students are directed to study *business policy* by getting acquainted with scores of case studies elaborating the situations encountered in real business. By this heuristic approach students are trained specific circumstances of a company and consequently derive practicable solutions.

However, late 1960s emerged a systematic and analytic approach to strategy formulation and implementation. These analytical approaches to strategy strongly rely on the assumption that what occurred in the past is strongly connected with what might happen in the future.

In 1980s strategy frequently leans on the adoption of a set of ‘best practices’ what

may be regarded as a reflection of emerging business excellence. The idea was not to copy the solution from a company that made it excellent but to transpose some practices that might contribute to better results in own company. (Jelić, 2009)

Today’s corporate world is in the process of a global transformation. Acquisitions, mergers, downsizing and outsourcing are becoming common around the world. Strategic management takes a panoramic view of such chaining corporate landscape to show how big and small companies can become more efficient and effective in the years that come.

Strategic management consists of the set of managerial decisions and actions aimed to pave the way for the successful company performance in the long term. It encompasses environmental scanning, strategy formulation, strategy implementation, evaluation and control.

Strategic management provides the route map for the organization. It furnishes a framework to ensure that decisions concerning the future are taken in a systematic and intentional way. In addition, strategic management plays a major role as a hedge against uncertainty, i.e. a hedge against totally unexpected developments on the business horizon.

## 2. Strategy embracing uncertainty

A capital challenge of strategy facing uncertainty is to make choice instantly but the payoff takes place in future environment that is quite vague. A critical step in embracing uncertainty is to define exactly what variety is faced.

### 2.1. Bias at strategy setting

One of the problems may be found in unintentional fuzzy thinking. Behavioral economists have marked many brain characteristics that are strengths in our personal environment but can have negative effects in decision making process. They include overoptimism (tendency to hope the best and excessively believe in own forecasts or abilities), loss aversion (be emphasized on avoiding down-sides and escaping worth taking risks), anchoring (regarding own valuation of something to an arbitrary reference point), herding (feeling comfortable in following the crowd), the confirmation bias (overweighting statements that validate management opinion), and the champion bias (giving merit to an idea based on the person who proposes it).

Strategy is particularly susceptible to faulty logic since it relies on extrapolating ways to achieve success in the future from a complex set of factors recorded today. The two problems frequently encountered are attribution error and survivorship bias. Attribution error denotes the false attribution of success to observed factors, grounded on assumption that replicating the actions of

another company lead to similar results. Survivorship bias refers to an analysis based on surviving population, without reference to those who did not live to tell their view. This approach sees what caused success neglecting insight what might cause failure. (Lovallo&Sibony, 2006)

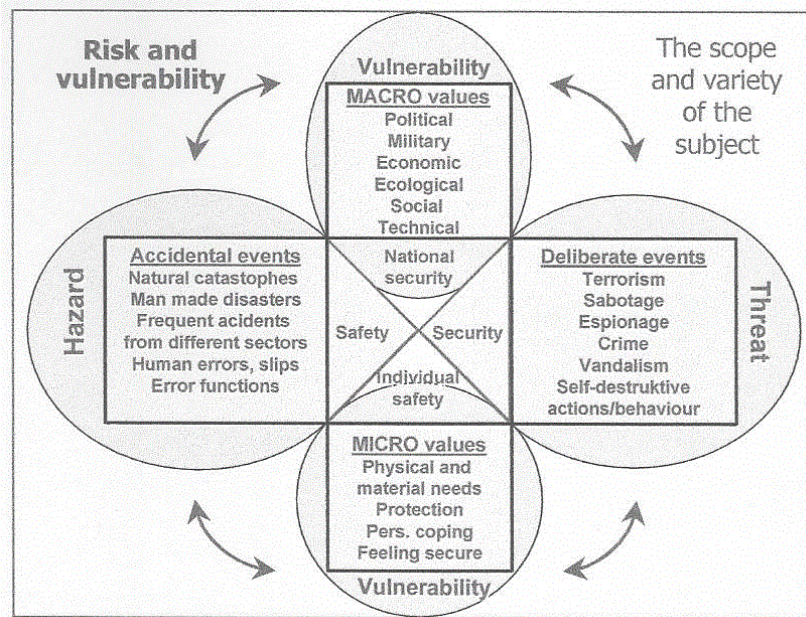
### 2.2. Risk at strategy setting

Eversince Aristotle who said: "It is probable that improbable will happen" dealing with risk and vulnerability issues have remained with many open questions. The new technological, nuclear, chemical and ecological, biologic, and genetic risks, along with political and social risks, such as terrorism, are difficult to separate and determine in time and space and to explain with the rules of causality to be able to compensate and to insure such risks, (Beck, 1992).

Figure 1 shows full variety of the subject. The vertical axis gives the links between international, national, local, and individual stressors at various levels. The key challenge is to coordinate information between the levels and vulnerability management systems. The horizontal axis shows that the field covers from natural events, accidentally man-made, technologically induced disasters to deliberate, malicious acts against others. Social vulnerability usually refers to problems linked to survival and recovery of vital societal functions, i.e. threats to infrastructures, energy supplies, and ICT (Hovden, 2004).

The dichotomy between natural scientific objectivism and cultural relativism can be paraphrased as follows (Lupton, 1999):

- Racionalist – One who sees risk as real world phenomena to be measured and estimated by statistics and controlled by scientific management.
- Realist – One who sees risk as objective hazards or threats that exist and can be



**Figure 1.** The vertical macro-micro perspective on risk management combined with types of hazards, threats, and events (Hovden, 1998)

estimated independently of social and cultural processes but may be distorted through social and cultural frameworks of interpretation.

**Constructionist** – One who sees nothing at risk in itself. What other sees as a risk the constructionist sees as a product of historically, socially, and politically contingent ways of seeing.

Middle positions lies between realist and constructivist theory. The proponents see risk as an objective hazard or threat that is inevitably mediated through social and cultural processes and can never be known if isolated from these processes.

### 2.3. Risk management strategies

To deal with the features of distinct risk types three combined risk management strategies are proposed (Klinke&Renn, 2001):

- Risk informed management strategies,
- Resilience based strategies,
- Discursive management strategies.

Risk informed management puts the stress on scientific assessment, reduction of exposure/ probabilities, risk management according to expected values on risks and benefits, and reliance on inspections and audits. Ostensibly, it may be used where there is sufficient knowledge of key parameters.

Resilience based management is characterized by an emphasis on transdisciplinary research and investigations, the containment of application (in time and space), constant monitoring, redundancy and diversity in safety design, firm liability and zero tolerance policy for risk control. This approach is used where high uncertainty or ignorance rate is encountered.

Discourse based management mainly focuses on reaching political consensus, the importance of procedure or transparency, the establishment of trust-generating institutions, the involvement of stakeholders, and public participation. Such approach is convenient for situations characterised by high ambiguity.

### **3. Levels of uncertainty**

Making right strategic decision under uncertainty cannot be obtained by applying a set of powerful analytical tools that is used in traditional approach to strategy. When the future is undoubtedly uncertain the traditional approach may lead to strategies that neither defend organizations against the threats nor may take advantage that higher levels of uncertainty may offer.

The uncertainty that remains after thorough analysis can be regarded as residual uncertainty. The residual uncertainty may have rates in a wide range but it is common to classify in one of four broad levels. (Courtney et al, 2005)

**Level I:** At this level, residual uncertainty is practically negligible, and managers are able to define their strategy based on one prediction. Although every business environment inherently carries elements of uncertainty, predictions are enough to guide strategy in one direction. To help generate this usefully precise prediction of the future, managers can use the standard strategy tool kit: market research, analyses of competitors' costs and capacity, value chain analysis. This level can be called the level of clear enough future.

**Level II:** Here, the future is viewed through several separate scenarios that can be played out. The analysis cannot determine which scenario will unfold, but it is significant if the probability of certain scenarios unfolding can be determined. In that case, usually the degree of elaboration of each alternative scenario is proportional to the probability of

its unfolding. For example, if a competitor opens a new capacity, it is likely to affect the price and placement of an organization's products.

Here, managers must develop a set of discrete scenarios based on their understanding of how the key residual uncertainties might play out. Each scenario may require a different valuation model. Getting information that helps establish the relative probabilities of the alternative outcomes should be a high priority. After establishing an appropriate valuation model for—and determining the probability of—each possible outcome, the risks and returns of alternative strategies can be evaluated with a classic decision analysis framework. Therefore, this level may be referred to as the alternative futures level.

**Level III:** At this level there is an area of possible development of the situation. That area is defined by a number of key variables, but the actual outcome can be found anywhere along that continuum. A lot of development strategies are at this level, for example: profit from new technologies, market share with a new product, companies entering new geographic markets, etc.

The analysis in level three is similar to that in level two: a set of scenarios describing alternative future outcomes must be identified, and analysis should focus on the trigger events indicating that the market is moving toward one or another scenario. Developing a meaningful set of scenarios, however, is less straightforward in level three. Scenarios that describe the extreme points in the range of possible outcomes are often relatively easy to develop but rarely provide much concrete guidance for current strategic decisions. Since there are no other natural discrete scenarios in level three, deciding which possible outcomes should be fully developed into alternative scenarios is a highly creative work. Establishing the range of scenarios should allow managers to decide how robust their strategies are as well



as to identify likely winners and losers. Complying above elaboration may be marked as a range of futures.

Level IV: At the last level of uncertainty, the number of dimensions of uncertainty creates such an environment that is impossible to predict. Here, it is impossible to predict the range of possible outcomes, let alone the scenarios within the field of possible events. Such situations are quite rare and they are related to politically unstable countries or to the appearance on the market of completely unknown technologies.

Situation analysis at level four is highly qualitative. Still, it is critical to avoid the urge to throw up your hands and act purely on instinct. Instead, managers need to catalog systematically what they know and what it is possible to know. Even if it is impossible to develop a meaningful set of probable, or even possible, outcomes, managers can gain a valuable strategic perspective. Usually, they can identify at least a subset of the variables determining how the market will evolve over time. They can also identify favorable and unfavorable indicators of these variables—indicators that will let them track the market's evolution over time and adapt their strategy as new information becomes available. Fortunately, level IV situations ordinarily does not last too much and turn to level III, and even level II, as soon as the environment begins to stabilize.

#### 4. Strategic responses in volatile business environment

After the outbreak of the global crises (the pandemic, the war in Ukraine), classic approaches to organizational strategy and modalities for their implementation can no longer be effective. Therefore, organizations shall incline to new strategies that will match the environment of highly elevated uncertainty. Some specific strategic governances are suggested by

*McKinsey & Company, 2023.*

- **Increasing speed, strengthening resilience** Volatility is a feature, not a bug in today's organizations. However, surveys show that half of companies declare to be unprepared to react to future shocks. Hence, those able to bounce forward may gain significant advantage over others. To be able to do so requires organizing for speed of response, giving power to the people, and developing a culture of continuous learning.

- **The new balance of in-person and remote work**

Since the pandemic, vast majority of organizations have embraced a range of hybrid work models that allow employees to work remotely from off-site locations (including home) for some or much of the time. The key issue for organizations was to provide structure and support around the activities best done in person or remotely. By remaining fully open to options for how, when, and where employees work, including with a reset of performance expectations, "true hybrid" organizations can distinguish themselves as destination workspaces.

- **Making way for applied AI**

Artificial intelligence doesn't just have the potential to supercharge a company's operations; it can also be used to build better organizations. Companies are already using artificial intelligence to create sustainable, long-term talent pipelines; drastically improve ways of working; and make faster, data driven structural changes to their organizations. As organizations embrace the opportunities offered by artificial intelligence, they need to focus on embedding its use in corporate culture, and being thoughtful about artificial intelligence-related risks and ethical concerns.

- **New rules of attraction, retention, and attrition**

People are revising their attitudes both toward work and at work. Employees who quit say it isn't just money, work-life

balance, professional development, or purpose that will bring them back to work in 2023: it's a combination of all those things. Organizations can respond by tailoring employee value propositions to individualized preferences in ways that can help close the gap between what today's workers want and what companies need.

• **Closing the capability gap**

Companies across sectors often announce technological or digital elements in their strategies without necessarily having the right capabilities in place to integrate them. To achieve a competitive advantage, organizations need to build institutional capabilities—that is, an integrated set of people, processes, and technology that creates value by enabling an organization to do something consistently better than its competitors do. That means filling gaps in their core activities, which are often the result of insufficient resources or inconsistent commitment.

• **Walking the talent tightrope**

Business leaders have long walked a talent tightrope—carefully balancing budgets while retaining key people. In today's uncertain economic climate, organizations need to focus more on finding ways to match top talent to the highest-value roles. The idea isn't new, but it's the right one in this era of hybrid work models, increased employee mobility, and skill shortages.

• **Leadership that is self-aware and inspiring**

Many organizations are focusing on diversity, equity, and inclusion (DEI), but in many cases, the initiatives aren't translating into meaningful progress. What's often missing is a clear link between DEI strategy and the business strategy. One path forward is for leaders to be more systematic early on, considering the objectives and desired level of impact from their programs. To realize DEI aspirations, leaders will need to identify opportunities for making progress within

their organizations, as well as for improving their external communities and society.

• **Mental health: Investing in a portfolio of interventions**

Roughly 90% of organizations around the world offer some form of well-being program. But global health and well-being scores remain poor, despite well-intended interventions. Research highlights the link between reports of poor mental health and wellbeing and organizational issues, including attrition, absenteeism, lower engagement, and decreased productivity. In current business environment, organizations need to refocus their efforts on addressing the root causes of mental-health and wellbeing challenges in a systematic way.

• **Efficiency reloaded**

In today's uncertain business climate, companies are refocusing attention on efficiency measures among key organizational priorities. Boosting efficiency is about more than managing immediate crises or getting the same work done with fewer resources. Deploying resources more effectively to where they matter the most promises substantial benefits, including improved organizational health, higher shareholder returns, and better and faster decisions.

## 5. Conclusion

Rising interest rates, high inflation, low unemployment, supply chain concerns, elevated commodity prices, low consumer sentiment, and febrile geopolitics are among factors leading to financial and economic volatility—and deepening uncertainty for company strategists. Company decision makers are to take actions that will provide it to remain successful.

The company is to use objective fact base to uncover opportunities for improvement. The more organization is committed to use facts to assess maximum benefits from changes,

the more confidence managers will have in pursuing ambitious goals.

Communicating a compelling reason why strategy changes are inevitable. Role modeling, developing talent and skills, and fostering understanding is the manner to assure people to stay on board.

Finally, to remain succesful in the volatile world the organization has to take care that the company's best talent is matched to company's crutial initiatives. Once business and talent priorities are fully in line the organization will have ability to deliver value generated in the company.

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## BUSINESS PROCESS IMPROVEMENT. IMPROVEMENT OF INTERNAL CERTIFICATION PROCESSES

**Abstract:** *The purpose of this paper is to expose the processes which are important to run into the organizations.*

*Consumers around the world increasingly demand products and services that are simultaneously good for the economy, for the environment, and for society — the triple bottom line of sustainable growth.*

*Based on your existing systems, the Sustainable organization certificate demonstrates that you have implemented and documented processes with some elements of international standards (ISO 14001 and ISO 27001).*

*A Sustainable organization implements sustainability strategies that provide them with economic and cultural benefits attained through environmental and social responsibility and intensive care for employees. This rising demand is creating new pathways for businesses and governments to drive change for the global good. Developed countries are also home to sophisticated consumers whose choices drive business decisions worldwide and are increasingly aware of the triple bottom line of sustainable growth.*

**Keywords:** *Keywords: process, improvement, standards, certificates, method of work, guidelines, board*

### 1. Introduction

Processes play a crucial role in organizations at they provide structure, efficiency and consistency in carrying out tasks and achieving organizational objectives. Overall, processes are essential for organizations to operate efficiently, achieve their goals, maintain consistency, manage risks, and adapt to changing environments. By establishing effective processes organizations can enhance their performance, customer and employee satisfaction and long-term success. Arabi, M. 2007.

Among some essential roles that processes

fulfil in organizations are Efficiency and Productivity, Consistency and Quality, Clarity and Accountability, Risk management and Compliance, Scalability and Growth, Continuous Improvement, Customer Satisfaction, Decision Making and Agility and Knowledge Management. Dowey, J. (1929). Introduction.

Efficiency and productivity help streamline workflows and eliminate unnecessary steps or bottlenecks, leading to improved efficiency and productivity. Well-designed processes ensure that tasks are completed in a standardized and optimized manner, reducing wasted time, effort and resources.

Consistency and quality establish

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standardized procedures and guidelines for performing tasks, ensuring consistency and quality in the organization's outputs. By following established processes, employees can consistently deliver products or services that meet or exceed customer expectations.

Clarity and accountability provide clarity on roles, responsibilities and the sequence of activities required to accomplish specific tasks. This helps employees understand their responsibilities and be accountable for their work. Schoorman, F.D., Mayer, R.C., & Davis, J.H. (2007). Clear processes also facilitate effective coordination and collaboration among team members.

Risk management and compliance processes enable organizations to manage risks and ensure compliance with legal, regulatory and industry requirements. Processes can include checks, controls and approvals that help mitigate risks, ensure data security and adhere to relevant standards or regulations.

Well defined processes lay the foundation for scalability and growth within organizations. As the organization expands, processes can be replicated or modified to accommodate increased workloads, additional departments or new business units. Standardized processes also facilitate knowledge transfer and onboarding of new employees.

Continuous Improvement processes provide a framework for continuous improvement and learning within organizations. By monitoring and analysing process performance, organizations can identify areas for improvement, implement changes and optimize their operations over time. This continuous improvement mindset fosters innovation and enhances the organization's competitiveness.

Customer satisfaction processes directly impact customer satisfaction by ensuring consistent delivery of high-quality products or services. Well-designed processes consider customer needs, preferences and

feedback, allowing organizations to meet or exceed customer expectations. Customer-centric processes contribute to enhanced customer loyalty and positive brand reputation. Stephenson, K. (1998).

Decision making and agility processes provide valuable information and insights for decision making. By capturing data, metrics and feedback related to processes organizations can make informed decisions, identify areas requiring attention and allocate resources effectively. Flexible processes also enable organizations to adapt quickly to changing market conditions or internal dynamics.

Knowledge management serves as a mechanism for capturing and sharing knowledge within organizations. They facilitate the transfer of best practices, lessons learned and expertise among employees, ensuring that valuable institutional knowledge is preserved and leveraged. This promotes learning, innovation and knowledge continuity.

## **2. The organization and its basic composition**

Organizations often consist of various departments or functional units, each with its own specific role and responsibilities. The specific departments within an organization can vary depending on its size, industry, and structure.

It's important to note that the specific departments can vary significantly depending on the organization's industry, size and structure. Some organizations may have additional departments specific to their sector, such as a healthcare organization having a medical services department or a retail organization having a merchandising department, military offices have some defence departments etc.

We will introduce some common departments found in many organizations:

- 1) Human Resources (HR): The HR department handles matters related to recruitment, hiring, onboarding, training, performance management, employee relations, compensation and benefits, and overall workforce management.
- 2) Finance and Accounting: The finance department is responsible for managing the organization's financial resources, including financial planning, budgeting, financial reporting, accounts payable and receivable, payroll, and financial analysis.
- 3) Operations or Production: The operations department oversees the organization's core activities, such as manufacturing, production, service delivery, and process optimization. It ensures that products or services are delivered efficiently and in line with quality standards.
- 4) Marketing and Sales: The marketing and sales department is responsible for promoting the organization's products or services, conducting market research, developing marketing strategies, managing advertising and promotional campaigns, and handling sales activities to generate revenue. Bosh, T. 2013.
- 5) Information Technology (IT): The IT department manages the organization's technology infrastructure, including computer systems, networks, software applications, data management, cybersecurity, and IT support for employees.
- 6) Research and development (R&D): The R&D department focuses on innovation and new product development. It conducts research, experiments, and analysis to drive product improvements, explore new technologies, and stay ahead of market trends.
- 7) Customer Service: The customer service department handles inquiries, complaints, and support requests from customers. It plays a crucial role in maintaining positive customer relationships and ensuring customer satisfaction.
- 8) Administration or Operations Support: The administration department provides support services to the organization, including facilities management, office administration, procurement, logistics, and administrative support to various departments.
- 9) Legal and Compliance: The legal department ensures that the organization operates in compliance with relevant laws and regulations. Keil, F. C. (1989)., It handles legal matters, contract management, intellectual property protection and risk management.
- 10) Strategic Planning or Business Development: This department is responsible for long-term strategic planning, market analysis, identifying growth opportunities, mergers and acquisitions, partnerships, and overall business development.

### **3. What basic processes are carried out within the organization regardless of its composition**

In general, organizations consist of various processes that help them function and achieve their goals effectively. Here are some basic processes commonly found in organizations, but there's also some specific

processes and their implementation may vary depending on the nature, size, and industry of the organization.

**Communication:** Effective communication is essential for coordination, collaboration and sharing information within an organization. This process involves exchanging messages, ideas, and feedback through various channels such as meetings, emails, phone calls, and digital communication tools.

**Decision Making:** Decision-making processes involve analysing information, evaluating options, and choosing the best course of action to address organizational challenges or opportunities. Decision making can be hierarchical, where decisions are made by higher level authorities, or participatory, involving input from multiple stakeholders.

**Planning:** Planning involves setting goals, defining strategies, and developing action plans to achieve desired outcomes. It includes assessing the current situation, identifying priorities, allocating resources, and establishing timelines. Planning helps organizations anticipate future needs and align efforts towards achieving objectives.

**Organizational Structure:** This process involves designing the organizational structure, which determines how tasks, responsibilities and authority are distributed within the organization. It includes defining reporting lines, establishing departments or functional units and specifying roles and responsibilities.

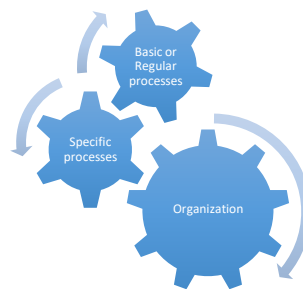
**Human Resource Management:** Human resources processes involve activities related to managing and developing an organization's workforce. This includes recruitment, selection, training, performance evaluation, compensation and employee development. Human resources processes ensure that the organization has the right with the right skills to achieve its objectives.

**Operational Processes:** These processes are directly related to the organization's core

activities or production of goods and services. They may include manufacturing processes, service delivery processes, quality control, supply chain management and customer relationship management. Operational processes are specific to the nature of the organization's industry or sector.

**Monitoring and Evaluation:** Organizations need processes to monitor and evaluate their performance and progress towards their goals. This includes setting performance indicators, collecting data, analysing results and making necessary adjustments to improve performance. Monitoring and evaluation processes help organizations measure success, identify areas for improvement and make informed decisions.

**Continuous improvement:** Organizations should have processes in place to foster a culture of continuous improvement. This involves identifying opportunities for innovation, gathering feedback from stakeholders and implementing changes to enhance efficiency, quality and effectiveness.



**Figure 1.** Processes in organization

#### **4. The importance of knowledge in organization**

Knowledge plays a vital role in organizations and is considered a valuable asset. To effectively harness knowledge, organizations often implement knowledge



management practices, including knowledge sharing platforms, communities of practice, training programs, and knowledge documentation. By valuing and leveraging knowledge, organizations can enhance their performance, drive innovation and remain competitive in dynamic business environments. Among reasons why knowledge is important in organizations is: Decision Making where knowledge provides the foundation for decision making. It enables organizations to make better choices by drawing on insights, expertise and lessons learned from past experiences. Knowledge helps in evaluating alternatives, assessing risks, and considering various perspectives before making strategic or operational

decisions. On the other hand with knowledge we can solving problems. Organizations face numerous challenges and problems on a regular basis. Knowledge equips employees with the necessary information and expertise to identify, analyse and solve problems effectively. We can also prove that sharing knowledge within teams and departments enhances problem-solving capabilities and accelerates the resolution of issues. Of course we can approve that innovation and adaption is essential for fostering and driving organizational growth. By leveraging existing knowledge and encouraging the generation of new ideas, organizations can develop innovative products, services and processes. Rezayian, A. 2005.



**Figure 2.** Competitive advantage

Knowledge also enables organization to adapt to changing market conditions, technological advancements and customer preferences. Knowledge Is also a key driver of learning and development within organizations. By sharing knowledge and providing access to resources, organizations empower their employees to acquire new skills, expand their knowledge base and continuously improve their performance. This fosters a culture of learning, growth and professional development.

Knowledge is also a sticker for collaborations and teamwork. That means when employees have access to relevant knowledge and expertise they can collaborate more effectively share ideas and work together towards common goals. The enhances productivity, creativity and overall

team performance. Results shows that's organizations with knowledge has competitive advantage and effectively manage and leverage their knowledge and make strategic decisions that differentiate them from competitors. Is allows them to innovate, deliver superior products or services and create unique value capturing valuable propositions. Novak, J. (2009)

Most of leaders know that the organization is good as the people it keeps. Knowledge serves as the organizational memory, capturing valuable insights, lessons and experiences. By preserving and sharing knowledge, organizations avoid reinventing the wheel and benefit from past success and failures. This knowledge continuity ensures that valuable expertise and institutional knowledge are retained even when

individual employees leave the organization. Allen, T.d. (2003).

With all these knowledge components organization is on the highest level in customers eyes. Why? Because make customer satisfaction. Knowledge about customer's needs, preferences and feedback is crucial for delivering personalized and satisfactory experience. By leveraging customer knowledge, organizations can tailor their products, services and interactions to meet customer expectations. Robbinz, S. 2012. This leads them to higher customer satisfaction, loyalty and positive brand reputation. What else an organization need?

### **5. Creating a knowledge map in the organization as part of business process improvement**

In today's fast-paced business world, organizations are constantly seeking to improve their processes and increase their competitiveness. One area that has gained significant attention in recent years is knowledge management. Knowledge is recognized as a critical asset for organizations, and effective management of knowledge can lead to significant benefits such as increased innovation, reduced costs, and improved decision-making. One way to manage knowledge effectively is to create a knowledge map in the organization as part of business process improvement.

Creating a knowledge map in the organization as part of business process improvement is a crucial step towards achieving success in any organization. A knowledge map is a visual representation of the knowledge assets of an organization, including the people, processes, and technology that support the organization's goals. It helps to identify the knowledge gaps and opportunities for improvement in the organization's business processes.

A knowledge map is a visual representation of an organization's knowledge assets and how they are connected. It provides a comprehensive overview of the knowledge resources available within the organization, the locations where they are stored, and how they are used. A knowledge map can be used to identify gaps in knowledge, redundancies, and areas where knowledge is not being effectively utilized. It can also help identify potential areas for improvement and provide a framework for knowledge sharing and collaboration.

The process of creating a knowledge map involves several steps. The first step is to identify the knowledge assets within the organization. This includes both explicit knowledge, such as documents, reports, and databases, and tacit knowledge, such as skills, expertise, and experience. Keil, F. C. (1989). Once the knowledge assets have been identified, the next step is to map them. This involves creating a visual representation of the knowledge assets and how they are connected. The knowledge map can be created using a variety of tools, such as mind mapping software, concept mapping software, or even a simple spreadsheet.

After the knowledge map has been created, it can be used to identify areas for improvement. For example, the map may reveal that there are redundancies in certain areas or that certain knowledge assets are not being effectively utilized. This information can be used to develop strategies to address these issues and improve knowledge management within the organization. The knowledge map can also be used to identify areas where collaboration and knowledge sharing could be improved. By creating a framework for knowledge sharing, the organization can leverage its collective knowledge to drive innovation and improve decision-making.

Creating a knowledge map in the organization as part of business process improvement is a valuable tool for effective

knowledge management. It provides a visual representation of the organization's knowledge assets and how they are connected and can be used to identify areas for improvement and develop strategies for knowledge sharing and collaboration. The use of a knowledge map can lead to significant benefits for organizations, including increased innovation, reduced costs, and improved decision-making.

In addition to the benefits mentioned previously, creating a knowledge map can also help facilitate knowledge transfer during employee turnover or succession planning. It can also assist in identifying key knowledge experts within an organization and their specific areas of expertise.

The process of creating a knowledge map typically involves several steps. The first step is to identify the knowledge assets within the organization, including both explicit and tacit knowledge. This can be done through interviews, surveys, and other data collection methods.

The next step is to organize the knowledge assets into categories and subcategories based on their relevance and importance to the organization. This can be done using a variety of methods, such as mind maps or hierarchical diagrams.

Once the knowledge assets are organized, the next step is to identify the relationships between them. This can be done by mapping the connections between different knowledge assets, such as identifying which pieces of knowledge are required to understand others.

Joseph D. Novak's book, *Learning, Creating, and Using Knowledge: Concept Maps as Facilitative Tools in Schools and Corporations*, provides a comprehensive guide to using concept maps as a tool for knowledge mapping. Novak argues that concept maps are an effective way to organize and represent knowledge, as they allow individuals to visualize complex

relationships between different concepts.

In the book, Novak provides detailed instructions on how to create concept maps, including tips on selecting appropriate concepts, creating meaningful links between them, and using visual cues to enhance understanding. He also discusses the use of concept maps in educational settings, noting that they can be used to improve student learning and assessment by providing a way to measure understanding of complex ideas.

Furthermore, Novak discusses the value of using concept maps in corporate settings. He notes that concept maps can be used to identify gaps in knowledge and develop strategies for improving knowledge management within organizations. By mapping out an organization's knowledge assets, it becomes easier to identify areas where knowledge is lacking and to prioritize knowledge management efforts.

Overall, Novak's book highlights the value of using concept maps as a tool for knowledge mapping in both educational and organizational settings. By providing a visual representation of knowledge, concept maps can help individuals and organizations learn more effectively, promote communication and collaboration, and prioritize knowledge management efforts.

Finally, the knowledge map should be reviewed and updated regularly to ensure it remains relevant and up-to-date.

Overall, creating a knowledge map is a valuable tool for improving knowledge management within an organization. It provides a comprehensive overview of an organization's knowledge assets and can assist in identifying gaps, redundancies, and areas where knowledge is not being effectively utilized. By leveraging the power of a knowledge map, organizations can improve decision-making, reduce costs, and drive innovation. *Behavior*, 62, 134-154.

In general, developing a knowledge map is a useful tool for enhancing knowledge

management inside a company. It offers a thorough picture of a company's knowledge assets and can help find gaps, duplications, and places where knowledge isn't being used properly. Organizations may enhance decision-making, lower costs, and stimulate creativity by utilizing the potential of a knowledge map.

## 6. Knowledge transfer - the importance of mentoring in organizations

As mentoring has been in existence over a number of centuries; various theories on the origin of mentoring have been put forward by different people. Some scholars familiar with the original work of mentoring believe that the true origin of the modern use of the term more likely comes from the work of 18th Century French writer Fenelon, also an educator. African scholars have however noted that mentors were commonplace in Africa, long before the ancient Greek Civilization (Merlevede & Bridoux 2004:6).

In any group, there are people with more experience and knowledge and those with less. Connecting these two groups is vital to the smooth running of any organisation, so the formal and informal knowledge can flow easily between people, connecting them between themselves and the organisation's cause, best practised through mentorship. The main goal of mentoring is a quality development of an individual on personal, business and career levels. Mentorship is greatly valuable when it comes to hands-on, quality transfer of knowledge, but it can also help the people within the organisation feel a sense of belonging and guidance. L.M.,&Poteet, M.L. (2009).

Within organisations can be present formal and informal modes of mentoring both with different advantages. The organisation establishes a formal mentoring structure, including specific guidelines and goals, with

designated mentors and mentees. In informal mentoring, however, the mentor and mentees usually meet spontaneously and decide how to work together. Members of the organisation can also become more productive and at ease with their work since they receive hands-on advice from real-life experience and lessons from mentors. Crocitto, M., Sullivan, S.E.,&Carraher, S.M. (2005). Mentorship can save money for the education of employees and time searching for good resources because mentees learn directly from a mentor and their experience. Cascio, W.F.,&Aguinis, H. (2008).

### 6.1. Mentorship for entrepreneurs

If we move on to smaller organisations and individual entrepreneurs, we can see a great demand for mentorship in that area as well. Every person has at one point dealt with loneliness and isolation in some area of their life. Entrepreneurs and self-employed individuals are at even greater risk than most, as the covid 19 pandemic has shown us. Isolation and the absence of a feeling of belonging can kill the creative and business drive we all depend on to run our business. From this immediate need, an idea of mentorship was born within a small non-profit organisation in Slovenia. One entrepreneur started connecting with other like-minded individuals who felt the same need: to connect, educate each other and learn and, most importantly to support each other where needed. Entrepreneurs are incredibly curious individuals, and often we also need to share all the knowledge we gather.

Information and knowledge have also never been more accessible as they are now. With the rise of online classes and programs, one can get so easily lost in what is genuinely quality content. In response to this, organisations have started seeking out individual and curated mentorship and guidance. Mentors can recognise

individual's or group's unique needs and advantages. Every human being is different. Our learning styles, tempos and confidence vastly vary from individual to individual, but when we can adapt to the needs of a specific person or a group, their potential starts coming alive. Allen, T. D., Finkelstein,

For example, the before mentioned entrepreneurial organisation Podjetni became a specific tool that brings together those who offer knowledge and those who seek it. The organisation went through a process of research and experience to create

- a series of events that focus on connecting mentors and mentees,
- an online platform where mentors in almost every area can be easily highlighted and reached,
- a system that offers individuals free consultations from all the mentors,
- educational academies and programs based on the mentorship values for a qualitative transfer of knowledge. Buckley, G. (2001).

Mentorship also saves time. Instead of listening to broad educational classes on foreign study cases and examples, mentorship directly addresses the immediate needs of an entrepreneur. Mentors will help a person on their own work, so they can walk out of the door with already-applied results. An organisation like Zavod Podjetni, which connects multiple mentors, means a person can painlessly switch from area to area depending on their need. If they first need help with branding, they can later move on to direct sales and content writing with a different but in familiar and certified system.

## 6.2. Qualities of mentors

No matter who and what they are teaching, there are specific attributes a mentor has to embody. A mentor has to be a stable and continuous force in someone's life on who the mentee can always depend and look up.

They give guidance and assignments and challenge the mentee, but they do not do the work for them, so they can properly learn. When the mentor learns mentees life and business situation, their goals, challenges and ambitions, they can guide them if they ever stray from the mentees desires path. Wanberg, C.R., Welsh, E.T., & Hezlett, S.A. (2003). An individual also often just needs someone who will listen and offer a shoulder, and that is where the mentor guides as a therapist figure who helps them holistically. In the end, mentor also acts as a guardian since a mentees are often in vunrable position of learning and growing. Merlevede & Bridoux 2004:6). The mentor has to be emphatic to them, but they should never get involved personally into an individual's story.

Mentorship is becoming more recognised and sought after every year, in areas of personal and business growth. Mullen, E.J., & Noe, R.A. (1999). Small and large organisations are recognising the benefits of quality mentorship, which helps them save time and money, but also create deeper and more personal connections to the knowledge in the organisation.

## 7. Tools for measuring the performance of processes in the organization

There are several tools and techniques available for measuring the performance of processes in an organization. The selection of specific tool depends on the nature of the process in an organization. The selection of a specific tool depends on the nature of the

Process and the organization's objectives.

It's important to select the most appropriate tools based on the specific needs and objectives on the organization. Additionally, organizations may choose to combine multiple tools and techniques to gain a comprehensive understanding of process

performance and drive continuous improvement.

We will focus just on some commonly used tools for measuring process performance.

Very good tool for measuring is also Life Learning Academia certificate system. The process guide board team through the activities and questionnaires. When organization complete all the requested activities and fill all the questionnaires can show the results. Actually this is the

Current stage of the organization. This bigger picture shows all the gaps which need to be filled. Process last among 4- 6 month.

Another very important tool is Key Performance Indicators (KPI). KPIs are quantifiable metrics used to assess the performance and progress of specific processes or activities. KPIs should be aligned with organizational goals and can vary depending on the process being measured. Examples of KPIs include customer satisfaction scores, on-time delivery rate, process cycle time, defect rate, revenue growth and employee productivity.

Balanced scorecard is strategic performance measurement framework that considers multiple perspectives, including financial, customer, internal process and learning and growth perspectives. It provides a holistic view of the organization's performance and helps align process measurement with strategic objectives.

Process Mapping involves visually representing a process flow to identify bottlenecks, inefficiencies and areas for improvement. By mapping out the process steps and analysing the inputs, outputs and interactions, organizations can measure performance and identify opportunities for optimization.

Employee Feedback and performance evaluations can provide insights into the effectiveness of processes. Regular feedback, performance metrics, and performance appraisals help measure

individual and team contributions to process performance. Dewey. *Advances in Knowledge Organization*. 4, 109-117.

Customer Feedback and Survey is valuable tool for measuring process performance from the customer's perspective. Surveys, focus groups and customer satisfaction metrics can provide insights into the effectiveness of processes in meeting customer needs and expectations.

Data Analytics and Business Intelligence tools: Advanced analytics tools and technologies, such as data dashboards, predictive modelling and data mining, enable organizations to measure process performance by analysing large volumes of data. These tools provide real-time insights, identify trends and support data-driven decision making.

Six-Sigma is a data-driven methodology aimed at reducing process variations and defects. It utilizes statistical tools and techniques to measure process performance, such as process capability analysis, control charts and defect rates. Six Sigma focuses on improving process quality and achieving near-perfect performance levels.

Lean Manufacturing/Lean Six Sigma: Lean methodologies, often combined with Six Sigma, focus on eliminating waste and maximizing value. Tools such as value stream mapping 5S and Kaizen events are used to to measure and improve process performance by streamlining workflows, reducing lead times and enhancing overall efficiency.

Benchmarking involves comparing an organization's performance against industry best practices or competitors. By measuring key process metrics and comparing them to external benchmarks, organizations can identify performance gaps and set improvement targets.

Process Audits involve systematic evaluations of process adherence, compliance and effectiveness. Audits can be

conducted internally or by third-party experts to measure process performance, identify non compliance issues and recommend improvements.

## 8. Conclusion

Processes are vital components of organizations, serving multiple essential roles. They provide structure, efficiency and consistency in carrying out tasks, leading to improved productivity and quality. Key processes within organizations include those related to communication, decision making, planning, human resources management, operational activities, monitoring, evaluation and continuous improvement.

By establish all described processes organizations can enhance their efficiency, productivity, customer satisfaction and overall performance. Processes also

contribute to risk management, compliance, scalability and knowledge management within organizations. For organizations is also important to regularly review and improve their processes to adapt to changing environments, technological advancements and customer expectations. With well-designed and effectively implemented processes organizations are better equipped to navigate challenges, seize opportunities and achieve their strategic objectives.

Good processes provide a way to communicate and apply consistent standards and practices within the business, it helps the employees what needs to happen and creates a path for growth. Good processes save time and increase overall efficiency and take are built around the customer and users' needs. The most important thing is to manage employees on properly manners.

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## USE OF INTEGRATED MCDM APPROACH FOR THE SELECTION OF LEAN TOOLS TO IMPROVE THE ORGANIZATIONAL- BUSINESS PERFORMANCE

**Abstract:** *There are numerous strategies and concepts that management can use in order to improve the organizational business performance of companies in modern business conditions. Research shows that one of the most prevalent principles in the past few years is the use of Lean tools, which enable managers to continuously improve their business. Since in most cases the problem of choosing Lean tools is solved through experience, the paper proposes the application of an integrated multi-criteria approach for decision-making. The evaluation of the relative importance of the criteria was performed using the AHP method, while the selection of the most suitable Lean tool was carried out using the ELECTRE method, the PROMETHEE method and the Compromise Programming method, using specially developed software for that purpose. The aim of this paper is to point out the importance and quality of the application of the proposed model in real and modern conditions of business and organization.*

**Keywords:** *Lean tools, Multi-criteria decision making, AHP method, ELECTRE method, PROMETHEE method, Compromise Programming method*

### 1. Introduction

Modern business conditions require companies to continuously improve their organizational and business performance in a high-quality manner. Due to increasing market competition and increasingly complex customer requirements, companies are required to produce higher quality products, shorter delivery times and lower costs. Many companies face more and more challenges in finding ways to improve performance, which needs to be updated almost on an annual basis. These circumstances only make it difficult to choose the most appropriate approaches,

techniques and tools, as they should be applicable and add value to the enterprise.

The paper will present a proposal for a multi-criteria decision-making (MCDM) model of appropriate Lean tools for quality improvement of organizational and technical performance of companies in the metalworking industry. In practice, no single Lean tool can solve all problems and respond to all challenges an organization faces. All Lean tools have their advantages, but also certain limitations, which is why it is necessary to choose a group of the most suitable tools. The managerial initiative to improve quality and improve the company's performance refers to approaches to the use

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and implementation of the Lean concept and various tools in production systems (Hobbs, 2004; Hobbs, 2011).

Information technology is essential for the practical application of business decision-making methods. In this way, different methodologies of multi-criteria decision-making can be implemented in practice. Modern methodologies of multi-criteria decision-making are becoming more and more complex and sophisticated. The task of information technology is to support these methods, but on the other hand to enable users to use them easily. This paper presents a program for using multi-criteria ranking methods using Promethea, Compromise ranking and Electra. The specificity of this program is the possibility of visual presentation and analysis of preferences according to certain criteria using the calculation of the Universal Preference Function. This function allows the creation of an unlimited number of preference functions. The program enables their simple and comparative visual analysis as well as a comparative presentation of the results of other methods of multi-criteria analysis.

## **2. Selection of the most effective Lean tools based on defined criteria**

By reviewing the literature, many authors propose the Lean concept, that is, the use of Lean tools as one of the best and most effective ways to improve the organizational and business performance of a company. The ability to choose the appropriate tools and techniques of lean manufacturing, taking into account several critical criteria for decision-making, provides a significant improvement in the quality of business

(Yahya et al., 2016; Belekoukias, Garza-Reyes & Kumar, 2014). In practice, it has been shown that the use of Lean tools achieves a significant reduction in waste (Leksic, Stefanic & Veza, 2020). According to (Gonzalez et al., 2016) they can serve as a powerful tool for increasing the efficiency of the company. These tools measure the efficiency and quality of work performance (Pakdil & Leonard, 2014). A study conducted by (Reda & Dvivedi, 2022) suggests an innovative approach in selecting appropriate lean tools to maximize the company's core resources, while the case study (Kumar et al., 2021) showed a direct improvement in productivity and improved customer service. The findings presented in research of (Alaskari, Ahmad & Pinedo-Cuenca, 2016) revealed that the proposed methodology was effective in identifying appropriate lean tools for companies, according to key performance indicators in the SME manufacturing sector. Improvements in operational and environmental performance are demonstrated with a change in Lean tool application status (Liu, Niu & Li, 2022).

### **2.1. Selection of Lean Tools**

A significant role in the application of Lean tools in manufacturing companies is played by customers, who can directly influence the added value of the product. They don't attach much importance to the organizational and production activities of the manufacturer, but are exclusively interested in the quality, correctness and functionality of the product. Table 1. shows some of the most important Lean tools that the management of manufacturing companies use in order to qualitatively improve organizational and business performances.

**Table 1.** The most important Lean tools for quality improvement of organizational and business performance

	Lean Tools	Definition
a <sub>1</sub>	5S	5S is a five-step methodology for creating a more organized and productive workspace: sort, straighten, shine, standardize and maintain.
a <sub>2</sub>	Value Stream Mapping (VSM)	VSM is a flow chart that documents each step involved in the material and information flows required to bring a product from order to delivery. It is used in continuous improvement to identify and eliminate waste, reduce process cycle times, and implement process improvements.
a <sub>3</sub>	Plan-Do-Check-Act analysis (PDCA)	PDCA - Managers set targets (plans), Teams implement improvements (Do), then they measure (Check) the change to evaluate performance against the target. If the target is accomplished, it standardizes (Acts) the new method by updating the standardized work.
a <sub>4</sub>	Poka-Yoke (error avoidance)	Poka-Yoke is a technique that aims to minimize or completely eliminate the possibility of errors and defects resulting from errors, as well as to reduce the possibility of transferring defective products to the next production stage, or to the end user.
a <sub>5</sub>	Single-Minute-Exchange of Dies (SMED)	SMED is used in manufacturing to reduce equipment changeover time, it can also help reduce costs and increase flexibility within the process.
a <sub>6</sub>	Takt Time	Takt Time represents the quotient of the planned production time and the time required by the customer. It is a method for determining the production rhythm, thereby aligning production with customer requirements.
a <sub>7</sub>	Total Productive Maintenance (TPM)	TPM is the process of using machines, equipment, employees and supporting processes to maintain and improve the integrity of production and the quality of systems.

## 2.2. Criteria to be considered when selecting Lean Tools

The most important step in the application of multi-criteria decision-making methodology is the selection of alternatives and criteria that the decision-maker should consider, in the example of manufacturing companies, these are managers. The criteria for choosing the optimal alternative are of a diverse nature, and managers are required to perform an analysis and selection of criteria with regard to the qualitative improvement of organizational business performance.

Below are presented the criteria on the basis of which the considered alternatives were evaluated: **C1: Costs** (Costs of scrap and processing; of production per unit; of product; of product development; of transport; Inventory costs etc.); **C2: Quality** (Standardization of procedures and processes; Return rate of customers; Flow

time or production time; On-time delivery percentage etc.); **C3: Productivity** (Productivity of labor; Equipment utilization; Capacity utilization; Number of bottleneck stages etc.); **C4: Innovations** (Time to launch new products; Time spent on engineering changes; No. of proposals per employee per year; No. of new products introduced etc.) **C5: Flexibility** (General flexibility; Product expiration date; Percentage of production equipment that is digitized or automated etc.); **C6: Competitive advantages** (Annual gross profit; Total sales; Market share; Product price etc.) **C7: Morality** (Number of awards and rewards for employees; Employee turnover rate; Communication between employees and management etc.)

### 3. Application of an integrated MCDM approach when selecting lean tools

The paper presents the MCDM model based on the integration of the AHP and PROMETHEE methods, the ELECTRA method and the Compromise Programming Method. It is shown on the example of the evaluation of alternatives when choosing Lean tools for quality improvement of the organizational and business performance of a manufacturing company, which are the most significant in practice. The selection was made between seven alternative tools evaluated in a system of seven criteria. Since the management of the company makes these decisions in modern and dynamic business conditions, in order to perform an accurate evaluation of the considered alternatives, it is necessary to apply the

Integrated MCDM approach. The AHP method is used to evaluate the criteria used to evaluate the alternatives, where the weight coefficients obtained below for each criterion will be further used in the process of evaluating the alternatives using the modified PROMETHEE, ELECTRA and Compromise Programming methods (Radojicic et al., 2013). The evaluation process was carried out using specially developed software, where a comparative view of the results will be presented by applying these three methods.

#### 3.1. Evaluation of the weight of the criteria using the AHP method

The hierarchical structure of the problem developed by the AHP methodology is shown in Figure 1.

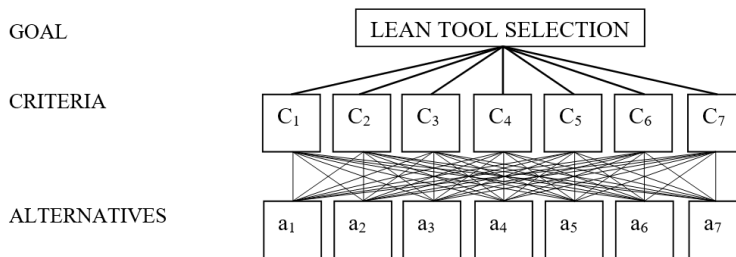


Figure 1. The hierarchy of the decision-making problem

The influence of the criteria on the choice of Lean tools depends on the subjective assessment of the decision maker, in this example the manager, in the conditions of uncertainty in which the decision is made. This would mean that any of the criteria can become crucial in the choice, depending on the situation, and that, also, depending on the criteria used, each of the alternatives can dominate over the others. In order to perform a correct and rational evaluation of the alternatives, it is first necessary to evaluate the relative importance of each individual

criterion. The criteria assessment matrix is given in Table 2.

The assessment matrix is further translated into a criteria priority scale by normalizing the weight vector of each individual criterion, the relative importance of the criteria is obtained (Table 3) according to the decision maker's priorities in the considered situation.

**Table 2.** Revised matrix of pairwise comparison of criterion weights

	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>
C <sub>1</sub>	1.0	0.5	3.0	5.0	6.0	4.0	7.0
C <sub>2</sub>	2.0	1.0	4.0	6.0	7.0	5.0	9.0
C <sub>3</sub>	0.33	0.25	1.0	4.0	5.0	2.0	6.0
C <sub>4</sub>	0.2	0.17	0.25	1.0	2.0	0.33	4.0
C <sub>5</sub>	0.17	0.14	0.2	0.5	1.0	0.2	3.0
C <sub>6</sub>	0.25	0.2	0.5	3.0	5.0	1.0	0.17
C <sub>7</sub>	0.14	0.11	0.17	0.25	0.33	6.0	1.0

**Table 3.** Criteria weights specified using AHP methods

Criteria	Criteria weight
C1: Costs	0.244742
C2: Quality	0.355284
C3: Productivity	0.142258
C4: Innovations	0.060537
C5: Flexibility	0.04235
C6: Competitive advantages	0.085935
C7: Morality	0.068895

The obtained results indicate that the "Quality" criterion with a weight coefficient of 0.355284 dominates over the other criteria, and the "Flexibility" criterion with a weight coefficient of 0.04235 was the least dominant. This solved the problem of conflicting criteria and imprecise information for their definition and assessment, and the obtained results served in the further process of evaluating alternatives.

### 3.2. Process of evaluation of alternatives using modified PROMETHEE method

For the considered MDCM problem the evaluation matrix (Table 4) was constructed, which compliantly with the defined hierarchical structure of the problem (Figure 1) encompasses the 7 alternatives assessed in the system of 7 criteria. The evaluation matrix was constructed on the basis of the impressions that managers, involved in the decision-making process, gained during the testing of Lean tools, as well as on the basis of the existing organizational and business performance of the company.

To solve the problem of decision-making and ranking of alternatives, in situations where qualitative criteria are present, the application of the modified PROMERHEE method is suggested. For each criterion, the same type of universal preference function was selected that most appropriately reflects the specifics of the given criteria, after which parameters were determined, as well as requirements for extremism (Figure 2). For the relative weights of the criteria, the results obtained in the previous procedure of evaluating the criteria using the AHP method were used (Table 3).

**Table 4.** The evaluation matrix

	Criteria			Alternatives						
	Relative Weights	Request	Type of preference function	a <sub>1</sub>	a <sub>2</sub>	a <sub>3</sub>	a <sub>4</sub>	a <sub>5</sub>	a <sub>6</sub>	a <sub>7</sub>
C <sub>1</sub>	0.244742	MIN	Universal	2.35	8.14	9	7	1.48	5.73	4.06
C <sub>2</sub>	0.355284	MAX	Universal	7.21	8.49	6.15	8	3.3	4.07	9.2
C <sub>3</sub>	0.142258	MAX	Universal	9	8	4	3	6	7	5
C <sub>4</sub>	0.060537	MAX	Universal	2.6	7.2	9.5	1.1	4.1	3	5.8
C <sub>5</sub>	0.04235	MAX	Universal	1.83	2.97	4.71	2.32	5	3.45	0.64
C <sub>6</sub>	0.085935	MAX	Universal	5.09	8.83	9.14	7.22	6.84	8.19	5.73
C <sub>7</sub>	0.068895	MAX	Universal	10	1.5	8	4	2	7.5	5.5

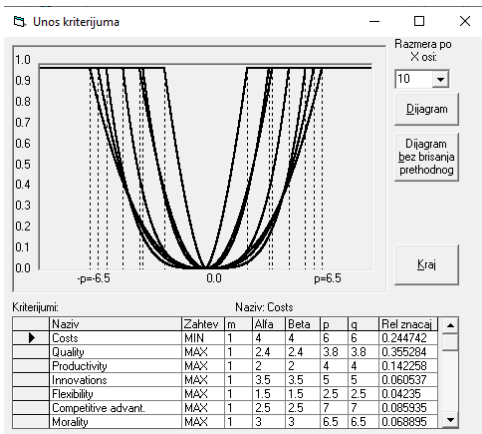


Figure 2. The Universal preference functions for criteria

The further ranking procedure of the considered alternatives according to the modified PROMETHEE methodology was carried out with the use of specially developed software.

The obtained results (Figure 3) indicate that the alternative “5S” singled out as an alternative that has the greatest impact on the improvement of the organizational business performance of the company.

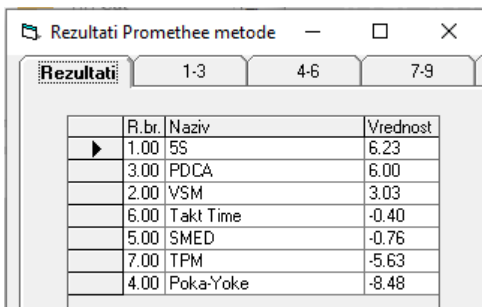


Figure 3. Evaluation of the alternatives using the modified PROMETHEE method

### 3.3. Process of evaluation of alternatives using ELECTRE method

Furthermore, the ranking of alternatives was performed using the ELECTRA method,

based on the parameters from the evaluation matrix (Table 4).

The following ranking of alternatives was obtained (Figure 4), where we can see that it differs from the ranking obtained by the analysis using the modified PROMETHEE method, and that the best ranked alternative is “TPM”.

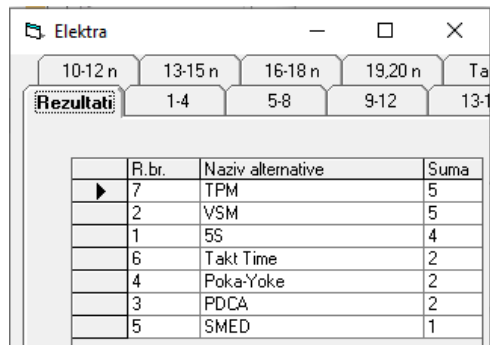


Figure 4. Evaluation of the alternatives using the ELECTRA method

### 3.4. Process of evaluation of alternatives using Compromise Programming method

Also, the ranking of alternatives was performed using Compromise Programming method, based on the parameters from the evaluation matrix (Table 4).

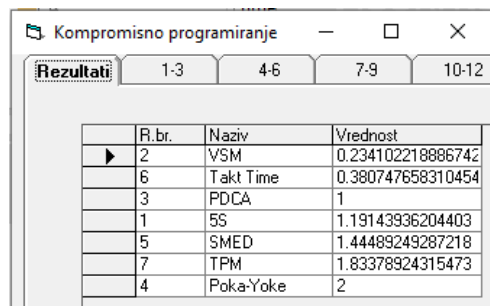


Figure 5. Evaluation of the alternatives using the Compromise Programming method

Based on the ranked alternatives (Figure 5), we can also see that the final ranking of the alternatives is different from the results of

the previous two methods, and that the best ranked alternative is “VMS”.

#### 4. Conclusion

The results of the comparative analysis of the evaluation of alternatives using three different MCDM methods indicate different rankings of the alternatives. So it can be concluded that none of the proposed Lean tools is dominant compared to the others. The proposed model reduces subjectivity when making decisions and generates much more rational solutions, based on reliable assessment of the weight of criteria, structuring of problems and overcoming problems. On the other hand, the modified PROMETHEE method improves the quality of decision-making by assigning appropriate

universal preference functions to each of the criteria and enables a rational ranking of the considered Lean tools. While the application of specially developed software provides decision makers with ease of use, speed and eliminates the possibility of error when solving problems. Therefore, further research is possible on the selection of appropriate lean tools, taking into account several critical decision criteria in modern business conditions.

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## THE IMPACT OF HORIZONTAL AND VERTICAL SYSTEM INTEGRATION ON QUALITY 4.0

**Abstract:** *The era of Industry 4.0 insists on the necessity of understanding the connection between the strategy of horizontal and vertical system integration with Quality 4.0. A key segment for the effective implementation of Quality 4.0 is the creation of an organizational system that combines vertical and horizontal integration. In the paper, an overview of the literature related to Quality 4.0 and the mentioned integration in Industry 4.0 was given, and the importance of their understanding in Industry 4.0 was pointed out. Also, the focus of the work is on pointing out advantages, challenges and presenting solutions to overcome these challenges. The motive of writing the paper lies in the fact that there is no paper in which these concepts are combined. The aim of the paper is to consolidate in one place a review of the available literature from these areas in order to achieve progress towards Industry 4.0.*

**Keywords:** *Horizontal and vertical integration, Industry 4.0, Quality 4.0, Quality Management system*

### 1. Introduction

The development of Industry 4.0 technologies had an identical and parallel impact on quality management practices that changed quality management methods and practices (Sader, S., Husti, I., & Daroczi, M., 2022). New technologies of Industry 4.0 enable the minimization of complications and errors, the improvement of process effectiveness through a significant increase in the quality of the final product (Javaid, M., Haleem, A., Singh, R. P., & Suman, R., 2021), productivity, standardization of processes (Zaidin, N. H. M., Diah, M. N. M., Yee, P. H., & Sorooshian, S., 2018), transformation of culture, leadership, cooperation and compliance (Jacob, 2017).

Globalization, turbulent conditions on the market, rapid development of information and communication technologies and digital

networks are causing a change in the classic business models of organizations. This creates a completely new world of functioning systems for horizontal and vertical integration (Chukalov, 2017) and conditions the application of new business trends called Industry 4.0, i.e. the introduction of a new quality management practice known as Quality 4.0. In order to adapt, managers and then employees must change their awareness and culture to a great extent, but also improve their skills in using Industry 4.0 technologies (Chiarini & Kumar, 2022).

By integrating the quality management system and the basic technologies of Industry 4.0, organizations are given the opportunity to effectively and adequately respond to the numerous challenges they face, such as the struggle for survival in the market and maintaining a competitive

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advantage. For this reason, there is an increased need to understand the connection of horizontal and vertical integration with quality 4.0 in order to better protect the intellectual property of the organization (Subramaniam, 2021).

Due to the extremely small number of available literature sources that connect Quality 4.0 and horizontal and vertical integration, the author's idea was to unite in one place the advantages and challenges related to horizontal and vertical integration in the new era of business. This is where the motive for writing this work comes from.

The paper pointed out the importance of the connection between horizontal and vertical integration and Quality 4.0, as a central and key element of Industry 4.0. This integration with quality 4.0 achieves a positive influence with each other. Also, the paper pointed out the importance of the relationship between horizontal and vertical integration and Quality 4.0.

The contribution of the work is reflected in a tabular representation of the advantages and challenges of horizontal and vertical integration and Quality 4.0, with a proposal for possible solutions to those challenges.

The work is organized as follows: Section 2 refers to the basics of the concept of Quality 4.0 and horizontal and vertical integration of the organization's system. Section 3 of the work describes the research methodology - method, sources and methods of collected samples of published works and tabular presentation of research results and discussion. The last part of the paper contains the conclusion.

## **2. Impact of horizontal and vertical integration on quality 4.0**

In Industry 4.0, there is a need to increase the understanding of horizontal and vertical

integration in which to better protect the intellectual property of the industry (Finance,2015; Subramaniam, 2021), due to the emergence of a new value network, as well as new business models (Sony, M., Antony, J., & Douglas, J. A., 2020). Accordingly, the interaction of implemented systems integrated into digital networks creates a completely new world. The interaction between machine and machine, machine and Internet, machine and person in the value chain, in real time forms the basis of the modern manufacturing cyber system (Chukalov, 2017) and has a long-term impact on the company's business strategy (Sewak, 2022).

The use of certain Industry 4.0 technologies could have a positive effect on quality control and management, and therefore on improving the horizontal and vertical integration of the system. Also, the quality management system in the concept of Industry 4.0 could, on the one hand, contribute to better horizontal and vertical integration, while on the other hand, it could benefit from the use of technologies such as Data Mining, analytics, cloud systems and feedback in decision-making. based on the evidence. Node.js®, Node Package Manager (NPM), MongoDB, Angular, Laravel and MySQL can be used to develop and maintain quality system documentation in the Industry 4.0 concept (Stefanović, M., Đorđević, A., Puškarić, H. & Petronijević, M., 2019).

### **2.1. Quality 4.0**

Given the lack of a generally accepted definition of quality 4.0, some authors define the concept of quality 4.0 in different ways (Aldag, M. & Eker, B., 2018). The term "Quality 4.0" was first used by the analytical company LNS Research in 2017, which defines Quality 4.0 as a set of the latest quality management practices and tools that are applicable for use in the context of Industry 4.0 (Akhmatova, M. S., Deniskina,

A., Akhmatova, D. M., & Prykina, L., 2022) state that quality 4.0 combines new technologies with traditional quality methods in order to reach new optimums in operational excellence, performance and innovation. (Sader et al., 2022) defines quality 4.0 as an expanded approach to quality management, where the latest technologies are integrated with traditional quality practices to expand the scope of quality management and improve quality management. (Salimova, T., Vatolkina, N., Makolov, V., & Anikina, N., 2020) defines quality 4.0 as a new understanding of the relationship and responsibility of stakeholders, the transformation of the basic principles on which decision-making in companies is based. In addition to the confirmation of the importance of combining

innovative methods of quality management and digital technologies, it has been shown that this process implies the transformation of managerial thinking itself.

The digital transformation of traditional quality cannot be carried out without the implementation of quality 4.0 tools (Richnák, 2022) and therefore, Industry 4.0 technologies are a key factor for understanding how to manage and improve quality processes in the Industry 4.0 era (Carvalho, A. V., Enrique, D. V., Chouchene, A., & Charrua-Santos, F., 2021). Quality management practices are proposed to identify technological progress as a key factor for the successful implementation of quality standards in the era of quality 4.0 (Sader et al., 2022), (Table 1).

**Table 1.** Quality management practices and technology relationship in Industry 4.0 (Carvalho et al., 2021)

I4.0 Tools and Technologies	Quality management practices							
	Management of obligations	Customer involvement	Supplier participation	Employee involvement	Benchmarking techniques	Process management	Information and analysis	Formal strategic planning
Data Science and Statistics	X					X	X	X
Enabling Technologies (IoT, IIoT, Integrated Systems, VR, AR, Cloud Computing (CC))	X	X	X	X	X	X	X	X
Big Data	X	X	X			X	X	
Blockchain	X			X		X		X
Artificial intelligence - AI	X			X			X	
Machine learning - ML	X						X	X
Neural Networks and Deep Learning	X					X	X	

Table 1 shows the relationship between quality management practices and seven tools and technologies that can be used to improve quality, in order to facilitate the decision of the type of tool that is most adequate for certain quality management practices.

## 2.2. Horizontal integration

In order to efficiently produce products and services, inter-organizational horizontal integration should be formed, which is made up of related corporations. In this way, an efficient system is formed, in which there is a smooth flow of materials, information and finances between these organizations. In the sub-module of horizontal integration,

activities such as planning, control and quality improvement are oriented towards all organizations that collaborate within the value creation process to produce products and services (Sony et al., 2020).

In Industry 4.0, horizontal integration implies the integration of information technologies and production systems with the established exchange of data and information between companies in geographically distant locations throughout the value chain (Chukalov, 2017). This is achieved through the provision of networking through cyber-physical systems, from inbound logistics through warehousing, manufacturing, marketing and sales to outbound logistics (Finance, 2015).

Horizontal integration takes place on several levels (Schuldenfrei, 2019):

- At the production level - connected machines and production units constantly communicate their status and respond autonomously to production demands.
- In multiple production plants - through production execution systems (MES) data about production plants (eg inventory levels, unexpected delays) is shared throughout the company.
- Throughout the supply chain - Suppliers and service providers must be firmly integrated horizontally into the company's production control and logistics systems.

Examples of successful horizontal integration include Microsoft - Activision Blizzard, Anheuser-Busch InBev and SABMiller, Walt Disney Company and 21st Century Fox (Moltz, 2022; Traver, 2022).

### 2.3. Vertical integration

Vertical integration occurs when organizations decide to expand by

purchasing a company that occupies a critical place in their supply chain process (Moltz, 2022) in order to gain control over the entire production process by integrating different levels of the organization ("Horizontal and Vertical System Integration in Industry 4.0", 2023), minimizing or eliminating the need for external subjects (Amadeo, 2022).

This type of integration in Industry 4.0 uses cyber-physical production systems (CPPS) to enable rapid response to changes in demand or inventory levels and to errors (Finance, 2015). Vertical integration of hierarchical subsystems such as different departments within the factory implies that physical (sensors, control) and informational subsystems (ERP and SAP) are integrated at different levels within the production system in order to create a flexible production system. Quality 4.0 as a sub-module for vertical integration deals with all activities of quality improvement, control and planning, within the organization (Sony et al., 2020).

Examples of vertical integration can be cited (Cook, n.d.; Traver, 2022): Walmart - JoiRun, NVIDIA - Bright Computing, Google and Motorola - Alphabet's Google (GOOG), Ikea and forests in Romania, Netflix (NFLX).

## 3. The importance of quality 4.0 on horizontal and vertical integration

### 3.1. Research methodology

This paper is based on a systematic review of the available literature. Available literature sources from Google scholar, researchgate, springer, science direct were used. Manual search was performed in Google Scholar and Google Chrome, and automated search in Science Direct and Springer.

The search at the mentioned locations was performed by entering keywords into the search engine. Various combinations of keywords were used to search for articles, such as: Quality 4.0, quality 4.0 and industry 4.0, horizontal and vertical integration and quality 4.0, horizontal and vertical integration in industry 4.0.

Papers were reviewed and selected, which, based on the analyzed titles, keywords and abstracts, were relevant to the main research topic of this paper. 23 relevant literary sources were used in writing this paper. The articles that were used for this paper were mostly published after 2018. with certain exceptions.

### 3.2. Research results and discussion

In this part of the work in table 2, based on the available literature in this area (Amadeo,

2022; Chukalov, 2017; Cook, n.d.; Finance, 2015; “Horizontal and Vertical System Integration in Industry 4.0”,2022; Moltz, 2022; Pipiyay, G. T., Chernenkaya, L. V., & Mager, V. E., 2021; Schuldenfrei, 2019; Sewak, 2022; Traver, 2022) the challenges of horizontal and vertical integration are shown and suggestions are given for overcoming these challenges and the advantages of those solutions are shown in Quality 4.0. Table 3 shows the advantages of horizontal and vertical integration to quality 4.0. In this way, topics from this area are united in one place. Based on a detailed analysis of the presented tables, it is easier to make a decision within the organization whether to choose one type of integration or both in accordance with the specifics of each company and in accordance with the needs and goals of the organization.

**Table 2.** Presentation of the challenges of horizontal and vertical integration with their solutions and the demonstrated advantages of those solutions to quality 4.0

Challenges	Integration	The solution
Data management - Analysis of accumulated data and knowledge in all sectors of the organization	Vertical and horizontal	Changing the organizational culture, the way of working and the awareness of employees for the use of intelligent systems, the use of digital technologies, such as IoT devices and blockchain, for the collection and sharing of quality data, production units equipped with a wide range of sensors, the establishment of a meta-network
Improvement of IT systems and infrastructure	Vertical and horizontal	Moving to cloud-based IT
Adopting a strong platform for managing and coordinating multiple computer systems and applications	Vertical and horizontal	Investing in the acquisition and updating of a suitable strong platform
Data security and availability	Horizontal	Moving to cloud-based IT
Standardization	Vertical	Implement a quality management system (QMS) that integrates quality management processes in various departments and functions
	Horizontal	Establishing clear quality standards and requirements for suppliers and regular monitoring and evaluation of supplier performance.
Cultural barriers	Vertical	Developing cross-functional teams that include representatives from different departments and functions.
	Horizontal	Developing partnerships and collaboration with other organizations in the supply chain to improve communication and collaboration
Costs	Vertical and horizontal	Using analytics and predictive modeling, continuous improvement that includes regular review and evaluation of quality management practices.

**Table 3.** Advantages of horizontal and vertical integration on quality 4.0

Quality 4.0 and horizontal integration	Quality 4.0 and vertical integration
Consistent quality throughout the supply chain	Consistent quality across functions within the organization
Improved cooperation and communication with other organizations	Improved communication and collaboration within the organization
Increased efficiency and productivity (Automation, flexibility and operational efficiency in production processes)	Increased efficiency (Quick resolution of change orders, fluctuations in quality or machine failure, reducing waste)
Resource efficiency in terms of efficient use of materials, energy and human resources	
Reducing downtime	
Dynamic management of quality, time, risk in real time	
Improved visibility and traceability	
Improved quality control (more efficient and accurate)	
More efficient decision-making (accuracy, systematicity and agility)	

In order to lead the organization towards industry 4.0, in addition to understanding its tools, it is necessary to understand and successfully implement quality 4.0 and establish connections with horizontal and vertical integration, which serve as key business strategies of the organization towards the key goal.

Industry 4.0, and therefore the quality of 4.0, is characterized by new tools and technologies, and the problems they carry due to insufficient knowledge in the sense of using the right technology in the right place, in this case, is also an advantage, with their proper use, which can be solved by understanding horizontal and vertical integration strategies, by adopting new knowledge and changing culture and awareness in order to achieve sustainability on the market and achieve progress towards industry 4.0.

Among the major problems of the successful introduction of these concepts are problems with large amounts of information, data and their processing (Pipipay et al., 2021), which are successfully solved with the help of modern tools and industry 4.0 practices and quality 4.0. Also, costs can be high due to the acquisition of Industry 4.0 and Quality 4.0 technologies, additional investments in employee training, but in the long run it is profitable. In order to avoid costs related to the inadequate implementation of horizontal

and vertical integration and the introduction of inadequate new technologies for a certain organization, it is necessary to change the culture, understand the strategies of horizontal and vertical integration and provide the necessary knowledge about new technologies.

What characterizes Industry 4.0, and therefore also Quality 4.0, are decision-making agility, successful integration with new technologies, and analysis of large amounts of data. With the proper implementation of horizontal and vertical integration in the new era of industry, quality has been improved and its control and management has been facilitated in all sectors. Also, efficiency in the use of resources and productivity are increased, costs are reduced, communication within and outside the organization is improved, which automatically leads to a reduction in costs and waste.

**4. Conclusion**

For the successful implementation of Quality 4.0, proper selection of business strategies that will lead the organization towards Industry 4.0 and maintaining competitive advantage is necessary.

Correct understanding of the use of horizontal and vertical integration in the era of Industry 4.0 and their impact on aspects of Quality 4.0 is of key importance for the

future successful operation of the organization. If implemented correctly, each of the integrations will bring benefits to the organization. The motivation for writing the paper lies in the fact that there is not a large number of scientific research papers dealing with this topic.

In order to better understand the advantages of each integration, the paper first gives an overview of the literature in the field of Quality 4.0 and horizontal and vertical system integration. After defining the key concepts, the advantages of each of the

integrations are tabulated so that organizations can decide which type of integration is best for them based on the goals and strategy of the organization. An overview of the advantages and challenges of horizontal and vertical integration of systems related to Quality 4.0 is given in the form of a tabular presentation, with proposed solutions to these challenges.

Further research will be focused on barriers related to the introduction of quality 4.0 in organizations and ways to overcome these challenges.

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## THE APPLICATION OF AHP IN ASSESSING QUALITATIVE ASPECTS OF WORK: A CASE STUDY OF A MUNICIPAL COMPANY

**Abstract:** *The article presents the use of the ahp in the evaluation of work in a selected municipal enterprise operating in one of the agglomerations in Poland. Based on the case study, the use of AHP was presented in terms of overall evaluation of jobs of municipal company, which enabled to determine the hierarchy of organizational positions due to the difficulty and arduousness of work. . The research proceedings were supplemented by document analysis, structured interviews, team work methods, and classification technique. The article shows that such an approach ensured, on the one hand, the inclusion of qualitative aspects of tasks performed at individual positions in the assessment of work difficulties, and ensures team coordination of assessments and opinions, promoted in quality management, on the basis of which decisions regarding remuneration are made.*

**Keywords:** *job evaluation, analytical hierarchy process, jobs ranking, municipal company*

### 1. Introduction

Rewarding system for employees is perceived as the predominant total quality management dimension that affects employees' performance (Bahjat, Khaled 2022). Rewards system that encourages employees play the major facilitating role in stimulating consumer satisfaction and continuous improvement programs (Koval et al., 2018). Essential in this regard is a proper remuneration system (Basera, Mwenje 2021, Bullinger, Wolfram 2002), which is fair, equitable, and consistent for everyone. Fair wage is wage that is reasonable for type of work done. In the reference to organization, fair wage address the relative value of the job (not the job holders) compared to other jobs in order to achieve the internal justice. the generally accepted thesis is that only job

evaluation makes it possible to develop a fair remuneration system (Armstrong et al., 2005, Arthur, 2015, Dogan et al., 2014).

Job evaluation is a systematic process of assessing the difficulty and nuisance of work to identify the relative value or size of jobs in an organization in order to establish internal relativity and provide the basis for designing a fair grade and pay structure, grading structure and relativity management (Armstrong et al., 2003). The main aim of job evaluation is to provide an acceptable rationale for determining the pay of existing hierarchies of jobs and for slotting in new ones (Arthur, 2015).

Job evaluation depends on the results of the job analysis that produce both the job description and specification, which allows to counterbalance the difference in job values by differences in wage levels (Balshy,

Ismael 2023). In that respect job evaluation encompass the elements of qualitative and quantitative assessment of work. Job evaluation, as the method of reducing wage inequities (Kutlu et.al, 2013, p. 659) is most common method for determining pay in over 75% of US organisations (Dogan et.al, 2014). The job evaluation can be analytical or non-analytical. Analytical one is about evaluating each of profession in organization basing upon a group of criteria, which enables to assess the difficulty and nuisance of work. Non-analytical are: job ranking, paired comparison, job classification (Armstrong et al., 2003, p. 19).

The key issue is to prevent job evaluation's results from subjectivity, therefore it is crucial to implement analytical decision making in job evaluation, in particular analytic hierarchy process (AHP). In order to prevent inequity problem and analytically support managers in job evaluations, in determining job evaluation criteria weights there is used AHP (Dogan et al., 2014), or more sophisticated fuzzy AHP (Senol, Dagdeviren 2019, Feng et al., 2023).

Though, the use of AHP in identification the ranking of company's jobs is relatively rare. Thus, paper presents the implementation of analytic hierarchy process in elaboration of ranking of jobs of the one of the municipal company in Poland. In that respect, the AHP was used in establishing the hierarchy of organizational positions due to the difficulty and arduousness of jobs. The research procedure was supplemented with document analysis, structured interviews, teamwork methods and a classification technique.

## **2. Data and Method**

The research study was conducted in one of the municipal enterprise in Poland, i.e. autonomous municipally owned corporation (MOCs) owned by municipalities outside the local bureaucracy, which have tariffs and commercial revenues, and produce and

deliver local public services (Voorn, et.al., 2017, p. 820). The decision-making problem was the assessment of 75 blue-collar jobs (see Fig 1). The study used data obtained in November-December 2022. Data were gathered from following internal sources of information: the scopes of responsibilities of jobs as well as the results of interviews with executive staff and employees in particular posts. Interviews – based on check lists forms (work sheets) – were conducted with the heads of organizational units and employees in order to gather information on the determinants of the difficulty and arduousness of jobs. Interviews were preceded by a review of the formal scopes of relevant duties. Interview sheets and the collected organizational documentation (organizational charts, formal job descriptions) were a basis for the next stage conducted by a team of 28 experts (composed of company executives), who had deep knowledge of the tasks and responsibilities at work positions. Team of experts were supposed – during one-day meeting – to assess the difficulty and arduousness of company's jobs using AHP.

Analytic hierarchy process is one of the multiple criteria decision method (MCDM) widely described and used by many academics, starting T. L. Saaty (2000) who created this method. Contemporary researchers such Prusak and Stefanów (2014) and Kułakowski (2020) attempted to explain this tool using a step-by-step approach. The first stage of the AHP is to build a decision-making, hierarchical model, which usually consists of the main goal, "parent" criteria, their "children" subcriteria (or factors) and decision variants. In the next stage, the hierarchy is evaluated using fundamental, 9-point pairwise comparison (PC) scale, where two alternatives are compared pairwise against each other with respect to the element one level above in the hierarchical structure. Assuming the criteria A, B and C, and their respective sub-criteria

A1, A2, A3; B1, B2, B3; C1, C2, C3, the example comparisons will be as follows: *With respect to B, which element is more preferred (important): A1 or A2? How much is this preference of one element over another?* There are 9 options: from “1” – A1 and A2 are equally preferred, to “9” – A1 has an extreme preference over A2, or A2 over A1. Based on these judgments, the square PC matrices (PCMs) are constructed, and subsequently, local priorities (weights) are calculated using one of a dozen prioritization methods. The results are presented as ranking vectors, indicating which element is the most preferred (important), and which is the least preferred.

Alongside priorities, the consistency ratio (CR) should be derived for each PCM, and if it exceeds 0,10 (10%), an inconsistent matrix should be modified by reconsidering the most inconsistent judgment. Then, global priorities can be calculated as multiplication of (local) priority for the parent criterion and (local) priority of its children sub-criterion. They indicate how meaningful is a given factor for the whole hierarchy. Finally, if the preference analysis is made by the group of experts, all their individual priorities must be aggregated into common ranking vectors using geometric mean. All these AHP stages have been applied in this research.

### 3. Results and discussion

The decision-making problem was the assessment of physical workstations from the point of view of their difficulties and strenuous work. 75 jobs were assessed, which were categorized into two groups, i.e. Core business jobs and Support activities jobs. This division results from the nature of the work performed. The overall model is shown in the diagram (Figure 1).

The analysis was carried out using the R language, the AHP package. The presented results refer to average values (from all respondents). According to Saaty's recommendations (Saaty 2000), those matrices were included in the analysis for which the CR coefficient is less than 0.20 (20%).

The global ranking is the main part of the research, allowing to determine the degree of nuisance and difficulty of work of each of the analyzed positions. To increase the transparency of the analysis, the positions were divided into four groups:

1. Group I (see: Tab. 1) - positions with the highest global priorities, i.e. those involving the greatest, very high difficulty and arduousness of work. It has been assumed that global priorities for these positions are from 2% and above. During the research, two positions with priorities above 6% were identified
2. Group II (see: Tab. 2) - positions with a medium-high value of global priorities, i.e. associated with medium-high difficulty and arduousness of work. It was assumed that global priorities for these positions range from 1.0-1.9%.
3. Group III (see: Tab. 3) - positions with an average value of global priorities, i.e. associated with an average difficulty and arduousness of work. It has been assumed that global priorities for these positions range from 0.5-0.9%.
4. Group IV (see: Tab. 4) - positions with a low value of global priorities, i.e. involving relatively low difficulty and arduousness of work. It has been assumed that global priorities for these positions are below 0.5%.

Selection of the position with the greatest difficulty and arduousness of work									
Core business jobs					Support activities jobs				
Filters-operators in ZUW	Conservators in w ZUW	Filters-operators w ZOS	Filters-operators w ZSK, ZKD i ZLSK	Filters-operators in ZSW	Obakuga klienta w BS, DA, DGM i CL	Crafting jobs in ZUR i ZT	Specialist jobs in ZUR i ZUW	Device operators in ZUR i ZT	Laborers in ZUR, ZT, DA, BHP, ZUW, ZOS
Engineer of the water pump station in ZUW Rudawa	Conservator of water equipment in ZUW Bielany	Driver-operator of road construction equipment in ZOS Kujawy	Filter-conservator of the overhead sewage system in ZSK	Filter-conservator of the water network - excavator-loader operator in ZSW	Water meter mechanic in BS	Welder in ZUR	Electrician in ZUR	Car diagnostics in ZT	Laborer in CL
Apparatus for water treatment in ZUW Rudawa	Conservator of water facilities in ZUW Dlubna	Engineer of machinery and equipment of a sewage treatment plant in ZOS Plaszow	Filter-conservator of the sewage network in ZSK	Filter-conservator of the water network - excavator operator in ZSW	Filter-conservator of the water network in BS	Carpenter in ZUR	Automation fitter in ZUR	Driver in ZT	Laborer in DA
Apparatus for water treatment in ZUW Bielany	Conservator of water facilities in ZUW Raba	Engineer of the water pump station in ZOS Plaszow	Filter-conservator of the sewage network - excavator operator in ZSK	Filter-conservator of the water network - driver in ZSW	Filter-conservator of the water network - driver in BS	Locksmith-driver in ZUR	Mariner in ZUW Raba	Car mechanic in ZT	Laborer in ZT
Engineer of the water pump station in ZUW Bielany	Mechanic-driver in ZUW Bielany	Filter and conservator of sewage treatment plant equipment in ZOS Plaszow	Filter-maintenance of the sewage network - excavator operator in ZSK	Filter-conservator of the water network - excavator operator in ZSW	Filter of water supply equipment and installations in BS	Locksmith-mechanic in ZUR		Operator of self-propelled cranes in ZT	Laborer in ZUR
Apparatus for water treatment in ZUW Dlubna	Filter-conservator of the water network - driver in ZUW Raba	Operator urządzeń oczyszczalni ścieków ZOS Kujawy	Filter-maintenance of the sewage network - excavator operator in ZSK	Filter, Conservator of the Water Supply Network, Foreman, Driver in ZSW	Water meter reader in BS	Locksmith-welder in ZUR		Excavator operator - driver in ZT	Laborer in ZUW Raba
Engineer of the water pump station in ZUW Dlubna		Operator of sewage treatment plant equipment in ZOS Plaszow	Filter of water and sewage systems, driver in ZSK	Filter, Conservator of the Water Supply Network, Foreman in ZSW	Water meter reader - driver in BS	Locksmith-turner in ZUR		Conservator of gas and heating equipment in ZUR	Laborer in ZOS Plaszow
Engineer of the water pump station in ZUW Raba		Operator of sewage treatment plant equipment - driver in ZOS Plaszow	Filter-maintenance of sewage treatment plant equipment - driver in ZLSK		Informant of the telephone exchange in DA	Locksmith-conservator of overhead cranes in ZUR		Filter of water and sewage equipment and installations in ZUR	Laborer, driver in DA
Apparatus for water treatment in ZUW Raba		Operator in STUO	Operator of sewage treatment plant equipment in ZLSK		Warehouseman in DGM	Turner in ZUR		Stoker-conservator of gas and heating equipment in ZUR	Laborer, driver in ZUR
					Laboratory assistant in CL	Welder and sheet metal worker in ZT		Laborer, factory security worker in BHP	
					Lab technician assistant in ZUW Raba	Blacksmith in ZUR			

**Figure 1.** AHP hierarchical model

**Table 1.** Global ranking for positions with weights of 2.0% and above

No	Job title	%
1	Automation fitter in ZUR	6,52
2	Fitter-conservator of the overhead sewage system in ZSK	6,46
3	Fitter, Conservator of the Water Supply Network, Foreman, Driver in ZSW	5,03
4	Electrician in ZUR	3,53
5	Fitter-maintenance of the sewage network - excavator operator in ZSK	3,52
6	Fitter, Conservator of the Water Supply Network, Foreman in ZSW	3,46
7	Fitter, Conservator of the Water Supply Network, Driver in ZSK	2,64
8	Fitter of water and sewage systems in ZSK	2,59
9	Operator in STUO	2,43
10	Operator of sewage treatment plant equipment - driver in ZOS Plaszow	2,30
11	Fitter of sewage system equipment – driver in ZKD	2,25
12	Fitter-conservator of the water network - excavator and loader operator in ZSW	2,20
13	Driver-operator of road construction equipment in ZOS Kujawy	2,11
14	Fitter and conservator of sewage treatment plant equipment in ZOS Plaszów	2,09

**Table 2.** Global ranking for positions with weights of 1.0-1.9%

No	Job title	%
15	Mariner in ZUW Raba	1,97
16	Fitter-conservator of the water network - excavator operator in ZSW	1,95
17	Fitter-conservator of the water network – driver in BS	1,93
18	Engineer of machinery and equipment of a sewage treatment plant in ZOS Plaszow	1,83
19	Operator of sewage treatment plant equipment in ZOS Plaszow	1,69
19	Fitter-maintenance of sewage treatment plant equipment – driver in ZLSK	1,69
20	Excavator operator – driver in ZT	1,64
21	Operator of sewage treatment plant equipment in ZLSK	1,60
22	Fitter-conservator of the water network – driver in ZUW Raba	1,55
23	Operator of sewage treatment plant equipment in ZOS Kujawy	1,54
24	Engineer of the water pump station in ZOS Plaszow	1,51
25	Fitter-conservator of the sewage network in ZSK	1,47
26	Fitter-conservator of the water network in BS	1,36
27	Fitter of water supply equipment and installations in BS	1,35

28	Water meter reader - driver in BS	1,27
29	Fitter of water and sewage equipment and installations in ZUR	1,19
30	Operator of self-propelled cranes in ZT	1,02
30	Fitter-conservator of the water network - driver in ZSW	1,02

**Table 3.** Global ranking for positions with weights of 0.5-0.9%

No	Job title	%
31	Conservator of gas and heating equipment in ZUR	0,96
32	Engineer of the water pump station in ZUW Rudawa	0,94
32	Water meter reader in BS	0,94
33	Locksmith-welder in ZUR	0,92
34	Engineer of the water pump station in ZUW Raba	0,91
35	Welder in ZUR	0,89
36	Engineer of the water pump station in ZUW Dłubnia	0,85
37	Car diagnostics in ZT	0,83
37	Water meter mechanic in the Sales Office in BS	0,83
38	Fitter-conservator of the water supply network in ZSW	0,81
38	Welder and sheet metal worker in ZT	0,81
38	Apparatus for water treatment in ZUW Rudawa	0,81
39	Apparatus for water treatment in ZUW Raba	0,80
40	Stoker-conservator of gas and heating equipment in ZUR	0,78
41	Engineer of the water pump station in ZUW Bielany	0,75
42	Car mechanic in ZT	0,74
43	Conservator of water facilities in ZUW Raba	0,71
43	Apparatus for water treatment in ZUW Dłubnia	0,71
44	Driver in ZT	0,70
45	Mechanic-driver in ZUW Bielany	0,67
46	Conservator of water equipment in ZUW Bielany	0,65
47	Apparatus for water treatment in ZUW Bielany	0,64
48	Locksmith-turner in ZUR	0,63
49	Conservator of water facilities in ZUW Dłubnia	0,61
50	Laboratory assistant in CL	0,60
51	Warehouseman in DGM	0,57
52	Locksmith-conservator of overhead cranes in ZUR	0,54
53	Locksmith-mechanic in ZUR	0,51

**Table 4.** Global ranking for positions with weights below 0.5

No	Job title	%
54	Lab technician assistant in ZUW Raba	0,49
55	Locksmith-driver in ZUR	0,45
56	Informant of the telephone exchange in DA	0,43
56	Turner in ZUR	0,43
57	Blacksmith in ZUR	0,37
58	Laborer - driver in ZUR	0,30
59	Laborer - driver in DA	0,28
60	Carpenter in ZUR	0,26
61	Laborer a factory security worker in BHP	0,19
62	Laborer in ZOS Plaszow	0,18
63	Laborer in CL	0,17
64	Laborer in ZT	0,16

65	Laborer in ZUR	0,15
66	Laborer in DA	0,14
66	Laborer in ZUW Raba	0,14

The team-worked ranking of jobs due to the difficulty and arduousness work difficulties with the use of AHP was accepted by the team members. Thus, it reflects the recognized, and indirectly acceptable, hierarchy of work difficulties in ranking jobs. It is worth mentioning that the developed ranking of positions, before it is adopted as input for the remuneration system, must be verified by applying analytical job evaluation with numerous criteria analyzing the content of work on evaluated jobs.

#### 4. Conclusion

The paper investigates procedure for using AHP in developing a ranking of positions of municipal company. Having employed the firm-level data, there was found that AHP is methodologically adequate technique of comparing of difficulty and arduousness of company's jobs. AHP is especially applicable where there are complex decision-making processes, which in relation to job evaluation refers to a relatively large number of positions to be compared with each other. Basing upon multiple experts knowledge a clear hierarchy of difficulties and arduousness of work in individual positions was agreed. So this approach, which includes teamwork and all aspects of employee, is in line with the key practices of

TQM (Pratima et al., 2022, Srinivasaiah et al., 2023).

Further research in the studied municipal enterprise ought to identify whether the ranking of positions developed using AHP is consistent with the results of analytical job evaluation. The direction of further research defined in this way, on the one hand, results from the need to verify the ranking of positions using AHP. On the other hand, it directly results from the methodology of job evaluation, which assumes that prior to starting the analytical job evaluation, a ranking of the evaluated positions should be developed (Armstrong et. al., 2005). Such a ranking, developed by company employees (working as a team) who have in-depth knowledge of the work content of the evaluated jobs, is to reflect the generally accepted hierarchy of difficulty and arduousness work difficulties in the company. It should be remembered that the remuneration system developed on the basis of the results of work evaluation is a social contract at the enterprise level. In other words, the hierarchy of work difficulties of individual positions, and ultimately differences in pay levels must be acceptable to employees and fair.

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Jelena Jovanović

## AN APPROACH FOR BUSINESS- MANUFACTURING SYSTEMS MODELING IN ORDER TO APPLY OPTIMIZATION PROCESSES

**Abstract:** *The optimal production program is based on the assumption that there are quantitative measures of comparison with other admissible solutions, and is often a compromise between the desired goals and constraints which act as a condition for achieving extreme solutions. The importance of optimization of the production is significant because it is the basis for all other plans. The purpose of this paper is to propose an approach for modeling the business-production system in order to determine the optimal production program. The paper deals with the applied simulation and optimization processes by which the mentioned system can lead to optimum-required state. A mathematical model was defined using the linear programming method and the results were presented using the Mathematica software package.*

**Keywords:** *Optimization, Production program, Software package Mathematica*

### 1. Introduction

Business-manufacturing systems (BMS) belong to a group of organizational, complex, dynamic, stochastic, and open systems, and as such, tend towards their own degeneration if various approaches to the application of optimization processes are not continuously implemented.

The question of the production program is of strategic importance for the business, survival, and development of BMS. It is natural for managers to aim for an expected-desired state that is also optimal. However, desires are always hindered by constraints that must always be taken into account when applying optimization methods and techniques. In market business conditions, the production program represents the result of the optimal use of production potentials while respecting real market constraints. If the BMS has "excess" capacity, it means that

it is not optimally utilizing its capacity through specific contracts, and it is necessary to determine the reason for this through appropriate expert teams. If there is a "shortage" of capacity, it means that the demand is greater than the production capacity. Then, it is necessary to identify "bottlenecks" in production and remove them through more efficient organization or investment, thus creating conditions for fulfilling contractual obligations.

The researchers aim to define a mathematical model that enables finding optimal solutions at different levels of management and from different aspects. According to Joppen et al. (2019), the biggest challenge is optimizing the overarching production planning and the lack of an overall optimum. The following methods are most commonly applied for production planning: LP (linear programming), NLP (nonlinear programming), and MILP (mixed integer

linear programming) (Kallrath et al., 2005). Numerous studies deal with this issue, and a small part of it is presented in this paper.

Joppen et al. (2019) present a practical framework for optimizing production management processes, which represents a holistic approach to optimizing production planning and control processes. Their framework describes how conflicting objectives can be systematically analyzed and how a reasonable operational status can be derived. The authors address issues related to medium and short-term production planning, including defining goal analysis, initial state analysis, and optimization.

Trachenko et al. (2021) developed an economic-mathematical model for the rational formation of a business process management system in the engineering services sector, taking into account the time factor. The results of using the optimization model for the management of business processes such as design, electro-maintenance, production of electrical equipment, commissioning and adjustment, and consulting were presented.

Hervert-Escobar & López-Pérez (2020) propose an optimization model that maximizes the fulfilment of requirements, taking into account typical constraints from production planning formulations, as well as production constraints in real-life scenarios such as limited product changeovers and minimum machine run lengths. The authors utilized a mixed-integer programming model.

Various models can be found in the literature, such as: a model (two linear programming models) for maximizing Net Present Value (Petridis et al., 2020); a model for minimizing the aggregate production costs (Golari et al., 2017; Naeem et al., 2013); a model for optimizing the input technical effectiveness and efficiency of production process (Donini & Barbiroli, 1997); a mixed integer linear programming

model for optimizing the placement of composite parts in an autoclave (Dios et al., 2017); a mixed integer linear programming model for integrating production, inventory, distribution, and routing decisions in a single framework (Miranda et al, 2018); a model for finding the optimum production rate in factories that use seasonally produced raw materials (Kioulafas & Kapralos, 1980); a fuzzy multi-objective linear programming model that formulates the problem of mold production and outsourcing decisions (Wang et al., 2013); a cost model for evaluating the cost and benefit analysis of implementing Industry 4.0 elements in the production plant (Alami & ElMaraghy, 2021).

This paper aims to propose a different approach for modeling BMS in order to determine the optimal production program from the perspective of maximum utilization of available workforce capacity, within a one-year time interval, and to strive to describe the production system, as a hierarchical system with multiple levels, by a mathematical model. A mathematical model will be defined for the selected business-production system, using the method of linear programming, and the results will be presented by applying the Mathematica software package.

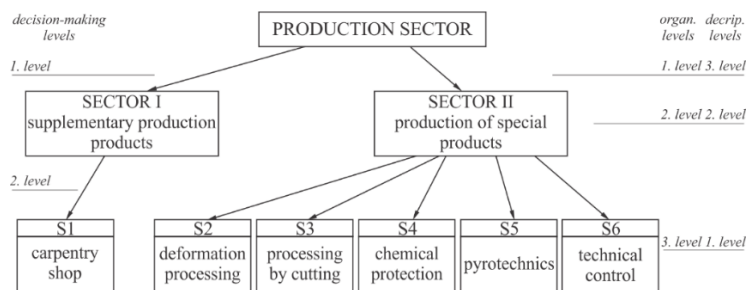
## 2. Defining the Mathematical Model

We can explore the optimal production program at the level of the BMS as a whole or at the level of its subsystems. If we model the BMS as a system that cannot be further broken down, then we determine the optimal production program at one level. The corresponding parameters in the mathematical model are usually grouped at the product level and constraints at the level of the system as a whole. However, optimizing the production program of a BMS by considering it as a complex system, consisting of multiple subsystems (possible

horizontal and vertical decomposition), is a much more complex task. The question arises whether the optimum at the system level is also the optimum at the subsystem level, i.e., whether there is a unity of goals between subsystems and the system as a whole.

When studying and modeling hierarchical systems, it is necessary to define organizational levels, description levels, and decision-making levels. Constraints in the model are closely related to organizational levels, management criteria for decision-

making levels, and corresponding parameters in the mathematical model can be grouped at the level of products, parts, or technological variants of production. The long-term aspect of the production program is usually based on assumptions and predictions, where qualitative elements prevail. Short-term production program planning is based on facts, with quantifiable elements prevailing. Depending on the adopted concept of programming orientation, from prediction to short-term planning, various methods and techniques can be used.



**Figure 1.** Hierarchical representation of the selected BMS Defining the coefficients in the mathematical model

As the goal of this paper is to determine the optimal production program from the perspective of maximizing the use of available workforce capacity and to describe the production system using a mathematical model, the most suitable method is linear programming (LP). The advantage of using this method is that there is a well-developed procedure (method) for solving such problems. However, it should also be noted that the application of LP is based on the assumption that relevant variables are deterministic, which does not correspond to reality, as they are stochastic variables. In this context, it is necessary to thoroughly investigate all parameters that are included in the model and perform a sensitivity analysis so that the obtained solution has practical value. The application of the LP method involves defining a mathematical model consisting of an objective function or

management criterion and a set of constraints. Figure 1 shows a system model in the form of a graph, with a hierarchical arrangement of subsystems and connections between levels. Vertical decomposition is performed with three organizational levels, three levels of description, and two levels of decision-making. The mathematical model for production optimization in the matrix form is presented by equations (1) – (4). Relation (1) represents the objective function that needs to be maximized, taking into account the optimal solution from the perspective of maximum utilization of available production human resources. Constraints (2) define the available production human resource capacities (B), while constraints (3) define the minimum (D) and maximum (G) market demands. To apply software tools, it is necessary to

represent the mathematical model in an expanded form.

$$\max F(x) = C \cdot X \quad (1)$$

$$A \cdot X \leq B \quad (2)$$

$$D \leq X \leq G \quad (3)$$

$$X \geq 0 \quad (4)$$

The mathematical model enables finding optimal solutions at the system level as a whole (first decision-making level, third description level), with constraints on the available human resources defined at the third organizational level (level of work units). The production plan includes 41 products ( $X_i$ ). To define the coefficients (elements of matrices C, A, B, D, and G) in the mathematical model, it is necessary to determine: total manufacturing time at the product level ( $c_i$ ); manufacturing times for current products by work units ( $a_{ij}$ ); available potential of production human resources ( $b_i$ ), in accordance with Relation (5); market absorption capacity ( $d_k$  and  $g_k$ ). If market constraints are not included in the mathematical model, it is assumed that everything produced can be sold.

**Table 1.** Overview of the necessary data for the calculation of the coefficients  $b_i$

$S_i$	$z_i$	$p_{ni}$	$\eta_{ri}$	$b_i$
S1	85	1,10	0,75	135166
S2	182	1,22	0,75	320987
S3	235	1,19	0,74	398879
S4	38	1,19	0,73	63628
S5	222	1,18	0,72	363549
S6	71	1,25	0,71	121457
$D_r = 257$ (work./yr), $C_s = 7,5$ (h/shift)				

Table 1 shows an overview of available workforce capacities per work unit ( $S_i$ ) i.e. the coefficients  $b_i$  in the mathematical model are defined.

$$b_i = z_i \cdot \eta_{ri} \cdot D_r \cdot C_s \cdot p_{ni} \quad (5)$$

Where:  $D_r$  - total number of workdays (workdays/ $\tau$ ),  $C_s$  - projected effective working hours per shift (h/shift),  $z_i$  - total number of production workers (workers/ $\tau$ ),  $p_{ni}$  - average norm-hour execution for the

observed organizational unit and time period,  $\eta_{ri}$  - productive human resources utilization level.

**Table 2.** Input data for defining the mathematical model

$X_i$	$d_k$	$g_k$	$c_i$
1	2	3	4
X1	5000	18000	0,51203
X2	500	5000	0,28000
X3	5000	17000	0,35000
X4	7000	7000	0,51203
X5	200	2200	0,40789
X6	9000	20000	1,75969
X7	10000	34000	1,45700
X8	12000	67000	1,45700
X9	39900	40000	2,898
X10	21300	21500	2,99500
X11	16800	17000	2,36516
X12	50000	115500	2,27764
X13	300	8500	0,43236
X14	700	28500	2,41000
X15	1000	56700	2,29300
X16	100	1200	2,20300
X17	800	3500	2,04563
X18	900	5500	3,22500
X19	4500	15500	2,79258
X20	35400	35600	0,05568
X21	35400	35600	0,02655
X22	3000	17800	1,60858
X23	500	5500	0,29800
X24	1600	11000	0,30100
X25	500	6000	0,59100
X26	700	3100	0,91900
X27	30	300	1,69500
X28	3000	17900	0,65600
X29	20000	75000	0,61955
X30	200	5000	1,25400
X31	70	2500	0,77100
X32	70	2500	0,64300
X33	70	2500	0,73820
X34	120	1250	9,48600
X35	700	6500	17,51300
X36	3928	9000	16,65867
X37	600	5500	9,85520
X38	30	650	10,32450
X39	300	850	12,01230
X40	90	1000	5,42150
X41	30	350	3,50000

By analyzing the trend of the achieved production over a period of five years, respecting the average values, minimum and maximum constraints were determined (Table 2, columns 2 and 3). In Table 2, column 4 shows the elements of matrix C, Relation (1).

Due to limited space the coefficients  $a_{ij}$  in Objective:

$$\max F(x) = 0,51203x_1 + 0,28x_2 + 0,35x_3 + \dots + 2,203x_{16} + \dots + 5,4215x_{40} + 3,5x_{41} \quad (6)$$

Production human resource constraint  $j = \overline{1,6}$ :

$$\begin{aligned} 0,017409x_1 + 0,00896x_2 + 0,021x_3 + \dots + 0,173488x_{40} + 0,112x_{41} &\leq 135166 \\ 0,087045x_1 + 0,0448x_2 + 0,0805x_3 + \dots + 0,742745x_{40} + 0,4795x_{41} &\leq 320987 \\ 0,095238x_1 + 0,0532x_2 + 0,06545x_3 + \dots + 1,116829x_{40} + 0,721x_{41} &\leq 398879 \\ 0,06554x_1 + 0,0434x_2 + 0,06755x_3 + \dots + 0,623472x_{40} + 0,4025x_{41} &\leq 63628 \\ 0,186891x_1 + 0,10444x_2 + 0,07x_3 + \dots + 2,087278x_{40} + 1,3475x_{41} &\leq 363549 \\ 0,059907x_1 + 0,0252x_2 + 0,0455x_3 + \dots + 0,677688x_{40} + 0,4375x_{41} &\leq 121457 \end{aligned} \quad (7)$$

Market constraints  $j = \overline{7,88}$ :

$$\begin{aligned} x_1 \leq 18000; x_2 \leq 5000; x_3 \leq 17000; \dots x_{40} \leq 1000; x_{41} \leq 350; \\ x_1 \geq 5000; x_2 \geq 500; x_3 \geq 5000; \dots x_{40} \geq 90; x_{41} \geq 30; \end{aligned} \quad (8)$$

### 3. Results and Discussion

To secure optimal solutions, the use of various software tools can be employed (Grenci, 2022; Cecílio & dos Santos, 2018). In this paper, a program written in the Mathematica software package is used. The program is designed to provide not only optimal solutions at the output (Relation (9)) but also a capacity analysis (Table 3) that indicates the presence of unrealistic constraints and unused capacities. The optimal production program engages 525236 h/year, which represents 37,42 % of the available human resources potential of 1403666 h/year.

Degree of engagement of the workforce at the level  $S_i$ :  $S_1$  - 14,84%,  $S_2$  - 24,83%,  $S_3$  - 27,29%,  $S_4$  - 100%,  $S_5$  - 53,51%,  $S_6$  - 48,11%.

the mathematical model are not shown in the paper.

The mathematical model for optimizing the production program from the aspect of maximizing the use of available workforce capacities by subsystems  $S_i$  while respecting market constraints has the following form, Relations (6-8):

**Table 3.** Part of the results of capacity analysis

Constraint	Planned Capacity	Unused Capacity
135166	20065,10	115100,90
320987	79704,90	241282,10
398879	108847,00	290032,00
63628	63627,30	0,70
363549	194548,00	169001,00
121457	58438,60	63018,40
18000	5000	13000
5000	500	4500
⋮	⋮	⋮
120	120	0
700	700	0
3928	3928	0
600	600	0
30	30	0
300	300	0
90	90	0
30	30	0

$$\{525236, \{x_1 \rightarrow 5000, x_2 \rightarrow 500, x_3 \rightarrow 5000, x_4 \rightarrow 7000, x_5 \rightarrow 200, x_6 \rightarrow 9000, x_7 \rightarrow 10000, x_8 \rightarrow 12000, x_9 \rightarrow 40000, x_{10} \rightarrow 21500, x_{11} \rightarrow 17000, x_{12} \rightarrow 50000, x_{13} \rightarrow 300, x_{14} \rightarrow 700, x_{15} \rightarrow 1000, x_{16} \rightarrow 100, x_{17} \rightarrow 800, x_{18} \rightarrow 900, x_{19} \rightarrow 4500, x_{20} \rightarrow 35600, x_{21} \rightarrow 35600, x_{22} \rightarrow 3000, x_{23} \rightarrow 500, x_{24} \rightarrow 1600, x_{25} \rightarrow 500, x_{26} \rightarrow 700, x_{27} \rightarrow 30, x_{28} \rightarrow 3000, x_{29} \rightarrow 20000, x_{30} \rightarrow 200, x_{31} \rightarrow 70, x_{32} \rightarrow 70, x_{33} \rightarrow 70, x_{34} \rightarrow 120, x_{35} \rightarrow 700, x_{36} \rightarrow 3929, x_{37} \rightarrow 600, x_{38} \rightarrow 30, x_{39} \rightarrow 300, x_{40} \rightarrow 90, x_{41} \rightarrow 30\}\} \quad (9)$$

#### 4. Conclusion

By applying simulation and optimization processes, it can be concluded that it is necessary to redistribute production human resources in order to increase the utilization rate of the workforce with the optimal production program. The optimal production

program engages 525236 h/year, which represents 37,42 % of the available human resources potential of 1403666 h/year. Since the established model has "surpluses" of capacity, it is necessary to redistribute the production of human resources in order to increase the degree of engagement of the available workforce.

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Dariusz Raś<sup>1</sup>

## THE NEW MULTICRITERIA-BASED MODEL FOR QUALITY ASSESSMENT OF WRITTEN MEDIA MESSAGES - PERSPECTIVES FOR APPLICATION

**Abstract:** *Media messages are any form of communication delivered to the audience, broadcasted in written, oral or visual form. They may include TV shows, web pages, advertisements, news stories, blogs or social media posts, inter alia. At present, facts are no longer the paradigm of journalism. They are often replaced by short messages constructed on the basis of biased or emotional content. In addition, commercial value of news and digitization of resources have also changed the formation of texts and images. They are built using entries posted on Facebook or Twitter (often by fake accounts), instead of face-to-face interviews, participant observation, or citing primary sources and opinions. On the other hand, there are numerous discussions on the quality of data and information, also in the context of journalism. Although there is no agreement whatsoever as to the factors contributing to high-quality communication, the author attempts to demonstrate a new model for quality assessment of written media messages. It comprises four main groups of quality factors, namely: 1) information, 2) linguistic, 3) publishing, and 4) useability. Each group consists of specific criteria, which are analyzed with respect to different media content. Its potential of application for quality assessment of press and social media will be discussed.*

**Keywords:** *media messages, quality assessment, quality of journalism, multicriteria model*

### 1. Introduction

The contemporary world is characterized by a wide variety of messages and their providers (senders). Paradoxically, the phenomenon of online loneliness is observed in the information noise, and social media often create isolating media bubbles. On the other hand, in the practice of large newsrooms, perfectly optimized content is

displayed by a large number of users. "Reach" journalists, or rather "media workers", can guess the audience's needs on their own, or being supported by artificial intelligence (AI), i.e. they can anticipate their enthusiasm or irritation. This process has intensified in the last decade.

AI, which is used more and more commonly in the news making process, does not protect the originality of opinions and the

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truthfulness of information. The most important thing is the clickability of the material. Click-through rate is a big nuisance for many contemporary journalists, which makes it necessary to prepare the material in advance, with the content of keywords best targeted at the tastes of the target audience, and most often omitting issues such as reliability, non-conformity, and sometimes even human dignity. Many observers believe that with further intensification of this process, tools such as ChatGPT will soon displace people from the creative process in the media. Click-through rate as a criterion will become the most important factor in evaluating the communication processes.

Therefore, the selection of information and opinions becomes a serious problem, not because of the “loudness” of the title and the emotions it evokes, but because of their internal quality: consistency, reliability, originality, journalistic sovereignty of thinking, social commitment, concern for the common goodness, creative attitude towards the work performed, etc. That is why this paper is looking for a multi-criteria measure of journalistic quality, a method that will indicate content that is worth following and then recommending to the audience both in real life and online. Although the dependence on intelligent technologies in communication is huge nowadays, it is necessary to reflect on the quality of journalism, and not only on the perfectly optimized and “clickable” content.

In the literature, a lot of space has been devoted to research on the quality of journalistic messages. As quality is a multidimensional concept, these are usually interdisciplinary projects, covering areas such as quantitative and qualitative content analysis, linguistics, multi-criteria analysis, data mining and many others (Raś 2023). The aim of this research is to demonstrate a new model for assessing the quality of press articles and the possibilities of its application to different types of press materials.

## 2. State-of-the-art knowledge on the quality of media messages

The literature on the quality assessment of media messages can be categorized in two main groups. First of them refers to the factors revolving around “quality journalism”, which is defined as “journalistic excellence” and described by values such as i.a. truth/facticity, 2) relevance/context, and 3) independence. However, these factors are multidimensional; for example, truth/facticity consists of diversity, transparency, interactivity and clarity of language and style (Meier 2019).

The second group of research papers refers to content quality assessment (CQA) based on the pre-established criteria. For example, Chai *et al.* (2010) provides a CQA framework for social media. It consists of Information Quality (IQ) dimensions which comprise factors such as i.a. *user feedback, amount of data, reputation, objectivity, relevancy, reliability, completeness, accuracy, timeliness, understandability, value-added, consistency, security and accessibility.*

Similar criteria may be also found in other, non-media contexts such as data quality assessment and the meaning of quality for data consumers. One of the first research attempts in this area was undertaken by Wang and Guarascio (1991), who identified 20 data quality attributes. This model was elaborated in the subsequent publications by Wand and Wang (1996) and Wand and Strong (2015), *inter alia*. The quality attributes distinguished by this group of researchers have been selectively used in studies related to the quality of databases and information systems.

According to Batini *et al.* (2009), they provided several important classifications of data quality criteria, allowing to distinguish a set of four key attributes most commonly described in the literature. They include:

*accuracy, completeness, consistency, and timeliness.* Other studies such as the report by DAMA (2003) described six criteria for assessing the quality of information in databases, calling them *basic* (primary). In addition to the four above, they distinguished *uniqueness* and *validity*. Additional features mentioned in this report include usability, flexibility, trust in data and data value. Sidi *et al.* (2012) additionally distinguished, on the basis of the literature review, over 20 additional data quality dimensions, including *accessibility, availability, security, effectiveness, efficiency, reliability, objectivity* and *ease of use*. The literature does not provide a universal set of data quality dimensions. Multiple discrepancies in types and definitions of the quality characteristics are due to the contextual nature of data quality.

As regards the quality criteria (QC) of written media messages specifically, little research has been done in this area. Pulikowski (2007) developed a framework for assessing Internet documents, which consists of two fundamental criteria: *usability* and *reliability*. The usability criterion is explained by *content* and *timeliness*, while reliability - by *authorship, goals, objectivity (impartiality)* and *correctness*. Although it can be useful in assessing some media messages, this model is insufficient to assess press releases, especially coming from the newspapers.

Comparing the quality of messages with a homogeneous thematic context, especially in the context of the press or Internet content, becomes necessary considering the contemporary tools, such as AI, supporting (or replacing sometimes) journalistic work. It seems necessary to verify such “artificial” outcomes. In response to this research gap, the study was conducted to develop a new, versatile, multicriteria-based framework for assessment of written media messages published in printed and online form.

## 3. Model and methodology

### 3.1. Building the model

The new model has been developed based on the thorough review of literature and preliminary tests on newspaper articles dated from 1865 to 2023. It has a hierarchical structure consisting of four fundamental quality dimensions: *Information, Linguistic, Publishing* and *Useability* (**Figure 1**).

**Informational quality** consists of seven criteria: *timeliness, accuracy, reliability, credibility, consistency, uniqueness, and completeness.* *Timeliness* refers to the question whether the press material appeared at the time of the event or contains information current as of the date of its publication. *Accuracy* indicates that content of the material contains details showing or describing the actual state of the event in question. *Reliability* means that the information in the press release is supported by appropriate and properly cited sources of information, either from a clearly identified and cited source or from a witness. *Credibility* indicates that the information comes from a reliable source and/or author. *Consistency* shows whether the press material is internally consistent and does not contain contradictory information. As regards *uniqueness*, it refers to unnecessary duplication of information inside a given material and/or across other press messages released at the same time. Finally, *completeness* is to measure whether the material properly explores a given topic in relation to the press genre it represents.

**Linguistic quality** comprises three criteria: *concise, readability and beauty of the language.* *Concise* means that the press material contains the right amount of information in relation to the genre it represents and the topic addressed. It refers to the so-called economy of the message, or its appropriate level of condensation. *Readability* defines the correctness in terms

of language and style, lack of different errors, and the proper organization of the content. *Beauty of the language* reflects the aesthetics of the text, which can be the source of so-called “aesthetic pleasure” for the reader.

**Publishing quality** consists of three characteristics: objectivity, relevance and attractiveness. *Objectivity* is a multidimensional criterion, indicating that the material clearly separates facts from opinions and its content is balanced. Based on its reading, it is impossible to notice any likes, worldviews and/or interests of the author. *Relevance* shows the matching of the content and headline to the press genre and nature of the event. *Attractiveness* means that the material (its content, title and lead) attracts the recipient's attention and makes them want to read it.

**Useability** is the quality dimension consisting of two features: *usefulness* and *availability*. *Usefulness* indicates that the

material contains information useful in some way to the recipient and/or sender and their decision-making processes. *Availability* shows the easiness of the material to obtain, retrieve and analyze.

### 3.2. Deriving weights using PC method

The application of the above model in assessment of media messages requires prioritization of QC. There are numerous multicriteria-based methods used to derive weights and produce relevant ranking of alternatives. One of them is the analytic hierarchy process, a PC-based (pairwise comparison) tool which allows analysis of complex hierarchical structures (eg. Kułakowski 2020). This method starts from building a hierarchical model (as shown in Figure 1), which is divided into groups of parent-children criteria, and analyzed using a 9-point, fundamental scale enabling comparison of two alternatives at a time.

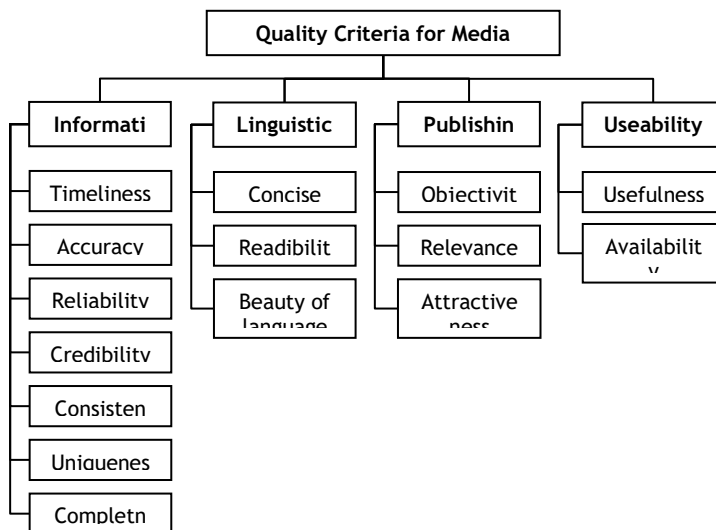


Figure 1. QAC for media messages

Assuming two elements being compared, *A* and *B*, the respondent has the following possibilities:

- *A* and *B* are equally important (value of intensity: *I*),
- *A* is of moderate importance over *B* (or: *B* over *A*) (3),
- *A* is of strong importance over *B* (or: *B* over *A*) (5),
- *A* is of very strong (essential) importance over *B* (or: *B* over *A*) (7),
- *A* is of absolute (extreme) importance over *B* (or: *B* over *A*) (9),
- intermediate values (2, 4, 6, 8) used if dominance of one alternative over another fits in somewhere between scale degrees of 1, 3, 5, 7 and 9.

Results of the comparisons are introduced into the *PC* matrix, which is always a square matrix with “1” in diagonal (an element compared with itself has always “the same importance”). All the entries above the main diagonal are the reciprocals of the entries below the diagonal (Table 1).

**Table 1.** Example of *PC* matrix

	A	B	C	D
A	1	3	1/3	7
B	3	1	8	5
C	1/3	1/8	1	3
D	1/7	1/5	1/3	1

The *PC* matrix allows us to derive the ranking vector of priorities (weights), which sums up to one:

$$w = [w_1, w_2, w_3, \dots, w_n]$$

The analysis can be performed using a number of prioritization procedures, such as eigenvector (*EV*), geometric mean (*GM*) or arithmetic mean (*AM*) method (Prusak 2017). In addition, each *PC* matrix should be tested for consistency based on the following formula:

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

where *CI* is Consistency Index,  $\lambda_{max}$  is the largest eigenvalue of the matrix, and *n* is the number of alternatives in a group being compared against each other. The final Consistency Ratio (*CR*) is calculated by dividing *CI* by the so-called random index (*RI*):

$$CR = \frac{CI}{RI}$$

where *RI* is a fixed, tabulated value for *n* = 3, ..., 15. For example, for *n*=4, *RI*=0,86. A matrix is consistent for *CR*<0,10, otherwise it is inconsistent and the judgments should be modified or repeated (eg. Vargas 2008).

For consistent results one can calculate the so-called global priorities. In multi-level hierarchies, global values are calculated as multiplication of weights of the main (parent) criteria and their (children) subcriteria. Additionally, if *PCs* are made by a group of respondents, the priorities (weights) derived for each of them can be aggregated into a common vector (Prusak and Stefanów 2014).

## 4. Results and discussion

As the AHP is an expert method (experts are individuals whose opinions can be used for final recommendations), three experts (two academic and one practitioner) in the area of journalism and media research were selected to evaluate the hierarchical model. The results were aggregated using a geometric mean method and presented as a percentage values in Table 2 and Table 3.

**Table 2.** Priorities for quality domains

Domain	Priority
Informational	0,3501 (35,01%)
Linguistic	0,1373 (13,73%)
Publishing	0,2298 (22,98%)
Useability	0,2827 (28,27%)

**Table 3.** Priorities for quality criteria (QC)

QC	Local	Global
Timeliness	0,0764	3,39%
Accuracy	0,2511	10,31%
Reliability	0,1941	5,49%
Credibility	0,2778	9,83%
Consistency	0,0742	2,19%
Uniqueness	0,0619	2,03%
Completeness	0,0645	1,76%
Concise	0,3515	4,52%
Readability	0,4675	7,24%
Beauty of language	0,1810	1,97%
Objectivity	0,7117	15,70%
Relevance	0,1777	4,24%
Attractiveness	0,1105	3,05%
Usefulness	0,7806	23,38%
Availability	0,2194	4,89%

The analysis shows that the matrices were highly consistent for all the experts, with CR ranging from 0,00 to 0,09. In one case CR=0,20, but after additional considerations it was accepted for further analysis as the inconsistency was at tolerable level (Wedley 1993). The priorities derived for quality domains clearly indicate that *Information* is the most important feature in quality assessment of media messages ( $w=35,01\%$ ), followed by *Useability* ( $w=28,27\%$ ). Within the domain of *Informational quality*, the most important QC is *credibility* ( $w=27,78\%$ ), and within the *Linguistic* domain, *readability* received the highest priority value ( $w=46,75\%$ ). As regards global QC ranking, *usefulness* and *objectivity* contribute the most to the quality analysis of media messages with priority values of 23,38% and 15,70%, respectively. It was followed by *accuracy* ( $w=10,31\%$ ) and almost equally significant *credibility* ( $w=9,83\%$ ). Such results can be explained by the common attitude towards practicality, usefulness, usability and information accuracy (which sums up to 38.58%). News regarding the daily weather forecast supports the recipient in choosing appropriate clothes. The media shows the public debates and

periodically supports electoral decisions at various levels of government, and provides economic information which supports customers in their decisions on a daily basis. It is also not surprising that the desired attitude towards objectivity and credibility of messages is observed (25.53% in total), which in everyday life is associated with authenticity and truthfulness, most often with regard to the collected information and its impartial representation. The key element here is a credible source of information, on the basis of which a multilateral or multifaceted opinion on a given topic is provided. Nowadays, access to the possibilities of creating information is almost unlimited, and some of it can simply be written with the use of “poisoned sources”. Therefore, in qualitative analyzes these four aspects of the assessment are strongly emphasized, which together account for almost 2/3 of the importance (64.11%) of written journalistic texts.

## 5. Conclusions and implications

The objective of the current research was to develop and demonstrate the analysis of a new, multicriteria-based framework for assessment of written media messages published in printed and online form. The model can be further employed to assess a number of press materials. As it would be difficult to use AHP for such an analysis (due to a limited number of PCs that can be performed effectively), each criterion can be operationalised using eg. five questions for “yes” or “no” answers. It would allow using another multicriteria analysis (ia. TOPSIS) to objectively rank the selected materials according to their quality.

New tools supporting the work of the media, such as ChatGPT, will probably gain more and more importance due to the generated click-through rate and usefulness of their materials. However, the increase in the

number of press releases generated by AI benefits primarily online aggregators and large technology platforms that have access to a wide range of information consumers. Such a complicated and rapidly changing world of written media messages needs deep quality-related narratives that will explain this complexity.

The research on the quality of written messages offers a protection tool, under

which publicists and journalists will still be able to reveal the secrets of people in power, politics, economy, judiciary, public administration, in the name of independence and journalistic quality. Click-through rate, however, cannot become the only or the most important criterion for evaluating information and opinion-forming messages.

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## ASSESSMENT OF SERVICE QUALITY USING SYNERGIES OF FUZZY SERVQUAL, FUZZY KANO'S MODEL, AND FUZZY ANALYTIC NETWORK PROCESS INTO QFD

**Abstract:** *The essence of banking service will always be service quality. To gain customer satisfaction, enhance market rivalry, and achieve sustainable performance. The primary goal of this article is to identify the primary factor contributing to high customer dissatisfaction and poor service quality in bank services. This article synergies fuzzy SERVQUAL, fuzzy Kano model, and fuzzy analytic network processing into QFD. Structured survey questions based on SERVQUAL and Kano models were developed and disseminated to collect data. According to the findings, the bank should offer the promised service within the time range, respond to client concerns immediately, and supply appropriate service within the time frame. Furthermore, an employee should give timely care to the client; the employee should never be too busy to respond to customer demands and inform the consumer when service is delivered. In conclusion, focusing on customer requirements can enhance the bank's service level, which increases customer satisfaction.*

**Keywords:** *Customer Satisfaction, Fuzzy SERVQUAL Model, Fuzzy Kano's Model, Fuzzy ANP, QFD, Service Quality*

### 1. Introduction

In today's competitive market, businesses lose customers owing to the poor quality of services or products they provide (Tsfaye, 2015). Meanwhile, the primary reason for client loss is that service providers frequently fail to adequately comprehend their customers' expectations, resulting in dissatisfaction with the service they receive. However, to overcome these issues, service providers must focus on customer service (Berushie, 2014). Hence, "the longer a customer stays with a bank, the more utility the customer generates" (Kebede, 2017). According to Basari & Shamsudin (2020); Hamzah & Shamsudin (2020); and Ilias & Shamsudin (2020), customers recreate a

significant persona in business performance. In line with this, customer satisfaction increases as the quality of services/products offered by the firm advances (Hasfar et al., 2020).

Johnston & Clark (2001), cited in Goldstein et al., (2002), define and pinpoint the concept of services in the following ways: Services operations: a method of extrading services; services experiences: the client directly uses the services; services outcomes: the welfare and success of the services; the value of the services: the benefits the client perceived to be inherent in the service's consideration of the service's cost. Furthermore, Grönroos (2001) defines the service concept as "an idea of how the quality-generating resource should function

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and what result they should achieve for the customer." On the other hand, Hernon & Nitecki (2001) define service quality from a different perspective; these include excellence, value, conformance to specification, and meeting or exceeding expectations. Also, Ramya et al., (2019) describe service quality as the capacity of a service provider to satisfy clients in a way that improves its commercial performance. The services sector encompasses a diverse and complex range of businesses and initiatives. Subsequently, Ghobadian et al., (1994) sort the services sector into three categories: national and local government, which includes areas like education, health, social security, police, military, transport, legal, information, and credits; non-profit private services, which includes institutions like charities and churches; mutual societies and art foundations; and for-profit private services, which includes utilities, hotels, airlines, architects, restaurants, solicitors, retailers, entertainment, banks, insurance companies, advertising agencies, consulting firms, market research companies, and communications. In short, several different types of research were done to determine what aspects affect service quality in the banking industry. For example, Gebre (2017) primary causes of poor service quality in the banking services sector are a lack of customer database management and inadequate infrastructure and technology. Furthermore, "employee competence and skills, the reliability of the electronic system, the reliability of the service system, the impeccability of the banking system's integrity, and the accountability instrument were among the other factors that affected the excellence of service quality of the bank services" (Pourmohammad et al., 2016). However, despite extensive research on the many facets of service quality, no study provides solid advice on how customer-oriented service businesses could raise customer satisfaction by combining various

quality measurement tools with customer-oriented approaches. Therefore, this article uses an optimal decision framework for bank services based on the synergies of fuzzy SERVQUAL, fuzzy Kano's model, and fuzzy analytic network processing into the QFD model.

## 2. Literature Review

### 2.1 Service Quality

Concepts of service quality have been contested for centuries and are still a prominent area of study today. In many academic works of literature, service quality is also primarily defined in terms of the superiority of the service (Gera et al., 2017; Marković et al., 2015). Harvey & Green (1993) summarized quality into two distinct relative concepts: first, quality has multiple meanings for different individuals, and second, quality is related to "process" or "outcomes." As a result, they reflected exceptional quality, fitness for purpose, value for money, and transformative. Considering this, the concept of quality leads to a meeting between what customers expect and perceive (Saghier & Nathan, 2013). Ghobadian et al., (1994) categorized the definition of quality into five broad categories based on how crucial they are to service businesses, including transcendence, product, process or supply, customer, and value approaches. While Mackay & Crompton (1990) defined service quality as "the relationship between what customers desire from a service and what they perceive that they receive." On the other hand, Lenka et al., (2009) specified that service quality is the discrepancy between customer expectations and perceived service. Accordingly, Elmayer (2011) defines the degree of service quality from the customer's perspective, and there is a relationship between anticipated and perceived service quality. Likewise, Sawant (2016) defines

service quality as "the overall assessment of service by the customer." Ali (2018) stated that definitions of service quality differ and are subject to various models, customer expectations, and satisfaction. Following that, Gupta et al., (2018) defined service quality as "the consumer's level of satisfaction from the service encounter; the consumer's expectations before taking the service; and how the service is conveyed concurrently." Satisfaction, in particular, is the result of a correlation between consumers' expectations and their views of the service's implementation (Shayestehfar & Yazdani, 2018). Furthermore, meeting or exceeding customers' service requirements will result in higher service quality and customer satisfaction (Uppal, 2019). Given that customer expectations are influenced by their perceptions of a company's image, and corporate image is the outcome of how customers perceive a company, improving the technical and functional quality of service by businesses increases customer satisfaction (Gronroos, 1984). Furthermore, there are two categories of service quality: first, "how" the service is delivered, and second, "what" the final perception of the customer is (Brady & Cronin, 2001; Kang, 2006). Also, Zameer et al., (2015) define a corporate image as "the perception about the organization that the customer holds in their memories." Venetis & Ghauri (2004), currently, operating service businesses consider service quality to be a significant success element; in general, two main mechanisms explain the influence of service quality on profitability: first, service quality is considered a way for service differentiation and competitive advantage to attract new customers and increase market share, and second, service quality is becoming a way for customer retention. Also, Ravichandran et al., (2001) indicated that several techniques were devised to keep customers, but the crux was to improve service quality. Moreover, Sigit Parawansa

(2015) stated that customer retention has four main stages, known as "the four-stage model of loyalty power," such as cognitive loyalty, affective loyalty, conative loyalty, and action loyalty. Service quality is remarkably relevant for the banking industry, as customers typically look for the service they perceive. Successful bank firms prioritize offering higher-quality service than their competitors. Likewise, quality of service is the principal determinant by which banks can invite new customers and helps to retain existing customers (Ahmed, 2017). Service quality has become a critical determinant for every business's survival and competitiveness (Hu et al., 2009). Therefore, service companies should plan, organize, implement, and control the quality system to meet or exceed customer expectations and increase customer satisfaction (Ramdhani et al., 2011). As a further significant causal aspect of company competitiveness, service quality is seen to have a direct bearing on firm costs and profits (Gounaris et al., 2003; Gupta et al., 2018).

## 2.2 Customer Satisfaction

Customer satisfaction has been a popular subject in marketing and academic research. (Cengiz, 2010; Chiguvu et al., 2017; Kombo, 2015; Murugiah & Akgam, 2015; Narteh & Kuada, 2014; Ozatac et al., 2016); and others are examples. Subsequently, Gunasekare (2016) states that "customer satisfaction is a set of feelings or outcomes attached to a customer's experience with any product or service." But nowadays, consumer happiness is a significant precursor to client retention and returning business (Syed, 2019). Also, Hanif et al., (2010) explained that in the telecommunications service sector, if a company wants to be profitable in the long run, it must satisfy its customers by crediting fair tariffs and high customer service, thereby dominating the market. On the other hand, Vásquez et al., (2017) explained that

measuring customer service satisfaction is a method that should be chronic in any company so that they can control the processes and activities executed to enhance their performance. Furthermore, a hospital is a significant healthcare provider and must acknowledge the value of patients' choices; patients call the hospital seeking relevant, high-quality medical care, a safe environment, and moderately sufficient facilities (Singh, 2012). Meanwhile, Manzoor et al., (2019) stated that patient satisfaction is noted as a touchstone to assess the potency of health services given in the hospital. Furthermore, the hotel is a primary hospitality industry and provides customer-confined service. In line with this, the hospitality industry's service sectors must put the customer need first to remain competitive and establish a name for themselves in the market (Pazir & Amin, 2015). Likewise, Luturlean & Anggadwita (2015) highlighted how businesses could use the customer experience management approach to keep customers and increase the intention to revisit. Nevertheless, in the banking service sector, the main component of customer satisfaction is the correlation between the customer, the service provider, and the service they perceive (Saghier & Nathan, 2013). Besides, Bena (2010) discovered two key issues: the criteria for assessing client happiness must be defined first, according to the field of business and the firm's requirements, and second, clients prefer to declare they are pleased or select an indecisive response. Therefore, to compete in the global market, any organization must put customer satisfaction before company profits and other operations. Similarly, customer satisfaction is critical for the continued success of any business (Mekonen et al., 2019). Customer satisfaction is a significant concern for all companies to enhance customer loyalty and design more reliable business performance (Grønholdt et al., 2000). Further, Munusamy et al., (2010)

define customer satisfaction as "global issues that affect all organizations, regardless of their size, whether profit or non-profit, local or multinational." As, Lenka et al., (2009) explained, customer satisfaction is a synergy of their cognitive and affective responses to the service encounter.

### **2.3 Quality Measurement Tools for Customer-Oriented Approaches**

Giannikas et al., (2019) assert that "customer orientation concerns the degree to which an organization focuses on the customer, recognizes their desires and places meeting their needs as a foremost priority." According to previous study findings, the impact of customer orientation, including value-based customer orientation, may be described in terms of two factors connected directly to customer satisfaction Wang et al., (2012) and action-based customer orientation (H. He & Li, 2011). Also, value-based concerns meet customer demand by being aware of the customer's expectations for service quality, which can determine customer satisfaction (Blocke et al., 2011). While action-based approaches emphasize utilizing customer feedback and accommodating it when making organizational choices (Y. He et al., 2011). Accordingly, Dragolea & Ungureanu (2008) explain how an organization's success depends on its capacity to control customer expectations while promoting investment and loyalty. Consequently, to keep its current customers, every organization needs to be customer-centric and open to hearing what they have to say.

#### **2.3.1 SERVQUAL Model**

Several research publications cover the theoretical and practical use of SERVQUAL in a wide range of industrial, business, and non-profit organizations. For example, in the healthcare sector (Anbari et al., 2014; Umath

et al., 2015), higher education (Galeeva, 2016; Ulewicz, 2014), tourism service (Home, 2006), restaurant (Lee & Hing, 1995; Yu-qiang & Jun-jia, 2011), bank (Ilyas et al., 2013; Lau et al., 2013), telecommunication (Alnsour et al., 2014), apparel retail (Bhaskar & Shekha, 2011), public service (Bryslan & Curry, 2001), local government (Donnelly et al., 1995), electronic commerce B2C (Alzola &

Robaina, 2005), business – to – business service (Mehta & Durvasula, 1998), technical and vocational colleges (Akhlaghi et al., 2012) and more. Further, SERVQUAL has a variety of potential applications; it can assist service and retail firms in assessing customer expectations and perceptions of service quality, as SERVQUAL has five universal dimensions (Parasuraman et al., 1988).

**Table 1.** Essential dimensions of service quality

SERVQUAL dimensions	Definitions	Source
Tangible	Physical facilities, equipment, and appearance of personnel.	Parasuraman et al., (1988)
Reliability	Ability to perform the promised service dependably and accurately.	
Responsiveness	Willing to help customers and provide prompt service.	
Assurance	Knowledge and courtesy of employees and their ability to inspire trust and confidence.	
Empathy	Carrying, individualized attention the firm provides its customer.	

SERVQUAL reports respondent responses on their expectations and perceptions of service quality (Prakasha & Mohanty, 2012). Moreover, SERVQUAL contains 22 items (Likert-type) with five dimensions, so each item in the SERVQUAL tool is of two classes: one to measure expectations and, thereby, firms overall within a business, and the second to measure perceptions about the particular company (Mohd. Adil et al., 2013). Accordingly, Robinson (1999) claims that the difference between the two findings provides a gauge for the discrepancy between expectations and perceived service quality, which is performance minus expectations. Following that, for the particular respondent, the service quality for each dimension is determined as follows:

$$SQ_j = \sum_{i=1}^{n_j} \frac{P_{ij} - E_{ij}}{n_j} \quad (1)$$

Where

$SQ_j$  = service quality of dimensions

$E_{ij}$  = expectations of the firms for item  $i$  in dimension  $j$

$P_{ij}$  = perceived performance of the form on item  $i$  in dimension  $j$

$n_j$  = number of items in dimension  $j$ .

However, despite its widespread usage and popularity, SERVQUAL has received several philosophical and practical objections. See, for example: (Babakus & Boller, 1992; Bolton & Drew, 1991; Boulding et al., 1993; Cronin & Taylor, 1992; Genestre & Herbig, 1996; Teas, 1993) As a result, Buttle (1996) categorizes the critiques into two parts: one theoretical (paradigmatic objections, gaps model, process orientation, and dimensionality) and one operational (expectations, item composition, a moment of truth (MOT), polarity, scale points, too much administrative work, and variance extracted).

2.3.2 Kano's Model

Doctor Noriaki Kano, a Tokyo professor, created the Kano model in 1984 to define service quality based on customer satisfaction (Seyedi et al., 2012). In the meantime, customer satisfaction is a one-dimensional operation, implying that the higher the perceived service quality, the higher the customer satisfaction (Kazemi et al., 2013). Perhaps, fulfilling the customer's request does not result in a higher degree of satisfaction from the customer (Mostafa et al., 2013). Based on the Kano model, customer needs were categorized into three phases: basic, performance, and excitement needs (Bhattacharyya & Rahman, 2004).

Similarly, Five kinds of customer satisfaction with a quality attribute exist, such as "must be," "one – dimensional," "attractive," "indifferent," and "reverse" Kurt & Atrek (2012); Lin et al., (2017), and the quality attribute is defined as shown in table 2.

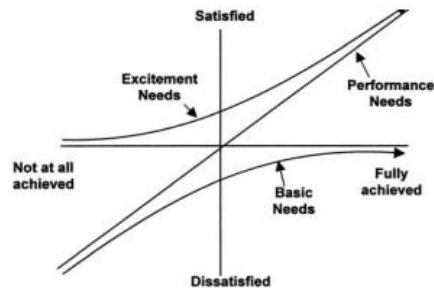


Figure 1. Kano's model.  
 Source: Bhattacharyya & Rahman (2004)

Table 2. Categories Kano's model of quality attributes

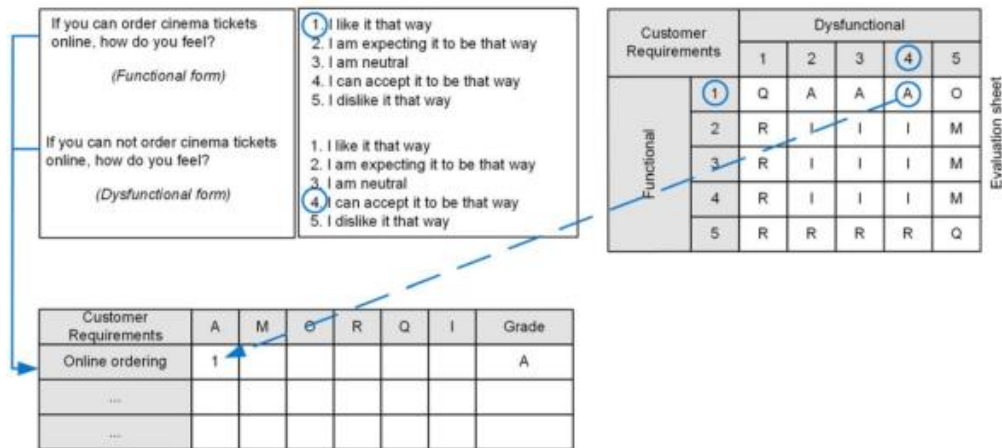
Quality attribute	Definitions	Source
Must – be	“Sufficient quality attributes <i>do not</i> lead to customer satisfaction but insufficient quality attributes lead to customer dissatisfaction.”	(Kurt & Atrek, 2012; Lin et al., 2017)
One – dimensional	“Sufficient quality attributes lead to customer satisfaction but insufficient quality attributes <i>do not</i> lead to customer dissatisfaction.”	
Attractive	“Sufficient quality attribute leads to customer satisfaction but insufficient quality attributes <i>do not</i> lead to customer dissatisfaction.”	
Indifferent	“Sufficient quality attributes <i>do not</i> lead to customer satisfaction and insufficient quality attributes <i>do not</i> lead to customer dissatisfaction.”	
Reverse	“Sufficient quality attributes lead to customer dissatisfaction and insufficient quality attributes lead to customer dissatisfaction.”	

Likewise, to categorize requirements or quality attributes, it is necessary to use Kano's questionnaires, which are sorted into two types, i.e., functional and dysfunctional forms of questions. See, for example, the figure 2 (Madzik et al., pp. 3, 2019).

Numerous research papers consolidate the application of Kano's model in an

assortment of industrial, profit, and non-profit firms (table 3).

But, regardless of the numerous benefits of Kano's model, it may have been criticized for a case in which, Gregory & Parsa, pp -40 (2013) include lengthy questionnaires that exclude the quantitative or qualitative performance of the specific attributes.



**Figure 2.** Categorization of a requirement using the Kano approach.

Source: Madzík et al., pp-3 (2019)

**Table 3.** Analysis of the application of Kano’s model

Author & year	Description	Kano’s quality element	Model type
Madzík et al., (2019)	Understanding customer requirements in higher education	Kano method	CR
HSU et al., (2007)	Capturing passenger’s voice in the airline industry	Kano method	CS
Chiang et al., (2019)	Classifying technological innovation attributes for hotel service	Use synergies of the Kano method, self-importance questioners, and factor analysis	CS
Gregory & Parsa (2013)	Hospitality and Tourism industry	Kano method	CS
Llinares & Page (2011)	Kansie Engineering to evaluate subjective real estate consumer preference	Use synergies of the Kano method, self-importance questioners, and factor analysis	CR
Ma et al., (2019)	Differentiate between future vehicle-driving services	Use synergies of the Kano method, self-importance questioners, and factor analysis	CS
Rozaq et al., (2019)	Assessing customer satisfaction with hospital service quality	Kano method	CS
Velikova et al., (2016)	Identification of wine festival satisfaction drivers	Penalty – Reward Contrast Analysis (PRCA)	CS

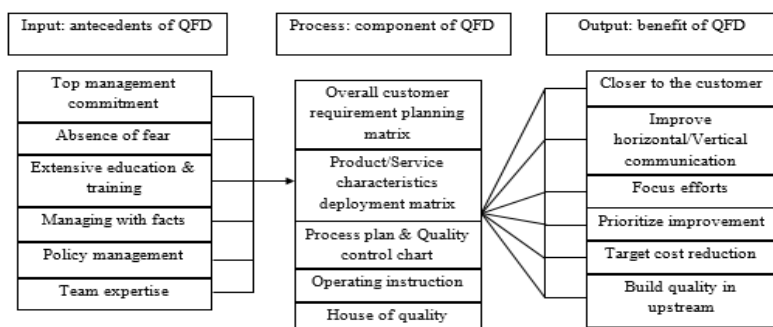
### 2.3.3 Quality Function Deployment (QFD)

Bouchereau & Rowlands (2000) define QFD as “a visual connective process that helps teams focus on the needs of the customer throughout the total development cycle.” Quality function deployment (QFD) is supported by a matrix approach to design

and function the essentials (commencing with customer requirement) upon the way of attaining them (Jagdev et al., 1997). As a result, a set of charts originated to show the connection between client expectations for service attributes and service planning. Likewise, “Quality Function Deployment (QFD) is a service planning and

development support method, which provides a structured way for service providers to assure quality and customer satisfaction while maintaining a sustainable competitive advantage” (Andronikidis et al., pp-320, 2009). The indicated usage of the QFD approach in many service areas demonstrates its universal applicability. Such as bank service (Purba et al., 2018), hospitality (hotel service) (Paryani et al., 2010), healthcare service (Dijkstra & Bij,

2002; Gremyr & Raharjo, 2013), utility service (Jahanzaib et al., 2016), design/build project (Pheng & Yeap, 2001), software product development (Haag et al., 1996; Thackeray & Van Treeck, 1990) and more. In light of this, numerous circumstances or significant aspects described in the illustration below are necessary to put into practice and advance QFD (Kathawala & Motwani, 1994).



**Figure 3.** The Three Components of QFD: A System Model. Source: Kathawala & Motwani (1994) Modified

Despite its popularity and widespread acceptance, quality function deployment is subject to numerous criticisms; see, for example, Wolniak, pp-16 (2018), who argue that it is not flexible, time-consuming, labor-intensive, only allows for qualitative data, and creates difficulties for collaboration within multidisciplinary teams; and Andronikidis et al., pp-321 (2009), who assume linear association within customer requirements and service attributes, impose a Poel (2007) critiques quality function deployment from a methodological aspect, which includes that "customer demands are product/service dependent, customer demand can not always be represented by a linear additive value function, individual customer preference cannot be translated into a collective customer preference ordering without violating a number of very reasonable conditions, the correlation between customer demand and engineering

characteristics is not always non-negative and constant, the relative importance of customer demand can not be uniformly translated into a relative importance of the engineering characteristics, and the meaning of tragedy values is unclear or disputable."

#### 2.4. Multi-Criteria Decision-Making Tools

Multi-criteria decision-making analysis (MCDA) was introduced as a subsection of operations research intended to assist in solving problems (Jato-Espino et al., 2014). Since then, numerous multi-criteria decision-making techniques have been introduced to use them for different service and manufacturing sectors (Kiker et al., 2005; Lahdelma et al., 2000; Løken, 2007; Słowiński, 1986; Tonietto & Carbonneau, 2004).



## 2.4.1 Analytic Network Process (ANP)

The analytic network process consists of similar attributes to the analytic hierarchy process, which includes simplicity, flexibility, and coincident implementation of qualitative and quantitative measures and can add ebullience to the judicial process. In addition, the analytic network process deals with every event, i.e., a network of criteria, sub-criteria, and alternatives; moreover, in the analytic network process, every component in the network can interplay with each other by any means (Kheybari et al., 2020). Likewise, Kheybari et al., (2020)

recapitulate the analytic network process in four main steps, such as:

Step1. Building a model and converting a problem into a topic network structure.

Step2. Formulating a pairwise comparison matrix and determining priority vectors.

Step3. Generating a supermatrix and converting it to a weighted supermatrix.

Step4. Selecting the best option.

Numerous research papers discuss the use of analytic network processing (ANP) in a variety of industrial, profit, and non-profit organizations (table 4).

**Table 4.** Analysis of the Application area of the Analytic Network Process (ANP)

Author & year	Description	Area
Galankashi et al., (2015)	Prioritizing green supplier selection criteria	Green supply chain
Çelebi et al., (2010)	Logistics management	Small electronic appliance manufacturer
Simwanda et al., (2020)	Modeling the drivers of urban land-use change	Urban development
Abdi (2012)	Product family formation & selection for configurability	Manufacturing system
Gheshlaghi et al., (2019)	GIS-based forest fire risk mapping	Environmental planning
Bayazit (2006)	Vendor selection decisions	Supply chain
Boateng et al., (2015)	Risk prioritization in mega projects	Project management
Cheng & Li (2004)	Contractor selection	Project management
Cheng & Li (2005)	Project selection	Construction management
Cooper et al., (2012)	Selection of a third-party logistics provider	Pharmaceutical company
Dabestani et al., (2017)	Evaluation and prioritization of service quality dimension	4 – star hotel
Farman et al., (2017)	Optimum cluster head selection	Wireless sensor network
Genevois et al., (2015)	Automatic teller machine deployment problem	Bank service sector
Godse et al., (2008)	Web service selection	Web service industry
Hasanzadeh et al., (2013)	Coastal oil jetties site selection	Oil production industry
S. H. Chen et al., (2004)	Enterprise partner selection	Vocational education
Jharkharia & Shankar (2007)	Selection of logistics service provider	Logistics
Meade & Presley (2002)	R&D project selection	Research & Development program
Mulebeke & Zheng (2006)	Software selection in product development	Manufacturing industry
Wu et al., (2012)	Porter's Five Force analysis	Strategic management
Zhu et al., (2010)	A portfolio-based analysis for green supplier management	Supply chain management
Zare et al., (2018)	Prioritizing shift work disorder	Hospital service

Despite its reputation and widespread use, ANP has been subjected to several theoretical and practical criticisms. For instance, the method's complexity, the length of the implementation, and the uncertainty in giving judgment, especially at the cluster level (Kadoić et al., 2017).

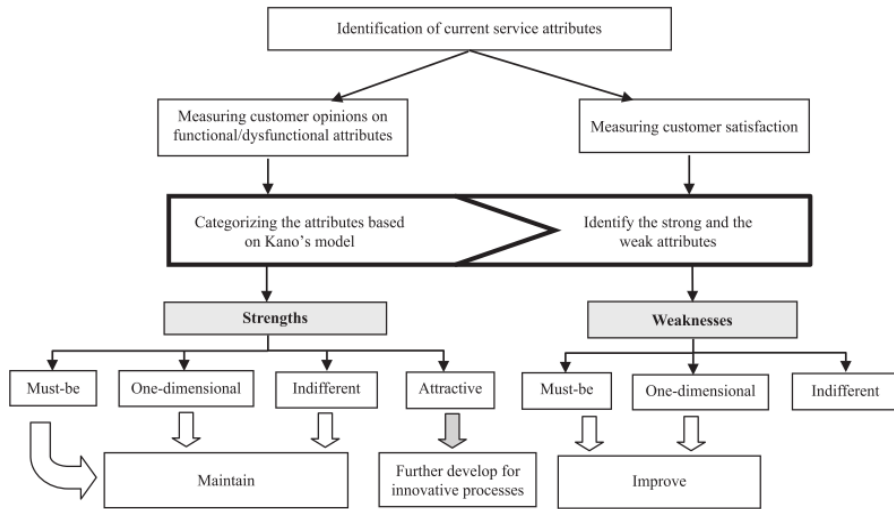
**2.5 Integration of Customer-Oriented Tools for Improving Service Quality**

In the current worldwide competitive market, it is not adequate for firms to depend exclusively on continuous improvement to sustain and advance their competitive advantage. The introduction of integrated customer-oriented tools for increasing service quality, similar to the synergy of changed processes, has been widely applied in many service and industrial businesses. See, for example, a fuzzy QFD approach using SERVQUAL and Kano models (in the case of hotel service) (Beheshtinia & Farzaneh Azad, 2017), integration of SERVQUAL and Kano models (in the case of airline service) (Basfirinci & Mitra, 2015), application of integration of Kano model, AHP technique and QFD matrix (case of banking service) (Pakizehkar et al., 2016); integration of Kano model and AHP

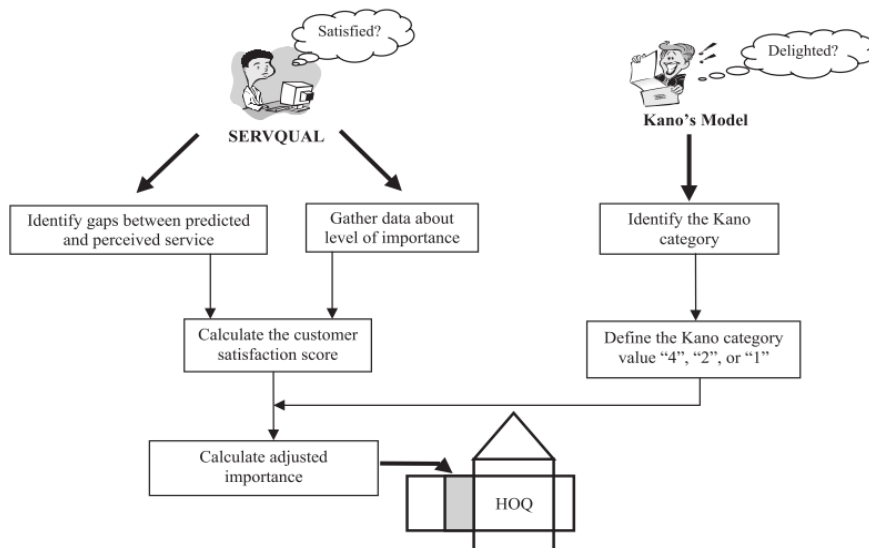
(case of banking service) (Kazemi et al., 2013), application of integrating SERVQUAL and Kano model into QFD (case of logistics service) (Baki et al., 2009), integrating SERVQUAL and Kano model into QFD (case of simulation – based training on project management) (Rahmana et al., 2014), integrating SERVQUAL and Kano model into QFD (case of hotel industry) (P. Gupta & Srivastava, 2012), a hybrid of Kano model and QFD (case of banking service) (Pourhasomi et al., 2013), integrating fuzzy SERVQUAL into refined Kano model (case of restaurant service) (Hsieh et al., 2015), combination of the Kano model and QFD (designing new product) (Tontini, 2007), integrating SERVQUAL and Kano model and QFD (case of PT POS Indonesia) (Singgih & Ardhiyani, 2010) and more. Accordingly, Tan & Pawitra (2001) mentioned and clarified the fundamentals of the procedure involving the collaboration of SERVQUAL, the Kano model, and QFD to evaluate customer satisfaction to develop service excellence and innovation for business organizations. The key arguments or problems for incorporating SERVQUAL and the Kano model into QFD are then briefly reviewed.

**Table 5.** The Major Point for Integrating SERVQUAL and Kano’s Model into QFD

SERVQUAL	Kano’s model	QFD
Assumes a linear relationship between customer satisfaction & service attributes performance.	Helps SERVQUAL to prioritize the improvement of an organization's weakness based on the category of needs that can lead to the highest customer satisfaction.	
As a continuous improvement & innovation tool.	It Helps SERVQUAL to address innovation issues, attractive attributes are a source of customer delight so it is one area where effort for improvement should be targeted.	Generally serves as the planning process for translating customer needs into an appropriate organizational requirement.
Provides important information on the gap between predicate service and perceived service, however, it is not able to address how the gaps can be closed.	Helps SERVQUAL to prioritize which service gap to focus on and to make effort on.	



**Figure 4.** A framework of integrated Kano's model into SERVQUAL.  
Source: Tan & Pawitra (2001)



**Figure 5.** A framework of integrated SERVQUAL and Kano's model into QFD.  
Source: Tan & Pawitra (2001).

Andronikidis et al., (2009) assessed and stated that when working with quantitative methods related to QFD, various issues arise at different stages of QFD execution, as follows: "QFD methodology imposes the need to deal with large amounts of data

gathered from customers, competitors, and cross-functional, time-consuming, requiring input and analyzing a large amount of subjective data, bias may be easily inserted into any stage of the QFD, etc." The employment of quantitative approaches like

the analytic hierarchy process (AHP) is thus necessary to build a new strategy for enhancing QFD's efficacy to resolve those problems. A better service delivery that meets or surpasses client expectations is made possible by the analytic network process (ANP) and Markov chains, increasing sales and customer satisfaction.

### 3. Material and Methods

#### 3.1. Fuzzy SERVQUAL Model

The main steps incorporated in the appraisal of bank service quality are discussed as follows: the questionnaires' design; distributing survey questionnaires and gathering survey data; analyzing customer expectations and perceptions of service quality; and finally, the interpretation of fuzzy SERVQUAL analysis.

#### Step 1. Questionnaire Design

This article adapts questionnaires from previous literature. The SERVQUAL model questionnaires addressing customer perceptions and expectations are weighted

using the linguistic variables scale. For instance, the linguistic variables include "strongly disagree," "disagree," "neutral," "agree," and "strongly agree."

**Table 6.** A linguistic variable of perceptions & expectations.

Likert scale	Linguistic variables	Fuzzy membership function
1	Strongly disagree	(1, 1, 3)
2	Disagree	(1, 3, 5)
3	Neutral	(3, 5, 7)
4	Agree	(5, 7, 9)
5	Strongly agree	(7, 9, 9)

#### Step 2. Distribution of Survey Questionnaires and Collection of Survey Data

A simple random sampling technique was used for the SERVQUAL model questionnaire's respondents. In line with this, the basic formula for calculating the sampling error for a sample estimate of a population parameter is as follows (Bozorgi, 2007).

$$\text{Sample error} = \frac{\text{Variability of the measurement (Values among the sampling units)}}{\sqrt{\text{Size of the sample}}} \quad (2)$$

Also, this article describes a pilot test and the standard variation in factors of service quality measurement in the Grönroos model.

Likewise, table 7 summarizes the standard deviation of service quality variables (Grönroos, 2000).

**Table 7.** Mean standard variation of services quality measurement. Source: Grönroos (2000)

Items	Mean standard variation
Tangibles	0.708
Reliability	0.301
Responsiveness	0.521
Assurance	0.263
Empathy	0.755
Technical factor	0.605
Image	0.603

Therefore, for this purpose, this article considers using a 5% sample error to be adequate for academic research.

Accordingly, to get an accurate sample size, we should select the maximum value of the mean variation of a factor, so the sample size

is calculated as follows:

$$0.05 = \frac{(0.755)}{\sqrt{\text{Size of the sample}}} = 240.24 \approx 240$$

### Step 3. Analysis of Customer Expectations and Perceptions

The main mathematical operations on fuzzy number

Previous literature has discussed the mathematical operations of the fuzzy number (Adamo, 1980; Campos & Verdegay, 1989; Dubois & Prade, 1978; Nahmias, 1978).

The primary mathematical operations on fuzzy numbers include the ones listed below: Triangular fuzzy numbers  $A_1 = (c_1, a_1, b_1)$  and  $A_2 = (c_2, a_2, b_2)$  should be used as examples.

1. The triangular fuzzy number  $Y = (c, a, b)$  is a special case of a generalized trapezoidal fuzzy number. The ranked average integration representation of the triangular fuzzy number  $Y$  will be.

$$P(Y) = \frac{1}{6}(c + 4a + b) \quad (3)$$

2. Addition operation of  $A_1$  and  $A_2$

$$A_1 + A_2 = (c_1 + c_2, a_1 + a_2, b_1 + b_2) \quad (4)$$

Where:  $c_1, c_2, a_1, a_2, b_1, b_2$  are real numbers

3. Subtraction operation of  $A_1$  and  $A_2$

$$A_1 - A_2 = (c_1 - b_2, a_1 - a_2, b_1 - c_2) \quad (5)$$

Where:  $c_1, c_2, a_1, a_2, b_1, b_2$  are real numbers

4. Division operation of  $A$  and any real number  $r$

$$\frac{A}{r} = \left( \frac{c}{r}, \frac{a}{r}, \frac{b}{r} \right) \quad (6)$$

Where:  $r$  are real numbers

5. Multiplication operation

$$P(Y_1 * Y_2) = \frac{1}{6}(c_1 + 4a_1 + b_1) * \frac{1}{6}(c_2 + 4a_2 + b_2) \quad (7)$$

The analysis steps are discussed as follows:

1. Let fuzzy number  $A_{ein}$  be the service quality expectation from the  $n^{\text{th}}$  customer under service item  $i$ , let fuzzy number  $A_{pin}$  be the service quality perceptions from the  $n^{\text{th}}$  customer under service item  $i$ , and let fuzzy number  $TA_{ei}$  be the sum of service quality expectation from all customer under service item  $i$ , let fuzzy service number  $TA_{pi}$  be the sum of service quality perception from all customer under service item  $i$ .

$$TA_{ei} = \sum_1^N A_{ein} \quad (8)$$

$$TA_{pi} = \sum_1^N A_{pin} \quad (9)$$

By using equations (4) & (8) we can analyze the sum of service quality expectations from all customers under service item  $i$ , alike, by using (4) & (9) we can analyze the sum of service quality perception from all customers under service item  $i$ .

2. Let fuzzy number  $MA_{ei}$  be the average service quality expectations from all customers under service item  $i$ , and let fuzzy number  $MA_{pi}$  be the average service quality perceptions from all customers under service item  $i$ .

$$MA_{ei} = \frac{TA_{ei}}{N} \quad (10)$$

$$MA_{pi} = \frac{TA_{pi}}{N} \quad (11)$$

By using equations (6) & (10) we can analyze the average service quality expectation from all customers under service item  $i$ , alike, by using equations (6) & (11) we can analyze the average service quality perception from all customers under service item  $i$ .

3. Let fuzzy number  $Gap_i$  be the gap within the perception and expectation of service quality from all customers under service item  $i$ .

$$Gap_i = MA_{pi} - MA_{ei} \tag{12}$$

By using equations (5) & (12) we can analyze the service quality gap with the expectation and perception from all customers under service item  $i$ , likewise, by using equation (3) we can analyze the representation of a fuzzy number.

### 3.2. Fuzzy Kano's Model

Following is a discussion of the primary methods used to assess the functional and dysfunctional requirements for bank service quality: design, dissemination, and data gathering for Kano model questionnaires; Kano categorization; customer satisfaction and self-stated importance; and, lastly, customer needs and technical requirements.

#### Step 1. Kano's Model Questionnaire Design

This article adapts questionnaires from previous literature. Kano models' functional and dysfunctional interpretations were careful. In line with this, customer responses are weighted using linguistic variables. For example, the linguistic variables include "I like it," "I expect it," "I am neutral," "I can tolerate it," and "I dislike it." And the second type of Kano model questionnaire addresses customers' views on how important a given

feature is to them, and their responses are weighted using the linguistic variables scale. For example, the linguistic variables include "not important," "somewhat important," "important," "very important," and "extremely important."

**Table 8.** Linguistic variables of Kano's model.

Self-stated importance scale	Linguistic variable	Fuzzy membership function
1	Not important	(1, 1, 5)
3	Somewhat important	(1, 5, 7)
5	Important	(5, 7, 11)
7	Very important	(7, 11, 13)
9	Extremely important	(11, 13, 13)

#### Step 2. Distribution of Kano's Model Questionnaires and Collection of Survey Data

The snowball sampling technique was used for Kano's model questionnaire respondents, and the formula for calculating the sample size is as follows:

$$n = \frac{Z^2 * \sigma^2}{e^2} = \frac{Z^2 * P(1-P)}{e^2} \tag{13}$$

$$n = \frac{1.96^2 * 0.3(1-0.3)}{0.05^2} = 322.69 \approx 323$$

#### Step 3. Determine Kano's Classification, Customer Satisfaction Coefficient, and Self-Statement Importance

The customer satisfaction coefficient indicates whether a service's ability to satisfy criteria may boost customer satisfaction or whether doing so only keeps them from being unsatisfied. As seen below, the two equations were used to calculate how satisfied and unsatisfied people were with their lives.

$$\text{Customer satisfaction (better)} = \frac{A + O}{A + O + M + I} \quad (14)$$

$$\text{Customer dissatisfaction (worst)} = -\frac{O + M}{A + O + M + I} \quad (15)$$

#### Step 4. Determine Customer Requirements and Technical Requirement

Utilizing the fuzzy SERVQUAL and fuzzy Kano models, customer needs were determined. A similar concentrated group conversation with the branch manager and customer support representative led to the discovery of the technical necessity.

#### 3.3. Fuzzy Analytic Network Process

The major steps undertaken in the fuzzy analytic network process are discussed as follows.

##### Step 1. Establish Fuzzy Analytic Network Process Pairwise Comparison Matrices

Following the identification of the customer requirement from fuzzy SERVQUAL and

fuzzy Kano model analysis, the next step is to construct a fuzzy pairwise comparison of customer requirements to analyze the weight of each customer requirement, respectively. On the other hand, the analytic network process is weighted using the linguistic variables scale; for instance, the linguistic variables include "equally important," "weakly important," "fairly important," "strongly important," and "absolutely important."

##### Step 2. Analyze The Local Weight of Each Technical Requirement Concerning Customer Requirement

This step entails examining the fuzzy weights associated with each technical requirement and each customer requirement for compliance.

**Table 9.** Linguistic variables of the Analytic Network Process.

Saaty scale	Linguistic variable	Fuzzy membership function
1	Equally important	(1, 1, 1)
3	Weakly important	(2, 3, 4)
5	Fairly important	(4, 5, 6)
7	Strongly important	(6, 7, 8)
9	Absolutely important	(9, 9, 9)

#### 3.4. Integrated Fuzzy SERVQUAL, Fuzzy Kano's Model, and Fuzzy ANP into QFD

The approach incorporated in the design of an integrated HOQ is discussed as follows: Kano categories were allocated based on their fuzzy Kano model analysis, and the importance of "what" was gathered using fuzzy SERVQUAL analysis. The Kano categories were then multiplied with fuzzy SERVQUAL results to determine the

modified importance (importance of "what" value).

Also, the adjusted importance was then multiplied with each technical requirement in the row and summed up the results of the total value to determine the (importance of the "how" value). Briefly, the application of integrated fuzzy SERVQUAL, fuzzy Kano model, and fuzzy ANP into QFD is presented in the figure 7.

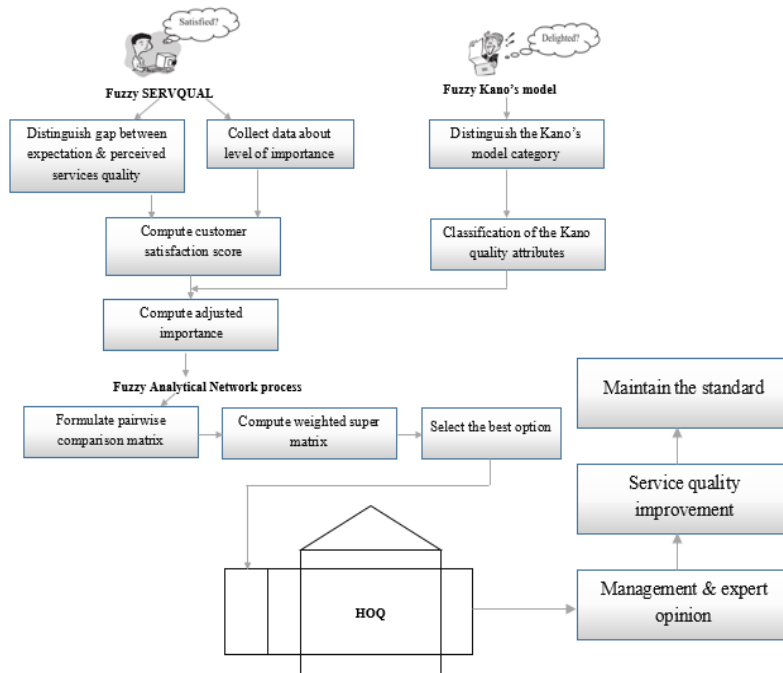


Figure 6. A framework of synergies of fuzzy SERVQUAL, fuzzy Kano's model, and fuzzy analytical network process into QFD.

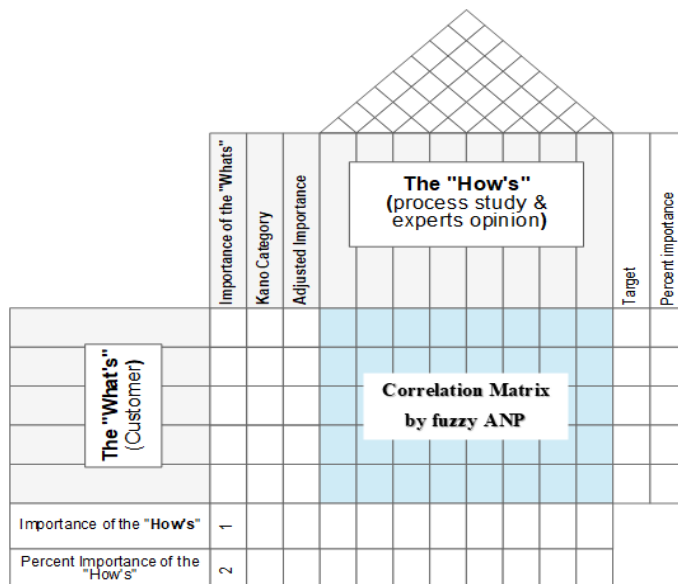


Figure 7. House of Quality (HOQ) for service quality design by using fuzzy ANP for correlation matrix



## 4. Results and Discussion

Based on the statistics obtained from the table below, we can interpret the following analysis result as follows: These include the first variable, reliability, which contains: the bank providing the promised service within a given time frame (-4.478); the bank responding to your claim fast and delivering adequate service within the time frame (-4.324); the bank performing the service right the first time (-3.310); and whenever you face a problem, the bank always shows a sincere interest in solving it (-3.216). The

second variable is responsiveness which contains bank employees delivering prompt service to you (-3.605), bank employees never being too busy to respond to your request (-3.533), and bank employees informing you exactly when service will be performed (-3.491). The third variable is empathy which contains the bank giving care and individual attention to you (-3.219), the bank giving you the best interest at heart (-3.112), and bank employees always understanding your specific needs of you (-3.010).

**Table 10.** The analysis of expectations and perceptions

Dimension	Expectation	Perception	Gap	Rank
<b>Reliability</b>	<b>7.726</b>	<b>4.089</b>	<b>-3.637</b>	<b>-3.637<sup>[1]</sup></b>
Item 1	8.154	3.676	-4.478	-4.478 <sup>[1]</sup>
Item 2	7.762	4.546	-3.216	-3.216 <sup>[8]</sup>
Item 3	7.762	4.905	-2.857	-2.857 <sup>[12]</sup>
Item 4	7.065	3.755	-3.310	-3.310 <sup>[6]</sup>
Item 5	7.886	3.562	-4.324	-4.324 <sup>[2]</sup>
<b>Assurance</b>	<b>7.580</b>	<b>5.279</b>	<b>-2.301</b>	<b>-2.301<sup>[4]</sup></b>
Item 6	7.811	5.918	-1.893	-1.893 <sup>[17]</sup>
Item 7	7.539	4.771	-2.768	-2.768 <sup>[13]</sup>
Item 8	7.686	5.680	-2.006	-2.006 <sup>[16]</sup>
Item 9	7.284	4.748	-2.536	-2.536 <sup>[15]</sup>
<b>Tangible</b>	<b>7.597</b>	<b>6.203</b>	<b>-1.394</b>	<b>-1.394<sup>[5]</sup></b>
Item 10	7.977	7.118	-0.859	-0.859 <sup>[22]</sup>
Item 11	7.441	5.739	-1.702	-1.702 <sup>[19]</sup>
Item 12	7.536	6.016	-1.520	-1.520 <sup>[20]</sup>
Item 13	7.435	5.938	-1.497	-1.497 <sup>[21]</sup>
<b>Empathy</b>	<b>7.175</b>	<b>4.388</b>	<b>-2.787</b>	<b>-2.787<sup>[3]</sup></b>
Item 14	7.232	4.013	-3.219	-3.219 <sup>[7]</sup>
Item 15	7.399	5.520	-1.879	-1.879 <sup>[18]</sup>
Item 16	6.814	4.098	-2.716	-2.716 <sup>[14]</sup>
Item 17	7.069	3.957	-3.112	-3.112 <sup>[9]</sup>
Item 18	7.363	4.353	-3.010	-3.010 <sup>[10]</sup>
<b>Responsiveness</b>	<b>7.885</b>	<b>4.485</b>	<b>-3.400</b>	<b>-3.400<sup>[2]</sup></b>
Item 19	7.814	4.323	-3.491	-3.491 <sup>[5]</sup>
Item 20	8.030	4.425	-3.605	-3.605 <sup>[3]</sup>
Item 21	8.124	5.154	-2.970	-2.970 <sup>[11]</sup>
Item 22	7.572	4.039	-3.533	-3.533 <sup>[4]</sup>

The majority of client requirements, according to the Kano classification study, are characterized as one-dimensional needs;

thus, the bank should take note of aspects in the design of the service system that suggest greater customer satisfaction. Examples of

one-dimensional items are item 14 (response of 61 and percentage of 60.40), item 3 (response of 57 and 56.44%), and item 1 (response of 53 and 52.48%). This analysis

enables us to determine or identify customer requirements, which also helps the company understand the voice of its customers to improve service quality.

**Table 11.** Kano classification

Customer requirement		A	O	M	I	R	Q	Total	Categories
Item 1	Response	14	<b>53</b>	22	10	1	1	101	<b>O</b>
	Percentage	13.86%	52.48%	21.78%	9.90%	0.99%	0.99%	100%	
Item 2	Response	8	24	<b>42</b>	10	4	13	101	<b>M</b>
	Percentage	7.92%	23.76%	41.58%	9.90%	3.96%	12.87%	100%	
Item 3	Response	21	<b>57</b>	13	6	2	2	101	<b>O</b>
	Percentage	20.79%	56.44%	12.87%	5.94%	1.98%	1.98%	100%	
Item 4	Response	17	28	<b>37</b>	14	2	3	101	<b>M</b>
	Percentage	16.83%	27.72%	36.63%	13.86%	1.98%	2.97%	100%	
Item 5	Response	27	<b>38</b>	13	18	1	4	101	<b>O</b>
	Percentage	26.73%	37.62%	12.87%	17.82%	0.99%	3.96%	100%	
Item 6	Response	14	<b>45</b>	20	20	0	2	101	<b>O</b>
	Percentage	13.86%	44.55%	19.80%	19.80%	0.00%	1.98%	100%	
Item 7	Response	25	<b>29</b>	22	20	1	4	101	<b>O</b>
	Percentage	24.75%	28.71%	21.78%	19.80%	0.99%	3.96%	100%	
Item 8	Response	16	<b>30</b>	23	29	1	2	101	<b>O</b>
	Percentage	15.84%	29.70%	22.77%	28.71%	0.99%	1.98%	100%	
Item 9	Response	12	<b>34</b>	22	28	3	2	101	<b>O</b>
	Percentage	11.88%	33.66%	21.78%	27.72%	2.97%	1.98%	100%	
Item 10	Response	10	33	<b>45</b>	9	1	3	101	<b>M</b>
	Percentage	9.90%	32.67%	44.55%	8.91%	0.99%	2.97%	100%	
Item 11	Response	22	38	13	22	1	5	101	<b>O</b>
	Percentage	21.78%	37.62%	12.87%	21.78%	0.99%	4.95%	100%	
Item 12	Response	30	<b>44</b>	14	7	3	3	101	<b>O</b>
	Percentage	29.70%	43.56%	13.86%	6.93%	2.97%	2.97%	100%	
Item 13	Response	8	<b>42</b>	30	14	4	3	101	<b>O</b>
	Percentage	7.92%	41.58%	29.70%	13.86%	3.96%	2.97%	100%	
Item 14	Response	0	<b>61</b>	36	1	3	0	101	<b>O</b>
	Percentage	0.00%	60.40%	35.64%	0.99%	2.97%	0.00%	100%	
Item 15	Response	13	<b>43</b>	17	10	14	4	101	<b>O</b>
	Percentage	12.87%	42.57%	16.83%	9.90%	13.86%	3.96%	100%	

**Customer Satisfaction Coefficient and Self-Stated Importance**

Based on the statistics obtained from the table above, we can interpret the following analysis result as follows: the self-stated importance analysis indicates that having the promised service within a given time frame (10.845), getting a fast claim response and getting adequate service within the time frame (11.082), having the employee inform

you exactly when the service will be performed (10.796), and having the employee deliver prompt service (10.944) are all significant. This analysis result is critical to distinguish features from each other and helps to know which are most relevant to the customer; therefore, in the next step, we can determine customer requirements from fuzzy SERVQUAL and fuzzy Kano's model analysis results.

**Table 12.** Customer satisfaction coefficient and self-stated importance

Service requirement	$Better = \frac{A + O}{A + O + M + I}$	$Worst = -\frac{O + M}{A + O + M + I}$	Self-stated importance
Item 1	0.68	-0.76	10.845
Item 2	0.38	-0.79	10.093
Item 3	0.80	-0.72	11.082
Item 4	0.47	-0.68	10.231
Item 5	0.68	-0.53	9.212
Item 6	0.60	-0.66	9.954
Item 7	0.56	-0.53	9.895
Item 8	0.47	-0.54	9.548
Item 9	0.48	-0.58	9.845
Item 10	0.44	-0.80	10.092
Item 11	0.63	-0.54	9.806
Item 12	0.78	-0.61	9.726
Item 13	0.53	-0.77	10.796
Item 14	0.62	-0.99	10.944
Item 15	0.67	-0.72	10.944

**Determine Customer Requirements and Technical Requirement**

Customer requirements were identified by using fuzzy SERVQUAL and fuzzy Kano's model. One of the main reasons for

identifying the main customer requirement is to determine which service attributes have a significant effect on customer service perception.

**Table 13.** List of customer requirements

No.	Customer requirement
1	The bank should provide the promised service within a given time frame
2	The bank should respond to customer clam fast and deliver adequate service within the time frame
3	An employee should deliver prompt service to the customer
4	The employee should never be too busy to respond to customer request
5	The employee should inform the customer exactly when service will be performed

Table 14 summarize the main technical requirements based on focused group discussions with the branch manager and

customer support representative led to the discovery of the technical requirements.

**Table 14.** List of technical requirements

No.	Technical requirement
1	Collect customer feedback on a continuous basis
2	Identify dissatisfied customers & frequent service failure issues
3	Update service standards & guidelines
4	Conduct adequate training, performance evaluation & rewards
5	Improve internal service quality by concentrating on employee issues and concerns
6	Establish experience-sharing conducts

**Analyze the Local Weight of each Technical Requirement Concerning Customer Requirement**

Following this, the next step is to determine the fuzzy weight of each customer

requirement correspondingly and evaluate each technological requirement's fuzzy weight by considering customer requirements as a factor.

**Table 15.** Fuzzy weight of customer requirement

	Fuzzy weight				Weight
CR <sub>1</sub>	0.329042	0.397976	0.472305	0.399774	0.4788824
CR <sub>2</sub>	0.078474	0.085344	0.092577	0.085465	0.10237726
CR <sub>3</sub>	0.056147	0.066162	0.078717	0.067009	0.08026851
CR <sub>4</sub>	0.166245	0.213171	0.264957	0.214791	0.25729409
CR <sub>5</sub>	0.051774	0.066162	0.085367	0.067768	0.08117774
	<b>Total</b>				0.834807
					1

**Acquire the Weighted Supermatrix**

In this section, the main task is to construct the weighted supermatrix; having done that,

the next step is to multiply each column of the technical requirement by a fuzzy weight.

**Table 16.** The weighted supermatrix

	Weight	TR <sub>1</sub>	TR <sub>2</sub>	TR <sub>3</sub>	TR <sub>4</sub>	TR <sub>5</sub>	TR <sub>6</sub>
CR <sub>1</sub>	0.479	0.354697	0.068647	0.255945	0.163718	0.125744	0.031248
CR <sub>2</sub>	0.102	0.241429	0.075028	0.097211	0.097211	0.244401	0.100502
CR <sub>3</sub>	0.080	0.270366	0.046822	0.132208	0.273316	0.054156	0.223131
CR <sub>4</sub>	0.257	0.222068	0.050393	0.102766	0.270215	0.114411	0.240147
CR <sub>5</sub>	0.081	0.12392	0.18745	0.121312	0.182614	0.117983	0.266722

**Analyze the Comprehensive Weight**

When the abovementioned stage is complete, we may build the relationship matrix

between customer needs and technical requirements, which is needed for HOQ analysis.

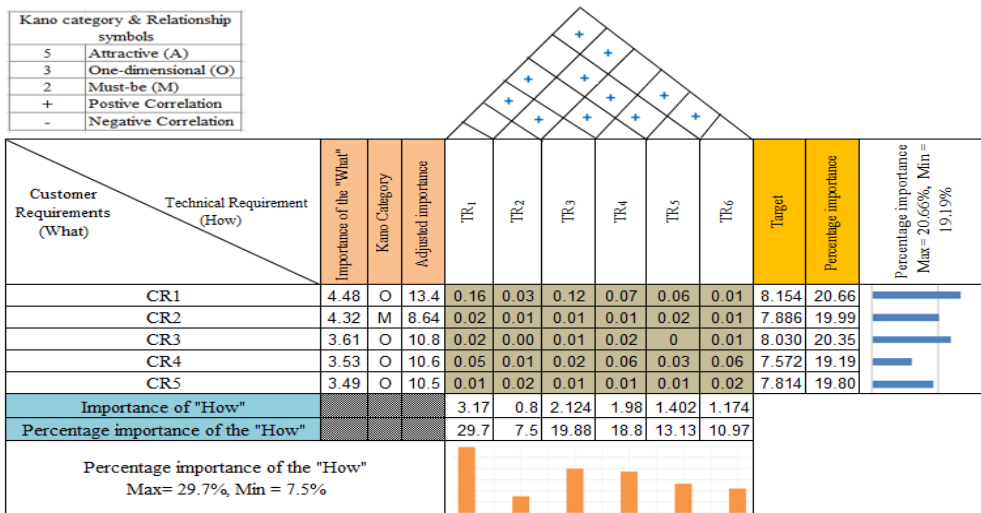
**Table 17.** Relationship matrix between customer requirement and technical requirement

	TR <sub>1</sub>	TR <sub>2</sub>	TR <sub>3</sub>	TR <sub>4</sub>	TR <sub>5</sub>	TR <sub>6</sub>
CR <sub>1</sub>	0.169858	0.0328738	0.122568	0.078402	0.060216	0.014964
CR <sub>2</sub>	0.024717	0.00768115	0.009952	0.009952	0.025021	0.010289
CR <sub>3</sub>	0.021702	0.00375836	0.010612	0.021939	0.004347	0.01791
CR <sub>4</sub>	0.057137	0.0129658	0.026441	0.069525	0.029437	0.061788
CR <sub>5</sub>	0.01006	0.01521673	0.009848	0.014824	0.009578	0.021652

**Integrated Fuzzy SERVQUAL, Fuzzy Kano's Model, and Fuzzy ANP into QFD**

From the integrated HOQ analysis, prioritize the technical requirements based on their importance, for example, collecting customer feedback continuously with a value of 29.7%, updating service standards and guidelines (19.88%), conducting adequate training, performance evaluation, and reward (18.8%), improving internal service quality

by concentrating on employee issues (13.3%), establishing experience sharing practices (10.97%), and finally identifying dissatisfied customers and frequent service failure issues (7.5%). Accordingly, the study claimed that enhancing each of those technical requirements might enhance the bank's level of customer satisfaction through higher service quality.



**Figure 8.** Integrated House of Quality

Besides, the analysis also prioritizes the customer requirements based on their importance. The bank should provide the promised service within a given time frame (20.66%), and an employee should deliver prompt service to the customer (20.35%). The bank should respond to a customer's claim fast and provide adequate service within the time frame (19.99%); the employee should inform the customer exactly when service will be performed (19.80%). And the employee should never be too busy to respond to customer requests (19.19%). Therefore, this article declares that fulfilling those customer requirements can increase customer satisfaction.

## 5. Conclusion

With the increasing progress in bank service in today's competitive market, people experience fast and prudent service delivery of bank service this phenomenon has enhanced customer expectations about bank service. The finding has a practical

implication for service industries to explore their drawbacks related to service quality. Likewise, increase customer satisfaction and increase their competitiveness in the current marketplace. The bank should also constantly collect customer feedback, identify the root causes of service failures that commonly leave customers dissatisfied, update service standards and guidelines, and implement proper training, performance assessments, and incentive schemes. And raise the standards of internal services by emphasizing worker issues and concerns. And finally, establish procedures for exchanging experiences.

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## SYSTEM OF BALANCED INDICATORS FOR NEW PRODUCT DEVELOPMENT STRUCTURES TAKING INTO ACCOUNT CUSTOMER SATISFACTION

**Abstract:** *This study considers the usage of balanced scorecard for planning and operative management of organisations responsible for developing new products. It is proposed to use five perspective of strategic map, taking into account the key strategy - development and commercialization of the intellectual activity results. In addition to four standard projections it is suggested to use the Customer Satisfaction projection.*

*This perspective includes the goals of increasing characteristics of the input flow developments coming or being created at the enterprise. It also reflects the quality objectives regarding the products created in the enterprise.*

*For each goal, indicators for monitoring their implementation are defined.*

*This balanced scorecard can be used as a starting point in building a model for evaluating organisational structures, and also develops the theory of planning and management development and production processes.*

**Keywords:** *management, organisation of production, quality, new products, organisational structure.*

### 1. Introduction

For the building an effective system of planning and operational management of the organisation's structures responsible for the development of new products it is necessary to determine the strategic purposes of the development company of additive manufacturing and carry out their decomposition to the level of separate units. It is sufficient to choose only these purposes which can be influenced by the activity of development units. Monitoring the implementation of objectives is carried out through the indication system where every aim is assigned to key performance

indicators.

Nevertheless, the aim of selecting the main points and indicators of their achievement for the organisational structures, working on creation of additive products, becomes non-trivial.

In rates elaboration it is essential to point out that realisation of new products, also in the additive technologies, being implemented within the project activity, which is oriented on meeting requirements of all projects' stakeholders. A balanced scorecard (BSC) is the most used instrument to identify strategic rates and metrics of their implementation. This method is considered to be more versatile from the management point of

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view, since such a system of goals can be used in different spheres on various levels of management.

Methodology of setting strategic objectives on the basis of a balanced scorecard has been used for a long time and recognised by many managers as an effective instrument for planning and managing. A traditional scorecard, proposed in 1992 by R. Kaplan and D. Norton, includes four projections: finances, processes, market and people.

Nowadays, it is important to notice that the external environment of the companies, developing additive technologies, becomes dynamic and non-permanent and the rate of technology diffusion is constantly increasing, which leads to a reduction in the life cycle of new product development projects. The focus of project management is shifting from meeting the project objectives and a product delivery to meeting client's requirements and supplying value.

However, in this interpretation, the indicators do not cover areas related to the supplying value to the customer of new products and stakeholders. Usage of unified projections seems insufficient, since it does not reflect the specifics of the activities of individual departments involved in the development of new products, and also does not allow assessing how the delivered results satisfy the customer. After all, in the end, it is this factor that determines the efficiency of the functioning of the entire system. In this regard, the formation of a modified system of balanced indicators of new product development structures, taking into account customer satisfaction, becomes an urgent task.

Many domestic [L.R. Batukova & Belyakova, 2015; E.V. Chmyshenko, & Satenaeva, 2019; V. V. Ermolenko et al., 2021; V.S. Kankhva, 2019; O.A. Kolegova & Zakharova, 2018; A.S. Shevchenko, 2017; N.S. Tsygankov & Petrunina, 2022; A.I. Utkin & Shitik, 2020; A.I. Utkin, Marintsev

& Utkin, 2020; A.I. Utkin & Tikhomirova, 2020] and foreign [V. Bohm, Lacaille, Spencer & Barber, 2021; R.E. Brimelow et al., 2022; T.H. Davenport, 2018; L.E. Farci, 2021; G.F. Frederico, Garza-Reyes, Kumar, & Kumar, 2020; E.G. Hansen & Schaltegger, 2017; E. Pierce, 2022] researchers, considering the application of a balanced scorecard for management structural subdivisions of enterprises note the need to form additional projections that meet the strategic goals and industry specifics of specific enterprises

## 2. Building a strategic map

As a methodological basis for the study, recommendations were used on the formation of a balanced scorecard of the Group of Companies "Modern Management Technologies" [Reference, nd].

In the context of project management for the development of new products in the additive industry, in order to determine new projections of the balanced scorecard, it is advisable to refer to modern project management standards. In the latest edition of the Guide to the Project Management Body of Knowledge [Guide to the PMBOK, 2021] from the leading American project management institute PMI, the fundamental principle is the delivery of value, not the product of the project, since it is this fact that ensures maximum satisfaction of stakeholders, and the customer of new products in the first place. It must be understood that it is customer satisfaction that determines the fulfilment of the goals of the "Market" projection and determines the level of achievement of the company's financial goals, which are the dominant projection in the balanced scorecard.

In this regard, the issues of including customer satisfaction criteria in the balanced scorecard are an important task of strategic management.

Within the framework of this study, in addition to the traditional four projections, it is proposed to introduce another one that reflects the degree of customer satisfaction with new products.

Table 1 reveals the essence of each projection (perspective) in accordance with the main strategy of the enterprise - the development of additive equipment.

For enterprises developing new equipment, it is required to define key indicators for each perspective.

**Table 1.** Essence of projections (prospects) of the balanced scorecard

Perspective	Description
Finances	It reflects the key financial and economic goals of both individual organisational structures for the development of new products, and the entire enterprise. Includes income and expense components
Clients (market)	Includes goals aimed at working with intermediate (within the distribution network) and end users and consumers of services and products, created on the basis of additive technologies
Processes	Reflects the key goals of creating, developing and improving individual processes for developing new products at the enterprise, interaction between all departments of the company
Staff training (Potential)	Includes goals related to the creation and development of internal points of growth, the improvement of the personnel component, as well as the increase in the efficiency of distribution and use of various types of resources or the creation of new ones
Customer Satisfaction	Indicates the goals of increasing the qualitative and quantitative characteristics of the input stream of developments coming and being created at the enterprise. It also reflects the goals of quality and individual parameters regarding the products created at the enterprise in accordance with the stage of development or life cycle

As key financial indicators, we highlight:

- increase in net profit. This indicator is used if the company does not have a significant increase in the scale of activities (an increase in the number of employees, the number of products created, etc.). In this case, the positive dynamics in the company will be associated with a reduction in the required investments, a reduction in R&D costs, or an increase in the effectiveness of the transfer process. Otherwise, the indicator may show negative dynamics and not be the basis of an effective management tool;
- increase in revenue. It is an alternative to increasing net profit if the company constantly increases the range of products through self-development and commercialization.

In order to define metrics from a market perspective, it seems necessary to identify specific customer segments for an additive manufacturing company.

Intermediate and end users of the results of the activities of innovative enterprises involved in the development of additive equipment, as well as their partners, can be called:

- industrial enterprises using additive technologies directly in production processes, tooling, prototyping or on repair lines of their own equipment;
- enterprises engaged in research, development and engineering of products using additive equipment;
- scientific and educational institutions that use additive technologies as part of the educational process (for example, "Tochki Rosta" project);
- distributors and dealers focused on the sale of additive equipment, materials and related products;
- individuals using personal equipment (3D printers, 3D scanners) for personal use or as part of a craft activity.

Based on the analysis of identified stakeholders in the use of additive equipment, a number of goals can be identified for the "market" perspective:

- ensuring the versatility of equipment for additive manufacturing. It is determined by the range of supported materials for manufacturing, the ability to configure 3D printing parameters to solve different types of tasks, the availability of support for various production technologies;
- formation of a perception of the correspondence between the price and quality of additive equipment in terms of their consumer and technical characteristics;
- ensuring a high degree of integration of additive manufacturing software systems with enterprise automated control systems;
- reduced requirements for 3D printers and users of additive process control equipment, regardless of the type of device, the

task being solved, and the industry of application;

- ensuring the availability of all elements of the additive manufacturing ecosystem for the full production cycle, including the manufacture and preparation of material, the creation of 3D models, management software, additive manufacturing, devices for post-processing and testing of finished products;
- formation of a high degree of integration of additive equipment into production chains for the production of final products.

One of the main goals of the "processes" perspective is to create an effective mechanism for the development of new additive equipment of the required quality with the optimal use of enterprise resources. It is the organisation of the activities of individual organisational structures in terms of development quality requirements, the operational management of departments and the distribution of resources between them that can achieve this goal.

Other objectives of this perspective are the key processes of infrastructure functioning:

- Ensuring that the input flow of developments is consistent with the planned one. Depending on the enterprise under consideration and its economic and social characteristics, it is necessary to determine the possible speed of development, the severity of input quality requirements, the number of considered quality indicators of the developed products, etc. However, regardless of these features, the key task is to adjust the parameters of the structures organisations responsible for development, in such a way that the planned qualitative and quantitative

indicators of those entering the development structure are observed;

- increase in the speed of development of new products at the enterprise. At each stage, various activities can be carried out to develop and strengthen the potential of the company's structures, including the development of competencies, the provision of resources. As a result, the company increases the scale of activities, expands the range, or improves the products or services provided;
- increasing the success of ongoing R&D and R&D to create new additive equipment. The main task of the departments of the enterprise responsible for the development of new products is to bring innovation to the final stage of the life cycle. Therefore, it is important to select projects that have a high potential for practical value;
- improving the management system of new product development structures to help achieve the company's key goals set for the short or medium term.
- As for the "potential" projection, based on the activities of the development structures, the following key goals can be distinguished:
- reducing the shortage of resources, primarily financial, required for the development of new products;
- increasing the degree of mutual use of the obtained results of intellectual activity both within one organisational structure and within the entire organisation;
- lack of unused resources. When the development structure is running for a long time, a surplus or completely unused resources may be formed. A typical example is

information resources, but it can also apply to material resources arising in the form of residuals as a result of improper planning.

The "customer satisfaction" perspective is aimed at evaluating and developing projects for the development of new products in the enterprise and includes the following goals:

- qualitative development of the developed additive equipment. Innovative companies should not only strive to increase the range of products or carry out periodic updates, but also ensure that they meet or outstrip the existing world technological level for each type of additive equipment;
- formation of protectable results of intellectual activity on the basis of increasing the research potential. Taking into account the considered approaches to assessing the effectiveness of organisational structures involved in the development of new products, it was found that the possibility of forming titles of protection plays an important role. If the enterprise is engaged in the development of media materials and research in the field of additive technologies, then it is additionally necessary to evaluate them;
- increasing the efficiency of the approaches, methods and models used to develop new products. The key task in this case is to choose the best control actions to ensure the stable development of organisational structures and, as a result, increase the development speed, the maximum number of simultaneously created products, and other indicators characterising the development efficiency;
- ensuring a synergistic effect within the framework of the interaction of individual organisational structures for customer satisfaction in the development of new products. First of all, this can be seen in a comparative analysis of the effectiveness of their functioning, which causes competition between departments and orientation to the

leader. Secondly, it is important to transfer projects for the development of new products between individual organisational structures both as part of the direct development process and in the case of a return for revision with a feedback mechanism;

- reduction of technological gap time (the time between the obsolescence of the current product and the release of a new one). The result of the activity of the process of developing new products is not only its creation and introduction to the market, but also the provision of the required parameters of commercialization and the achievement of the required sales volume;

- reduction of terms of commercialization of innovations. With a decrease in the duration of the life cycle of goods and increasing digitalization, which further accelerates this process, it is required to introduce mechanisms for the rapid introduction of innovation to the market.

To display interrelated goals, we will form a strategic map without specific indicators for monitoring their implementation. As the main financial goal, they chose "increase in revenue". As a result of the analysis of the selected goals, key relationships between them were established.

Most of the indicators of the "Customer Satisfaction" perspective contribute to the achievement of the goals of the "Processes" and "Potential" projections, with the exception of the goal "Reducing the time of commercialization of innovations", which is aimed at increasing the company's revenue as a whole.

It is important to note the impact of all goals of the Process projection on all goals of the Market projection, which is associated with

meeting the needs of intermediate and end users of additive equipment by increasing the efficiency of the development process.

The reverse situation is with the goals of the "Market" projection, which have a general impact on the financial goal of the functioning of both individual organisational structures of development, and the entire enterprise as a whole. The result of the construction of a strategic map by the authors is shown in Figure 1.

The recommended number of indicators for one goal is no more than 2-3. Based on the analysis of indicators for assessing individual infrastructure facilities of the enterprise, we selected and adapted the indicators presented in Table 2.

The indicators obtained make it possible to evaluate the organisational structure involved in the development of new products, in general, taking into account the current strategy - the search, selection, development and commercialization of the results of intellectual activity in the field of additive technologies.

To obtain an integral indicator, depending on the characteristics of the strategy of a particular organisational structure, it is required to determine their significance [N.S. Tsygankov, Kasimova & Moskalev, 2017]. In addition, any organisational structure for stable and long-term development must have the property of homeostasis.

An effective tool for determining the significance of indicators in the presence of statistical data is neural network analysis, which demonstrates qualitative results when working with such complex systems [T.H. Davenport, 2018; A.K. Moskalev, Petrunina, & Tsygankov, 2020; E. Pierce, 2022].



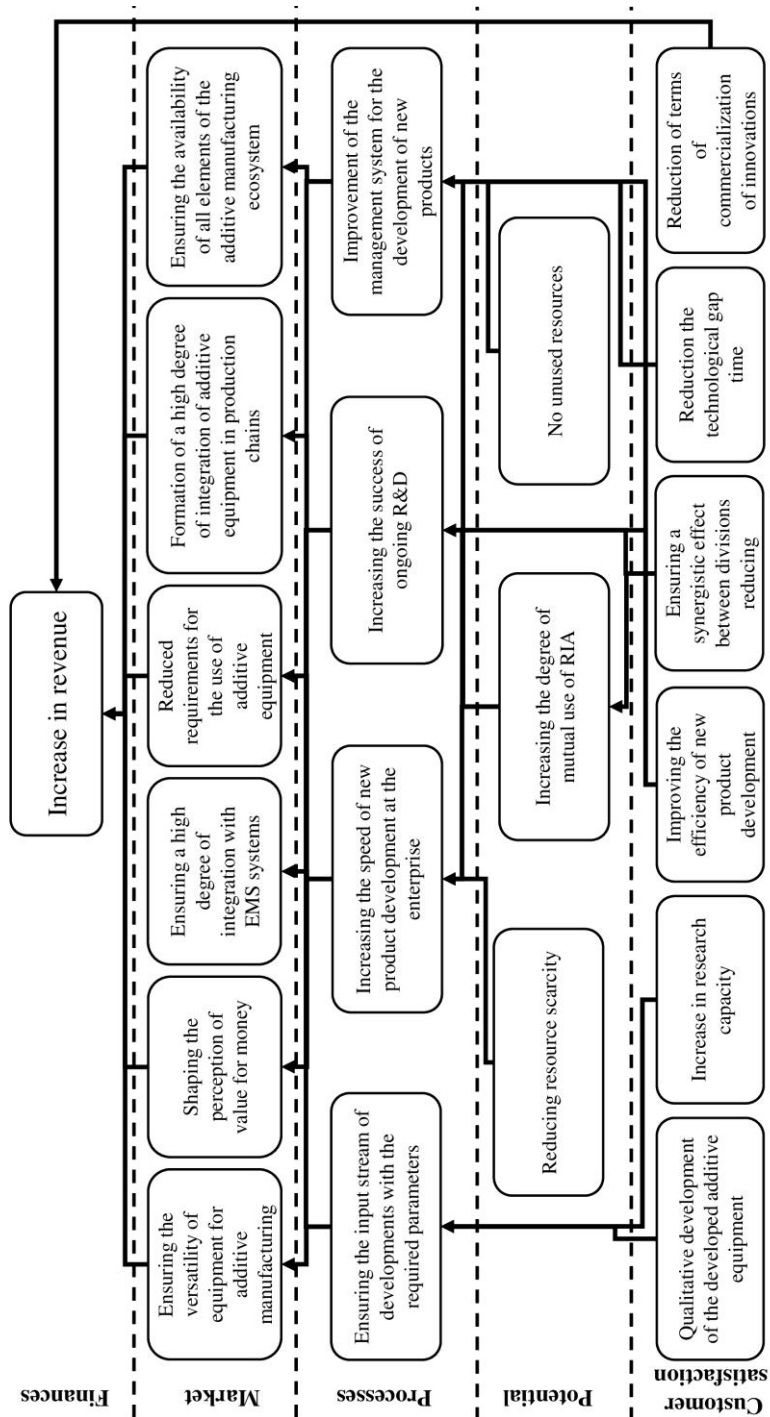


Figure 1. Strategic map

**Table 2.** Indicators of achieving the strategic goals of the organisational structure for the development of additive equipment

Purpose	
1. Increasing revenue	1. The percentage of growth in the total revenue of the enterprise 2. The share of the enterprise's revenue received from the sale of additive equipment developed by the organisational structure (or participating in the development)
2. Ensuring the versatility of equipment for additive manufacturing	1. Number of supported types of additive processes 2. The number of tasks solved by additive equipment 3. Number of materials supported for additive manufacturing
3. Formation of the perception of price / quality compliance	1. Percentage of surveyed buyers who believe that the price of additive equipment is too high (the sample should include both legal entities and individuals) 2. The share of abandonment of the purchase due to the high price 3. Percentage of surveyed buyers who believe that the price of additive equipment is too low (the sample should include both legal entities and individuals)
4. Ensuring a high degree of integration with Enterprise Management Systems(EMS)	1. An indicator of the level of integration. Separate objects of additive equipment and the EMS are selected as subsystems
5. Reducing requirements for the use of additive hardware	1. The number of calls of the consulting type on working with equipment to the technical support of the enterprise 2. Percentage of operations for setting up, launching and maintaining additive equipment that require the participation of an operator (not including the preparation of a 3D model)
6. Formation of a high degree of integration of additive equipment in production chains	1. SRL [O.V. Kalashnikova, Petrunina, Tsygankov & Moskalev, 2019; O.V. Kalashnikova, Petrunina, Tsygankov & Moskalev, 2020]. Separate objects of additive equipment and production technologies are selected as subsystems
7. Ensuring accessibility of all elements of the additive manufacturing ecosystem	1. The percentage of availability of specialised additive manufacturing equipment to ensure the full cycle of additive manufacturing for a particular type of technology (including software for preparing and working with 3D models, managing and controlling 3D printing, producing materials for additive manufacturing, etc.)
8. Ensuring the input stream of developments with the required parameters	1. Number of developments excluded during the initial evaluation (at the idea stage) 2. Average percentage of deviation of parameter values from the required level for excluded developments
9. Increasing the speed of new product development in the enterprise	1. Average time of work on a project to create a new product in the organisational structure, regardless of the result of the work 2. Maximum time to work on 1 new product development project
10. Increasing the success of ongoing R&D	1. Percentage of completed developments relative to those accepted for work by the organisational structure 2. Percentage of completed developments, relative to entering the organisational structure
11. Improving the management system for the development of new products	1. The degree of contribution to the implementation of the company's key goals. Determined by using expert approaches 2. Change in the integral indicator of the effectiveness of the organisational structure

12. Reducing the resource gap	<ol style="list-style-type: none"> <li>1. Number of changes to the work plan of the organisational structure due to lack of resources</li> <li>2. The share of the missing volume of each type of resources relative to the total volume</li> </ol>
13. Increasing the degree of mutual use of results of intellectual activity (RIA)	<ol style="list-style-type: none"> <li>1. Share of intellectual property used at least once in the development of other products</li> <li>2. The number of RIA not used in the developed products</li> </ol>
14. No wasted resources	<ol style="list-style-type: none"> <li>1. Free capacity</li> <li>2. Average equipment downtime</li> <li>3. Share of unused information resources</li> </ol>
15. Qualitative development of the developed additive equipment	<ol style="list-style-type: none"> <li>1. Average increase in the required quality indicators of the developed products relative to the previous development cycle</li> <li>2. The degree of compliance with the world technological level. Determined using an expert approach</li> </ol>
16. Increasing research capacity	<ol style="list-style-type: none"> <li>1. The share of highly qualified personnel in relation to the total number of employees</li> <li>2. The share of received protected RIAs relative to the total number of RIAs</li> <li>3. The number of proposals received for the creation of new products from the employees of the unit</li> </ol>
17. Improving the efficiency of new product development	<ol style="list-style-type: none"> <li>1. Maximum number of development projects implemented by the division</li> <li>2. The number of re-finishing projects for the creation of new products (returns to the previous stage of development)</li> </ol>
18. Ensuring synergies between departments	<ol style="list-style-type: none"> <li>1. Discrepancy between the performance of the worst and most successful organisational structure</li> <li>2. Average time to transfer development between organisational units</li> <li>3. Reduction of development time with the parallel participation of several organisational structures relative to the average development time</li> </ol>
19. Reduction of technological break time	<ol style="list-style-type: none"> <li>1. Duration of the period of decline in sales of a new product from one model range</li> </ol>
20. Decrease in terms of commercialization of innovations	<ol style="list-style-type: none"> <li>1. Average time from receipt of development to the organisation of production and marketing</li> </ol>

### 3. Conclusion

The proposed perspective "Customer Satisfaction" includes the goals of increasing the qualitative and quantitative characteristics of the input stream of developments coming or being created at the enterprise. It also reflects the goals of quality and individual parameters regarding the

products created at the enterprise in accordance with the stage of development or life cycle.

The developed balanced scorecard can be used as a starting point in building a model for evaluating organisational structures, and also develops the theory of planning and managing development and production processes.

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## QUALITY EVALUATION OF CONCRETE BLOCK FOR WALLS PRODUCTION USING STATISTICAL PROCESS CONTROL (SPC) TOOLS: A PALESTINIAN CASE STUDY

**Abstract:** *The objective of this article is to assess the feasibility of using statistical process control (SPC) techniques in the concrete block for walls production systems of the Palestinian construction companies to enhance their processes. The study specifically focused on improving the production process of the normal concrete block as it is the most commonly used type in the local market. To achieve this, a local construction company was chosen as a case study to monitor the density, crushing load and compressive strength of concrete blocks using various quality tools such as histogram, control charts and cause-and-effect diagrams. The findings demonstrate that these tools can be effectively implemented in this sector to improve production processes, resulting in material and cost savings.*

**Keywords:** *Statistical Process Control (SPC), Quality, Concrete Block, Variable Control Charts, Construction Materials, Capability Analysis*

### 1. Introduction

Quality is an essential aspect of any product, service, or experience. It refers to the degree of excellence or superiority of something, and it is a critical factor that determines whether something meets or exceeds expectations.

Nowadays, companies should adopt quality management strategies to increase their efficiencies and enhance their competitive advantage (Bottani et al., 2021) due to the influence of globalization as the competition between companies becomes intense and harsh (Manajemen et al., 2020) that led organizations to be more innovative in producing higher quality products with less cost as much as possible to maintain their competitiveness (Matias et al., 2016). So, it becomes mandatory for every organization

to adopt a continuous improvement methodology as an ongoing effort to improve processes (Gejdoš, 2015). The implementation of quality tools and methodologies is necessary to improve processes through reducing process variability, defective items and thus reducing the overall quality cost (Sousa et al., 2017). Statistical Process Control (SPC) is considered as an industrial tool to address a process variation through measuring the process (Keller et al., 2020). This tool is widely used in manufacturing industries to control and manage quality (Chen, 2020). Also, it can easily detect any abnormalities in the product quality in a scientific manner (Zan et al., 2020). Improving product quality and stabilizing production processes requires SPC as a set of problem solving tools (Azarmizad et al., 2022). The use of SPC helps organizations to identify and correct

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problems early, before they become serious issues that can affect product quality and customer satisfaction. As well as other constructions materials, concrete block for walls production has no exception in SPC implementation areas as it can be beneficial in improving the quality of blocks, reducing production cost and enhancing customer satisfaction. The concrete blocks have several measures and quality characteristics to be monitored and controlled to ensure their quality consistency and conformance to standards.

One of the main challenges in implementing SPC tools is the lack of expertise and training in statistical analysis and quality control as they are rarely applied in the Palestinian construction materials production market (Haddad, 2021). So that the main aim of this article is to explore how SPC tools can be implemented in such an important product like concrete blocks for walls to meet the Palestinian Standard of PS 6:2010. This article is considering the main quality characteristics which are: density, crushing load, and compressive strength.

## **2. Literature Review**

SPC is a quality management methodology that plays a critical role in monitoring and regulating industrial processes to ensure optimal efficiency and effectiveness. It finds wide-ranging applications in various sectors such as healthcare, manufacturing, and services. SPC is superior to other quality methods such as end product inspection as it enables the identification of faulty machines that could affect product quality. Consequently, operators need to be trained, and new documents need to be created to ensure the optimal performance of machines so that it is recommended to establish a monitoring system to review progress and results, with equal priority to financial outcomes (Madanhire & Mbohwa, 2016). SPC is not just a basic means of detecting

defective production, but it is also an effective method of preventing such production and considered as the most efficient and prevalent tool for managing process variability (Görmen, 2022). To ensure the effective implementation of SPC, several critical factors must be in place. These factors include management's dedication, teamwork, measurement system analysis, process prioritization, pilot project selection, comprehensive training, among other essential ingredients (Antony, 2000). By applying the SPC method objectively, waste can be eliminated, defects can be reduced, and process quality can be improved. However, if the SPC method is subjectively applied, it requires a high level of process commitment as the implementation of the method must be consistently carried out (Isniah & Purba, 2021).

SPC finds widespread applications across several industries, including manufacturing, healthcare, and service sectors. In the manufacturing industry, SPC is a popular tool to enhance product quality by identifying and preventing defects in the production process. SPC enables manufacturers to identify process variations and implement necessary corrective actions to ensure that the product quality is consistent.

The following are literature reviews regarding the most recent implementations of SPC. The quality characteristics of plastic moldings for the automotive industry was assessed using the Shewhart control charts method to evaluate the measured width and length of the plastic moldings produced through statistical analysis. The stability of the process has been confirmed, which demonstrated that the process was well-set. It was important to ensure the correct chronological arrangement and regular acquisition of measured values when setting the control charts (Malindzakova et al., 2023).



A novel method was presented for interpreting process capability indices in the context of assessing the performance of complex health profiles in the human body. Profile monitoring, a widely used multivariate statistical technique, is often too intricate or unfeasible when dealing with such profiles. To address this issue, the proposed method involves converting the health profile into a univariate specification by means of dissimilarity indices. The effectiveness of this new approach was demonstrated through a simulation study that employs human blood pressure profiles as an example (Nemati & Mehrdoost, 2023).

Faults in wind turbines and predict maintenance needs of wind turbines in Taiwan was diagnosed through employing statistical process control and machine learning techniques. Unlike previous studies that relied solely on historical wind turbine data, this study also integrated maintenance check list items into the data mining process, thereby incorporating practitioners' insight. Various methods such as Pareto analyses, scatter plots, and the cause-and-effect diagram were utilized to cluster and classify the different failure types of wind turbines based on the sensor data. Control charts were also used to establish a monitoring mechanism that could detect wind turbine abnormalities by tracking whether operation data deviated from the controls (i.e., standard deviations). Overall, this study provided a comprehensive approach to wind turbine fault diagnosis and maintenance prediction, which could have significant implications for the renewable energy industry (Hsu et al., 2020). Even in today's trend of big data, it is often necessary to monitor the underlying sequential process to ensure its stability and track any changes in distribution over time. SPC charts are a widely used statistical tool for monitoring such sequential processes. Traditionally, SPC charts have been used

mainly in the manufacturing industry for monitoring production lines. However, recent research has introduced new and versatile SPC methods that can extend the application of SPC charts to many big data applications beyond production line monitoring. As a result, it is believed that SPC charts can be a valuable tool for monitoring and analyzing sequential processes in a wide range of applications (Qiu, 2020).

Six Sigma tools were applied to identify and address improvement opportunities in a concrete block manufacturing company. The DMAIC (Define, Measure, Analyze, Improve, and Control) was used to identify problems, performance variables, and results. It demonstrated the effectiveness of Six Sigma in improving production operations, leading to benefits such as reduced machine downtime, decreased scrap, and improved plant layout and production facilities to increase productivity (Morales et al., 2016).

Quality control is essential in the production of construction materials to ensure they meet desired specifications and standards. It is crucial for safety, durability, cost-effectiveness, reputation, and compliance with regulations and codes. Substandard materials can lead to structural failures, injury, or loss of life, and may have shorter lifespans, resulting in costly repairs or replacements. Quality control can save costs in the long run, establish customer loyalty, and prevent legal and financial consequences for non-compliance.

Several articles on the quality of construction material production have been published especially about the quality of ready-mixed concrete (RMC) production systems. The concrete production processes and pouring methods were improved by identifying and evaluating opportunities for improvement. The results indicated that management should adopt systematic

procedures, including the use of quality tools such as histograms, control charts, and fishbone diagrams, to analyze concrete strength data and detect any abnormal variations (Aichouni et al., 2017). Lean Six Sigma has been adopted in the construction industry for the aim to test the hypothesis that Six Sigma can be applied to construction-based production systems using lean construction techniques. The case study involved applying Lean Six Sigma to a concrete-panel production system in a multi-housing complex project, resulting in improved and stabilized production rates. The variation of panel production was used as a critical total quality (CTQ) to measure the performance indicator of the Six Sigma system (Kim & Heon Han, 2012). A review of the basic concepts of process improvement and the benefits of applying these concepts in the construction industry have been reviewed that focuses on the use of basic quality tools to improve the production process of RMC, and presents a case study of a local RMC producer in Hail, Saudi Arabia. The study monitored and analyzed the 28-day compressive strength of the plant using histogram and Xbar-R control charts techniques, and concluded that producers can effectively improve their production processes, save money, and make their processes sustainable (M. Aichouni, 2014). The application of SPC tools has been reviewed in the concrete production systems of Palestinian construction companies, with a focus on improving the production process of B30 concrete. A case study of a local company is used to monitor the compressive strength of their B30 concrete using various quality tools. The analysis indicates that SPC tools can be effectively applied in this sector to improve production processes, save materials, and reduce costs (Haddad, 2021).

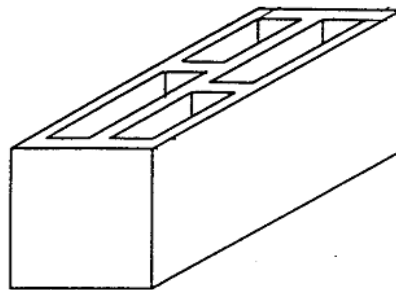
### 3. Methodology

The methodology adopted in this work can be summarized as follows:

1. Identifying the process and selecting the critical quality characteristics to be monitored.
2. Determining the method and frequency of data collection.
3. Establishing control charting methodology and setting control limits.
4. Monitoring the process and collecting data.
5. Analyzing the data to determine whether the process is in or out of control.
6. Assessing the process capability.
7. Sugesting corrective actions and improvement proposals if necessary.

### 4. Concrete Blocks for Walls Production

This article considers the most common type of concrete blocks used in the Palestinian Market which is called the normal block as shown in Figure 1.



**Figure 1.** The Normal Concrete Block

The common production steps for concrete blocks used for walls include:

1. **Mixing the ingredients:** Cement, sand, water, and aggregates such as crushed stone or gravel are mixed together in a concrete mixer to create the concrete mixture.
2. **Molding the blocks:** The concrete mixture is poured into molds. The molds are then vibrated to remove any air pockets and ensure the concrete is evenly distributed.
3. **Curing the blocks:** The molds are left to sit for a period of time, typically 24 to 48 hours, to allow the concrete to cure and harden.
4. **Stripping the molds:** Once the blocks have cured, they are removed from the molds.
5. **Finishing the blocks:** The blocks may be trimmed or shaped to meet

specific design requirements, or they may be left with a rough, textured finish.

6. **Storing the blocks:** The finished blocks are stored in a covered area to protect them from the elements until they are ready to be used in construction. These Steps are shown in Figure 2.

### 5.1. The Density Test

The density of the block, which has been dried in the air in a laboratory for at least 3 days, is examined as follows: the block is weighed accurately to 50 grams. Then, the volume of the brick is calculated by multiplying the dimensions of length, width and height. Finally, the density is calculated by dividing the mass of the brick (in kilograms) by its volume (in cubic meters).



**Figure 2.** Concrete Block Production Steps

## 5. Data Analysis and Results

According to the Palestinian Standard, one sample of blocks is defined as a group of three blocks of the same type, size, and shape, produced by a single manufacturer. The sample is randomly selected to represent a single lot of blocks. The results are considering the main three critical quality characteristics: block density, crushing load, and compressive strength. To ensure high-quality concrete block production, several factors must be considered. These include the quality and consistency of the raw materials used, the mix design and ratio of the raw materials, the type and quality of production equipment, and the curing

conditions such as temperature, humidity, and curing time. Proper attention to these factors can impact the strength, density, and durability of the final product.

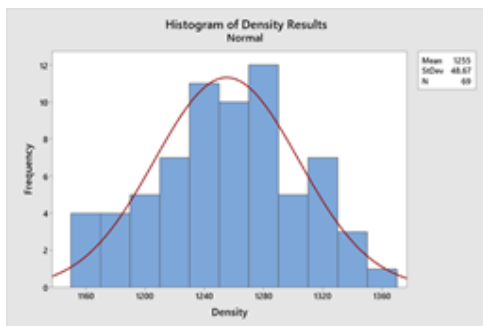
Twenty-three samples of size three were taken as a preliminary step to construct the appropriate control charts. The results and analysis of each quality characteristics will be discussed in the following sub-sections.

The results are shown in Table 1.

Histogram is used in statistical analysis to identify the underlying distribution of a density test dataset as shown in Figure 3.

**Table 1.** Density Test Results

Sample No.	Density (Kg/m <sup>3</sup> )		
	Block 1	Block 2	Block 3
1	1196	1191	1172
2	1281	1193	1222
3	1298	1257	1176
4	1166	1325	1161
5	1333	1191	1291
6	1220	1243	1164
7	1235	1186	1214
8	1223	1181	1279
9	1317	1292	1292
10	1265	1239	1224
11	1168	1286	1212
12	1322	1297	1197
13	1258	1256	1243
14	1323	1252	1314
15	1261	1242	1274
16	1267	1245	1236
17	1247	1267	1333
18	1284	1288	1331
19	1281	1285	1287
20	1246	1314	1243
21	1249	1218	1276
22	1269	1361	1311
23	1288	1259	1287

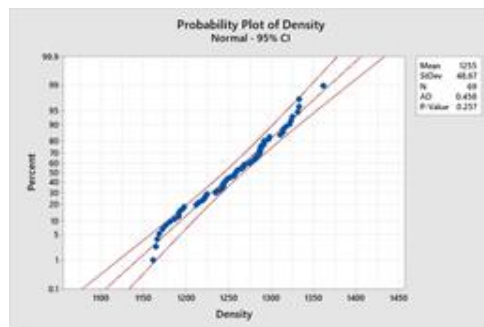


**Figure 3.** The Block Density Histogram

Based on the shape of the histogram, it appears that the distribution of block density is roughly normal. However, to confirm this assumption and further validate the normality of the distribution, a normal probability plot was created and tested using the Anderson-Darling (AD) test at a significance level of 0.05. The results of the AD test are displayed in Figure 4. By

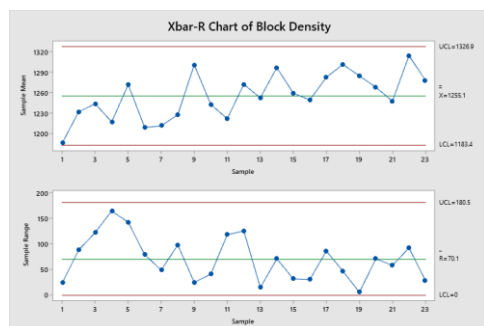
conducting this test, the normality of the distribution of block density can be more confidently assessed.

The (AD) test yielded a small AD value of 0.458, indicating that the normality assumption of the distribution of density is reasonable. Additionally, the p-value of 0.257 was obtained from the AD test, which is greater than the significance level of 0.05. Therefore, we fail to reject the null hypothesis that the distribution of density is normal.



**Figure 4.** The Block Density Normal Probability Plot

Then, Xbar-R charts were constructed to ensure the stability of the process before assessing the process capability as shown in Figure 5.

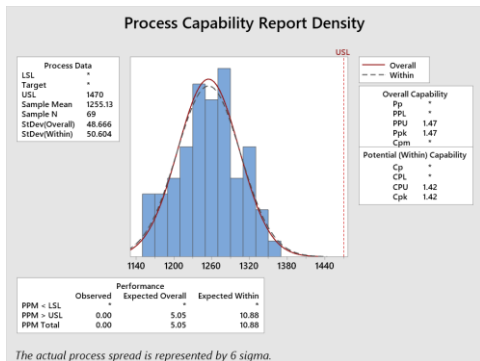


**Figure 5.** Xbar-R charts for Block Density

Based on the control charts, the process was found to be in statistical control and stable. This means that there were no unusual

patterns or outliers detected that would indicate a problem with the process. As a result, no assignable causes were identified that would affect the quality level of the process. The stability of a process in statistical control is crucial for interpreting process capability ratios (PCRs), which are used to assess the ability of a process to meet density specifications.

According to the standard, the maximum nominal value of density is 1400 Kg/cm<sup>3</sup> with no more than 5% above it (i.e., 1470 Kg/cm<sup>3</sup>). To assess the process capability, the resulting estimator of one-sided upper process capability ratio  $C_{pu}$  was calculated to be 1.42 which means that the process is capable of producing output that meets the specifications with a high degree of confidence. These results are shown in Figure 6.



**Figure 6.** The Block Density Capability Analysis

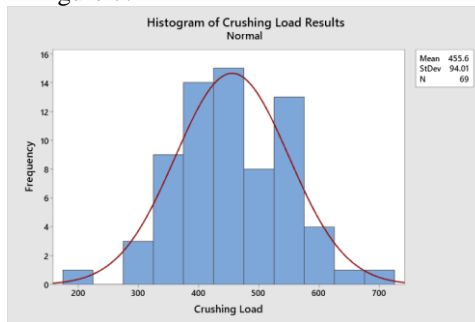
### 5.2. The Crushing Load Test

This load refers to the minimum compressive load or force required to cause a concrete block to fail or break. This load is expressed in in (Kg) according to the standard. The results are shown in Table 2.

**Table 2.** Crushing Load Results

Sample No.	Crushing Load (Kg)		
	Block 1	Block 2	Block 3
1	436	468	391
2	566	448	448
3	535	395	376
4	383	470	220
5	530	306	387
6	473	349	345
7	584	391	398
8	410	379	505
9	566	361	420
10	618	350	385
11	330	494	484
12	569	519	375
13	608	329	496
14	547	555	555
15	552	338	445
16	508	440	332
17	491	439	694
18	525	408	540
19	317	557	462
20	352	430	470
21	515	324	413
22	464	474	576
23	659	429	530

Histogram of crushing load dataset is shown in Figure 7.



**Figure 7.** The Histogram of Crushing Load

Based on the shape of the histogram, it appears that the distribution of the crushing load is roughly normal. A normal probability plot was created and tested using the (AD) test at a significance level of 0.05 as shown in Figure 8.

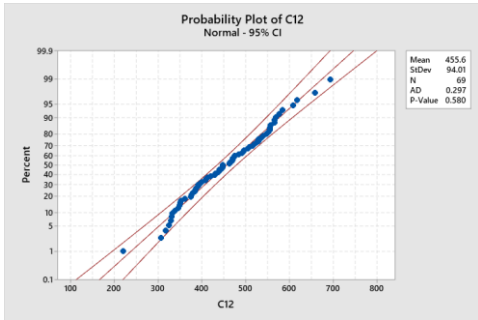


Figure 8. The Crushing Load Normal Probability Plot

The (AD) test yielded a small AD value of 0.297, indicating that the normality assumption of the distribution of density is reasonable. Additionally, the p-value of 0.580 was obtained from the AD test, which is greater than the significance level of 0.05. Therefore, we fail to reject the null hypothesis that the distribution of density is normal.

Then, Xbar-R charts were constructed to ensure the stability of the process as shown in Figure 9.

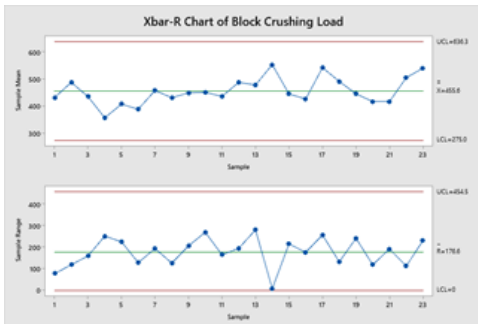


Figure 9. Xbar-R charts for The Crushing Load

The process was determined to be in statistical control and stable. This indicates that there were no unusual patterns or outliers detected that could suggest issues with the process. Therefore, no assignable causes were identified that could affect the quality of the process.

According to the standard, the minimum value of crushing load is 300 Kg. To assess the process capability, the resulting estimator of one-sided lower process capability ratio  $C_{pl}$  was calculated to be 0.55 which means that the process is incapable of producing output that meets the specifications and the results are shown in Figure 10.

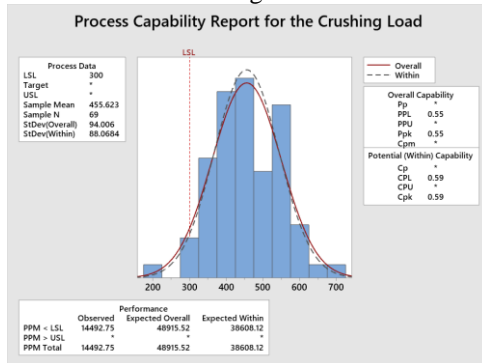


Figure 10. The Block Crushing Load Capability Analysis

The low value of the  $C_{pl}$  was caused by a high level of process variability that negatively impacted the process's ability to meet the required specifications. The underlying reason for this high variability could be traced back to changes in factors such as raw materials, equipment, improper process maintenance and control. These changes likely introduced variation into the process, leading to inconsistent results.

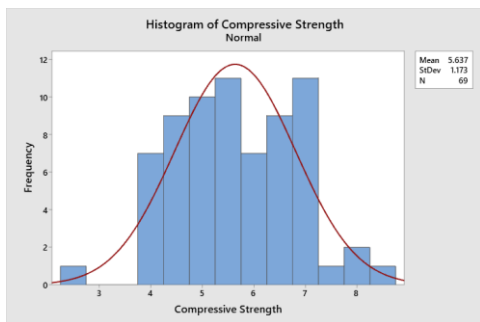
### 5.3. The Compressive Strength Test

The compressive strength of each block is calculated by dividing the crushing load in (N) by the area of the compression surface (in square millimeters). The average compressive strength for the sample is the arithmetic mean of the compression force for the three blocks in the sample. The results are shown in Table 3.

**Table 3. Compressive Strength Results**

Sample No.	Compressive Strength (N/mm <sup>2</sup> )		
	Block 1	Block 2	Block 3
1	5.4	5.7	4.87
2	7.0	5.56	5.49
3	6.72	4.78	4.56
4	4.75	5.86	2.66
5	6.59	3.78	4.8
6	5.94	4.37	4.19
7	7.21	4.78	4.94
8	5.07	4.58	6.27
9	7.06	4.43	5.27
10	7.82	4.36	4.74
11	4.07	6.44	5.9
12	7.01	6.42	4.66
13	7.31	4.08	6.09
14	6.84	6.92	6.89
15	6.78	4.25	5.41
16	6.3	5.42	4.08
17	6.02	5.42	8.57
18	6.56	5.02	6.75
19	4.03	6.95	5.7
20	4.31	5.35	5.85
21	6.3	4.01	5.11
22	5.67	5.85	7.18
23	8.04	5.24	6.59

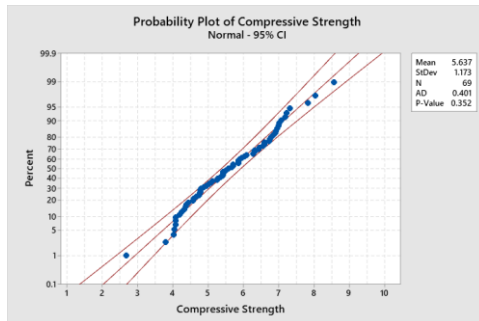
Histogram of crushing load dataset is shown in Figure 11.



**Figure 11. Histogram of Compressive Strength**

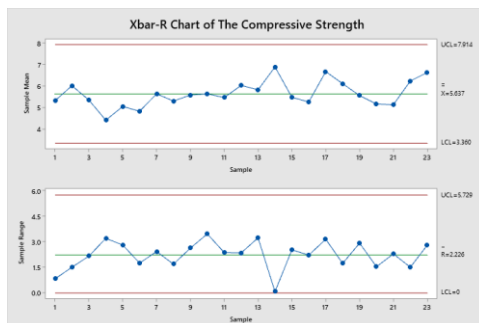
Based on the shape of the histogram, it appears that the distribution of the crushing load is roughly normal. A normal probability plot was created and tested using the (AD) test at a significance level of 0.05 as shown

in Figure 12.



**Figure 12. The Compressive Strength Normal Probability Plot**

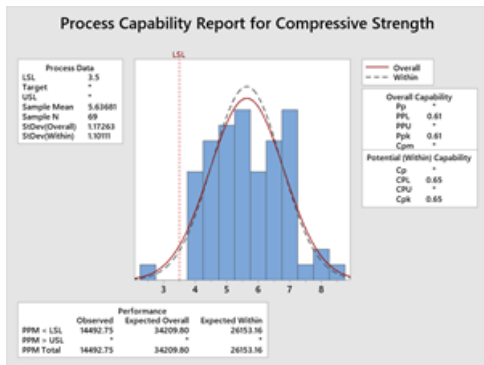
The (AD) test yielded a small AD value of 0.401, indicating that the normality assumption of the distribution of density is reasonable. Additionally, the p-value of 0.352 was obtained from the AD test, which is greater than the significance level of 0.05. Therefore, we fail to reject the null hypothesis that the distribution of density is normal. Then, Xbar-R charts were constructed to ensure the stability of the process as shown in Figure 13.



**Figure 13. Xbar-R charts for The Compressive Strength**

The process was also determined to be in statistical control and stable. According to the standard, the minimum value of the compressive strength is 3.5 N/mm<sup>2</sup>. To assess the process capability, the resulting estimator of one-sided lower process

capability ratio  $C_{pl}$  was calculated to be 0.65 which means that the process is incapable of producing output that meets the specifications and the results are shown in Figure 14.



**Figure 14.** The Block Compressive Strength Capability Analysis

The low value of the  $C_{pl}$  was caused by a high level of process variability that negatively impacted the process's ability to meet the required specifications. Since the compressive strength calculation is based on the crushing load, then the underlying reasons for this high variability are the same we mentioned in the previous sub-section. To explore the main causes of this large variation, a fishbone diagram or Ishikawa diagram is adopted to identify the different factors that influence the quality of concrete block production as shown in Figure 15. This diagram aids in exploring the underlying causes of issues and discovering potential solutions. By utilizing this diagram, producers can pinpoint the reasons behind substandard blocks and implement appropriate measures to address them. This may involve enhancing material quality, maintaining equipment, providing worker training, or refining the production process to ensure consistent and high-quality blocks.



**Figure 15.** Cause-and-Effect Diagram

The company was using excess ingredients in the production of concrete blocks to ensure a high crushing load and compressive strength, but this led to increased process variability and waste. Control charts showed that the company was prioritizing high overall averages over consistent adherence to specifications for each batch. The implementation tools can help the company produce high-quality batches with optimal ingredient quantities while reducing variability and cost. The company's current practices lack a clearly documented and planned implementation of SPC tools for continuous improvement and customer satisfaction.

## 6. Conclusions

The objective of this study is to demonstrate how Palestinian concrete block manufacturers can enhance their processes and save money and resources by implementing SPC tools and the results of the case study can be applied to other companies with varying practices. By monitoring the density, crushing load and compressive strength of the normal concrete block and making necessary improvements to their processes, manufacturers can optimize their mixtures and ingredients, ultimately reducing unnecessary material costs. By utilizing these tools, companies can identify the stability and capability of



their production processes, as a first step towards implementing continuous improvement strategies and addressing quality issues. These tools also increase productivity, prevent defects, and reduce the need for unnecessary adjustments. The study suggests that the manufacturers should establish a comprehensive system of documentation, data selection and analysis, training programs, and management

commitment to integrate quality tools into their quality management systems.

**Acknowledgment:** I would like to express my gratitude to the local Palestinian construction company for their valuable assistance in providing us with the required data, which enabled us to successfully complete this project.

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## **THE LOW-QUALITY INFLUENCE OF PURCHASING: THE CASE OF FASHION STORES IN INDONESIA**

**Abstract:** *Unplanned purchasing involves buying goods or services influenced by the external environment, creating low-quality purchasing. This research was conducted towards consumers of the Muslim clothing store in Jember East Java, Indonesia, as the population. Accidentally sampling was used to draw 125 respondents to address the questionnaire. The result shows that hedonic shopping, fashion involvement, and store environment influence low purchasing quality in Muslim fashion stores. Most consumers were mature female consumers and government officials with bachelor's degrees. Moreover, hedonic shopping, fashion involvement and store environment significantly influence low-quality purchase decisions. The research implied that consumers' shopping behaviour would underline the quality of buying decisions.*

**Keywords:** *Consumer Behaviour, Low Quality of Purchasing, Hedonic Shopping, Semantic Different*

### **1. Introduction**

The development of increasingly modern retailing has made the business more innovative and has led to the emergence of various business ventures. Along with the varied needs of consumers, it provides opportunities for businesspeople, especially in the fashion sector. According to State Global Islamic Economy, the consumption of Muslim fashion in Indonesia reached US\$20 million with 18.2% yearly growth (Dinar Standard, 2019). This sector contributes 18.1% or IDR 116 trillion to the national economy (CNBC-Indonesia, 2019). This fact has led to many specific retail stores that sell various types of fashion products, both men and women, where these shops provide service facilities and product quality, following the needs and expectations of different consumers

(Sudaryanto et al., 2019; Sudaryanto Sudaryanto et al., 2020).

A Muslim fashion store makes it easy for a specific ethnic of consumers to make purchases. The types of consumers purchasing a product are either rational or irrational (Schiffman & Joseph L., 2015). This rational purchase is planned (Sudaryanto Sudaryanto et al., 2020, 2021). This is an irrational, unplanned, or impulsive purchase (Iram, 2017). Most female consumers are likelier to purchase impulsively (Kwek et al., 2013; Ling et al., 2010). Most impulse buying is fashion shopping (Vinish et al., 2020). The decision with insufficient information and review availability is low-decision making (Elliot, 2018). In a philosophical approach, quality is the experience with universal acknowledgement that the entity has an absolute advantage (D. Garvin, 2007; D. A.

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Garvin, 1987). Accordingly, unplanned purchasing or impulse buying in this study was determined as low-quality purchasing.

Discussing about the shopping behavior, frequently consumer looking at many shops or boutiques that sell various kinds of clothing with various brands, models and, of course, at quite various prices. Jember is one of the cities whose fashion development is starting to rise. This can be seen from the number of Muslim fashion centres in Jember. The collection store here for the wider community, providing various kinds of Muslim clothing collections for men and women for adult, teenager or children sizes. This can indicate that the people of Jember always follow trendy fashion trends, including Muslim consumers. This can certainly trigger impulsive purchases for Jember people who have hedonistic traits or habits. Impulsive buyers usually pay more attention to their appearance and use more items, especially clothing.

Apart from that, the store also provides shoes, sandals, and Hajj and Umrah equipment. For consumers to be interested and motivated to make impulsive purchases, Rien Collection strives to create a comfortable and clean shop atmosphere. although the store sells various kinds of clothing in large quantities and complete, they always arrange the clothes neatly and in order. Other Muslim clothes in the store are mukenah, prayer mats, sarongs and other worship equipment. The products appear nicely in the glass that can be seen by everyone who pass the store and has impulse to buy and experienced in dissatisfaction and will not add a new value inherent. The research problem is then goes to what factors that influences of the low-quality decision purchasing in fashion store with the hedonic shopping, fashion involvement and the store environment.

## 2. Literature Review

### 2.1. The Low Quality of Purchasing

Customer decision making has been studied extensively. the basic assumption underlying this body of knowledge is that customer choices can be explained from a rational perspective where a choice is made after carefully considering different options from a set of alternatives. In some cases, customers violate these requirements of rationality, in such instances, choices are made without careful consideration of the available alternatives, with insufficient information about the product of interest, or without prior intent of purchase on such instance is impulse (Ayu Agustina Pratiwia, 2019; Hasim et al., 2020; Luo et al., 2021; Saad & Madiha Metawie, 2015).

Impulse buying in fashion store categorize as a low-quality decision of purchasing due to unplanned action (Elliot, 2018) (Iram, 2017; Vinish et al., 2020). (D. Garvin, 2007; Ton, 2002) (2007); D. A. Garvin, (1987) identify eight dimension of quality: Performance, Features, Reliability, Conformance, Durability, Serviceability, Aesthetics and Perceived quality (Hoe & Mansori, 2018). The affective response of decision to buy occurs when a consumer sees a certain product or brand and then the consumer becomes interested in getting it, usually because of an attractive stimulus from the store (Peter & Olson, 2010; Schiffman & Joseph L., 2015). This Impulse buying behaviour is often carried out by consumers when shopping, the action taken by consumers is to come and then begin by looking at the product first and deciding which product to buy. The product in question is in the form of a product that was previously planned by consumers for products that consumers did not think about at all. Usually, consumers have a strong urge from their hearts to buy a product immediately without strong self-control.

Hasim et al., (2020; Mirabi,( 2015); and Peter & Olson, (2010) states, unplanned purchases are all purchases made without prior planning, including of purchasing behavior where impulsive buying is making a decision to buy a product that is relatively fast and has the desire to have it immediately.

According to the findings of Li, Deng, and Moutinho (2015), consumers' interest in experience would considerably influence impulsive buying. However, surprisingly, up to the present, when studying marketing activities that encourage consumers' buying, most marketing management researchers neglect consumers' potential impulsive motivation and decision-making factors, as caused by interaction among products, situations, and experience.

The low-quality of fashion purchasing is mostly based on the consumer's affective response. Characteristic features The first consumer affective response is the affective system in general reactive. It means that the affective system cannot plan, make a decision, or deliberately achieve some goal. Even system affective in person usually it responds quickly and automatically toward aspects of significant environment(Burke & Ng, 2006; Hellier et al., 2003; Knoll & Matthes, 2017; Maros & Juniar, 2023; Schimmelpfennig & Hunt, 2020; Simon, 2016; Yuniarto, 2018; Zeithaml et al., 2018)

## 2.2. Hedonic Shopping

According to Chaudhuri, (2000); Kim et al., (2012); and Parsad et al., (2021), hedonic shopping is a motivation based on subjective or emotional thinking, sensory pleasures, dreams and aesthetic considerations. Hedonic shopping becomes a person's psychological needs such as satisfaction, prestige, emotions and other subjective feelings; these needs often arise to meet social and aesthetic demands. Consumers do shopping because they are driven by hedonic

desires or economic reasons, such as pleasure, fantasy and social or emotional satisfaction (Parsad et al., 2021). Since the goal of the shopping experience is to meet hedonic needs, this purchased product looks like it was chosen without planning and will present an Low quality of purchasing process. Hedonic shopping motives are similar to the task orientation of utilitarian shopping motives, only the task is concerned with hedonic fulfillment, such as experiencing fun, amusement, fantasy and sensory stimulation (Kim et al., 2012).

The first proposed hypothesis is:

**H1: hedonic shopping influences significantly towards low quality of purchasing**

## 2.3. Fashion Involvement

Bayley, et al (1998) in Hatane (2007), it is estimated that 65% of purchasing decisions at shopping centres with more than 50% being previously unplanned purchases or low quality of purchasing; this shows that impulsive purchases made by consumers are involved. contribute to the increase in sales turnover obtained by a retail store. Usually, consumers have a strong urge from their hearts to buy a product immediately without strong self-control. According to research by Bayley, et al (1998) in Hatane (2007), it is estimated that 65% of purchasing decisions at shopping centres with more than 50% being previously unplanned purchases or low quality of purchasing; this shows that impulsive purchases made by consumers are involved. contribute to the increase in sales turnover obtained by a retail store.

The development of the fashion world called fashion has experienced rapid progress in Indonesia. Psychologically, fashion is an expression and a person's attractiveness to his social environment. In today's world Fashion has become a common thing and has become everyone's lifestyle. From This lifestyle is the development of fashion

among the people to be a factor which can affect the style or style of each person. People will tend follow current fashion trends. Fashion itself comes from English which means fashion, style, way, model, and habit. In fact the meaning of fashion is different for everyone. The existence of a fashion store makes it easy for consumers to make purchases. The types of consumers purchasing a product are either rational or irrational (Schiffman & Joseph L., 2015).

According to Vinish et al., (2020) fashion involvement is a person's involvement with a fashion product because of their needs, interests, interests and values; fashion can confirm a person's identity in their social environment. Dhurup (2014) suggests that the pattern of impulsive buying behaviour by consumers can refer to the lifestyle of consumers who always follow the development of the fashion trends offered; this can be seen from the attitude and lifestyle of consumers in choosing fashion products, because of the nature of fashion involvement. towards fashion in consumers. Fashion involvement refers to the extent to which an individual finds a number of modes related to concepts, awareness, knowledge, interests, and reactions. To support fashion involvement in the consumer, Muslim Fashion store Jember always strives to provide clothes with trendy designs and the best quality so that consumers will want to buy these products to support their lifestyle. Muslim Fashion store Jember provides a variety of fashion and is always updated so that consumers who see this new product will like it and want to buy it even though it was not planned beforehand.

The second proposed hypothesis is:

**H2: fashion involvement influences significantly towards low quality of purchasing.**

## 2.4. Store Environment

Hussain & Ali, (2015) defines the store environment is a physical store building composed of several elements such as music, lighting, shop form, instructions that direct visitors and human resource elements such as cashiers. The Purpose of the Store Atmosphere that managers need to pay attention to include: Design Must Match Impressions and Strategies, Design Should Influence Positive Consumer Behavior, Design Should Consider Cost and Value, Design Should Be Flexible. Store environment which consists of music, lighting, layout and employees significant effect towards low quality of purchasing (Hasim et al., 2020; Hussain & Ali, 2015; Saad & Madiha Metawie, 2015)

The third proposed hypothesis is:

**H3: store environment influences significantly towards low quality of purchasing.**

## 3. Research Methods

### 3.1. Research Design

The research design used in a study depends on the method to be used in a study and/or the hypothesis to be tested and the variables to be observed. The research design is a master plan that contains methods and procedures for collecting and analyzing the required information (Babbie, 2001; Malhotra & Birks, 2007; Sudaryanto et al., 2021) This research is included in the category of explanatory research that explains the interdependency between predictors and predicted the variables.

### 3.2. Population and Sample

The population in this study were all consumers of the Rien Collection Jember Clothing. The sampling method in this study uses accidental sampling techniques. A non-



probability sampling is a sampling technique that does not provide equal opportunities or opportunities for each element or member of the population to be selected as samples, then accidental sampling is part of non-probability sampling where the sampling technique is based on chance (Malhotra & Birks, 2007). The sample in this study was 125 store consumers of the Rien Collection Muslim store in Jember District, East Java Indonesia, who met the research criteria based on chance.

### 3.3. Data

The primary data was collected from the questionnaire that was distributed to respondents offline before the Ramadhan festival. The response was measured using a Semantic different scale from 1 (very negative to 10 very positive). The data in this research is cross-section data, which was collected in June 2021. According to Sugiyono (2010: 137), primary data is data obtained directly from the original source, in this study related to perceptions of hedonic shopping, fashion involvement, and store environment on low quality of purchasing.

### 3.4. Statistical analysis

Multiple linear regression analysis is used to analyze the data with independent variables Hedonic Shopping (HS) and fashion involvement (FI) and the Store Environment (SE) with Low quality of purchasing (IB) as a dependent variable. Given that this study uses 3 independent variables, the regression equation according to Sugiyono (2010: 277) is as follows:

$$Y = \alpha + \beta_1 IB + \beta_2 HS + \beta_3 FI + \epsilon$$

### 3.5. Classic assumption test

The Gauss-Markov theorem consists of six classical assumptions that must be met when conducting multiple linear regression

analysis or ordinary least squares (OLS). This is well-known as BLUE (Beest Linear Unbiased Estimator), considering that not all data can be applied to regression and represent the actual populations.

The multicollinearity test aims to test whether the regression model found a correlation between the independent variables. The presence or absence of multicollinearity in the regression in this study was tested with the Variance Inflation Factor (VIF). The test results show that the tolerance value is less than 10 and the tolerance value is more than 0.1. It means that there is no multicollinearity problem.

The heteroscedasticity test aims to test whether in the regression model there is an inequality of variance from the residuals of one observation to another. In this study, the Glejser test is used. The provisions are that if the independent variables have no heteroscedasticity symptoms with statistically significantly more than 0.05.

### 3.6. Data Normality And Validity And Reliability Test

The data normality and validity and reliability test were executed using a statistical test. The data normality test used in this study was the Kolmogorov-Smirnov test data normality. The test criterion is that if the significance value is more than 0.05. All the data in this study has normally distributed with a significance value is less than 0.05 then the data is not normally distributed.

The validity test in this study was carried out using the Pearson correlation method with a cut-off value greater than the r table (critical value). All the instrument in this study is declared valid with each item obtaining a calculated r value greater than r table.

The reliability test aims to measure the reliability of the questionnaire which is an indicator of the variable. In this research, the

author uses Cronbach's Alpha  $\geq 0.6$ . The results of the reliability test show that each variable passes the criteria means that the instrument used in this study is reliable.

## 4. Result

### 4.1. Descriptive Statistics

The demographic characteristics of respondents are classified into, sex, age, education, and employment. Based upon sex, respondents of this research are male 34.4% and female 65.6%. Based on employment; housewives 15.6%; private employment 24.0% students as much as 6.3 %; government officials much as 29.2% entrepreneurs as much as 25.0%. Based on education; Senior high school 12.5% Diploma as much as 30.2% Bachelor 57.3%.

### 4.2. Hypothesis Testing

Hypothesis testing aims to determine the significant effect of the independent variable on the dependent variable. In this study, the hypothesis test was conducted by using the t-test. Ghozali (2013: 90) states that the t-test in multiple linear regression analysis aims to determine whether the independent variable (X) partially has a significant effect on the variable (Y). Testing on this partial hypothesis test uses a significance level of 5%, then the testing criteria is if the significance value  $t < 0.05$ , then there is a significant influence between one independent variable on the dependent variable, whereas if the significance value  $t > 0.05$ , then there is no significant effect between the independent variables on the dependent variable. The multiple linear regression results are presented in Table 1.

Based on Table 1, the resulting regression model as an explanatory model for the effect of HS, FI and SE on IB at the Rien Collection Jember fashion store can be stated as follows:

$$Y = 1,012 + 0.396 HS + 0.306 FI + 0.216 SE + e$$

- a. **Constant Value**  
 From the equation above, a positive value is obtained at a constant of 1.012, which means that if hedonic shopping (HS), fashion involvement (FI), and store environment (SE) are equal to zero, low quality of purchasing (IB) have a positive value of 1.012.
- b. **HS (hedonic shopping)**  
 The coefficient value of the HS variable is positive with a value of 0.396, which means that the higher the HS, the more impulse-buying consumers at the Rien Collection Jember fashion store will experience an increase. The HS variable in this study is the variable with the greatest influence on low quality of purchasing
- c. **Fashion Involvement (FI)**  
 The coefficient value of the fashion involvement variable is positive with a value of 0.306, which means that the higher the fashion involvement, the higher the of consumers at the Rien Collection Jember fashion shop.
- d. **Store Environment (SE)**  
 The coefficient value of the store environment variable is positive with a value of 0.216, which means that the better the store environment, the IBof consumers at the Rien Collection Jember fashion store will increase.

**Table 1.** Results of Multiple Linear Regression Analysis (Researcher analysis., 2022)

Variable	Regression Coefficient	Sig.	Information
a	1,012	-	-
<i>Hedonic Shopping (HS)</i>	0.396	0,000	Significant
<i>Fashion Involvement (FI)</i>	0.306	0.001	Significant
<i>Store Environment (SE)</i>	0.216	0.015	Significant

Note: the dependent variable is Low quality of purchasing (LQP)

**Table 2. The t-test results**

Variable	T count	T table	Sig.	Information
<i>HS</i>	4,800	1,986	0,000	Not to accept H0
<i>FI</i>	3,563	1,986	0.001	Not to accept H0
<i>SE</i>	2,489	1,986	0.015	Not to accept H0

Based on Table 2 can be explained the effect of each variable. The results of testing the effect of the HS variable on IB obtained t-statistics = 4,800 > t table = 1.986 with a p-value = 0,000 < 0.0. This means that not accepting H0 and accepting Ha, meaning that HS had an effect. significant towards IB on consumers of the Rien Collection Jember fashion store.

The influence of the FI variable on the IB obtained a t-statistics = 3.563 > t-table = 1.986 with p-value = 0.001 <  $\alpha$  = 0.05 so that H0 is rejected. And accepting Ha influences FI towards IB on consumers of the Rien Collection Jember fashion store.

The SE variable on IB obtained a t value of 2.489 which is greater than the t table, namely 1.986 and a significance value of p-value = 0.015 <  $\alpha$  = 0.05 so that not accepting H0 and accepting Ha meaning that the SE has an effect significant towards IB on consumers of the Rien Collection Jember fashion store.

## 5. Discussion

### 5.1. Effect of Hedonic Shopping on Low quality of purchasing

*The Hedonic Shopping* effect on Low quality of purchasing on consumers of the Muslim

fashion store Jember is evidenced by the results of the t-test which shows t-statistics greater than the t table (4,800 > 1,986) p-value  $\leq \alpha, 5\% = 0,000 < 0.05$ . The relationship shown by the coefficient value is positive, indicating that the higher the hedonic shopping level, the more consumers at the Muslim Fashion store Jember will increase. The results of this study are in line with previous research conducted by (Kim et al., 2012; Parsad et al., 2021) hedonic shopping has a significant effect on low quality of purchasing.

To create Hedonic Shopping for consumers, The Muslim Fashion store Jember seeks to create shopping emotions in consumers so that consumers will feel happy when shopping by providing complete products and facilities at the store so that consumers will be willing to linger in the shopping centre. Muslim Fashion store Jember also often holds sales discounts to increase consumers' Hedonic Shopping behaviour to create low quality of purchasing.

Based on the description of the research variables, it is found that consumers of the Muslim Fashion store Jember Clothing store have quite high hedonic shopping behaviour so the possibility of low quality of purchasing that consumers will make will also be higher.

Hedonic shopping in this study is measured through eight indicators consisting of novelty fun, praise from others, escapism, social interaction, money availability, time availability, and task definition. While low quality of purchasing (IB) is measured through four indicators consisting of spontaneity, out-of-control, non-cognitive evaluation, and disagreement of consequences.

In terms of the relationship between the two variables; the first indicator regarding novelty, many respondents, consider that the Muslim Fashion store Jember fashion store provides fashionable clothing products; this makes consumers buy a product even though they don't need it. Muslim Fashion store Jember always strives to provide trendy products because they are the target of consumers to make them look attractive, unique or cool.

The second indicator regarding fun, is that many respondents think that they feel quite happy when shopping at the Muslim Fashion store Jember. The many type of fashion products displayed impulse freely chooses the products according to their wishes.

The third indicator regarding praise of others is that most respondents think that a feeling of pride arises when using the products of the Muslim Fashion store Jember. The fashion sell the unique products that are not sold in other stores; this makes the product not impressed by the market so that the wearer will feel proud to use the product he bought.

The fourth indicator concerns escapism; most respondents think that the feeling of fatigue is quite lost when shopping at the Muslim Fashion store Jember. Feelings of fatigue can disappear when a consumer sees a lot of good, unique and attractive fashion products so that even though consumers are in the Muslim Fashion store for a long time, they will still feel happy because they can see and buy the products offered.

The fifth indicator is about social interaction; most respondents think shopping at the Muslim Fashion store Jember with friends is enough to increase intimacy; this makes a comfortable impression so that consumers are willing to linger in the store and make purchases without being planned because they are interested in something. product. Shopping with other people will certainly make a consumer able to discuss how to assess the fashion product that he will buy so that it will certainly create intimacy.

The sixth indicator regarding money availability is that most respondents perceive that shopping at the Muslim Fashion store Jember Clothing Store is done when they have enough money; this makes consumers not consider risks after purchasing fashion products at the store. The products offered by the Muslim Fashion store Jember relatively expensive. When consumer comes to this shop, they have to provide enough money to get the product they want and immediately buy it without thinking about the risk.

The seventh indicator regarding time availability; is the majority of respondents think that there is enough free time to shop at the Muslim Fashion store Jember Clothing Store, which makes consumers not rush to select the products and make a purchases without a plan. Consumers who are willing to linger in the Muslim Fashion store Jember fashion store will certainly see a lot of the products offered so they are more likely to make unplanned purchases.

The eighth indicator regarding task definition; is the majority of respondents think that sometimes there is a desire to shop at the Muslim Fashion store Jember Clothing Store when they see attractive promos so that consumers will immediately buy the product without thinking about the usefulness of the product being purchased. Promotion is the most powerful strategy to attract consumers; when Muslim Fashion store Jember provides promotions such as

discounted prices, consumers will be interested and want to buy these fashion products because the opportunity to get these products at a lower price is unlikely to happen next time.

## 5.2. Effect of Fashion involvement on Low quality of purchasing (LQP)

*Fashion involvement* effect on low quality of purchasing on consumers of the Muslim Fashion store Jember clothing store is evidenced by the results of the t-test which shows t-statistics is greater than the t table ( $3.563 > 1.986$ )  $p\text{-value} \leq \alpha$ ,  $5\% = 5\%(0.001 < 0.05)$ . The relationship shown by the coefficient value is positive indicating that the higher the fashion involvement, the more low quality of purchasing consumers at the Muslim Fashion store Jember will increase. The results of this study are in line with research conducted by (Nimmermann, 2019; Triwijayati et al., 2020; Vinish et al., 2020) showing that fashion involvement has a significant effect on decision making process.

Based on the description of the research variables, it is found that consumers of the Muslim Fashion store in Jember have a fairly high fashion involvement behaviour so that the possibility of low quality of purchasing that consumers will make will also be higher. Fashion involvement in this study is measured through four indicators consisting of important fashion probability or chance of error in purchasing, fashion showing a characteristic or a symbol, and pleasure in fashion. While low quality of purchasing is measured through four indicators consisting of spontaneity, out-of-control, non-cognitive evaluation and disagreement of consequences.

The following is the relationship between the two variables; (1) The first indicator is the first indicator regarding with fashion appearance that must be maintained to support daily activities. This makes

consumers willing to make unplanned purchases when they see the latest fashion products at the Muslim Fashion store Jember Clothing store. Appearance needs to be maintained by someone to make it look attractive than others. Consumers will strongly desire to buy fashion to judge that they look beautiful or handsome.

The second indicator is about the probability or chance of error in buying. The majority of respondents think that they feel quite confused when making choices when buying fashion products at the Muslim Fashion store Jember Clothing Store because of the availability of various attractive clothing choices so that consumers make purchases without prior consideration of the benefits of the clothes they buy. Consumers will immediately buy the product they want without thinking about the risks they expect, although when buying the product they want, consumers feel confused about choices.

The third indicator regarding fashion shows a characteristic or a symbol; eeeee majority of respondents consider the fashion products of the Muslim Fashion store Jember to adequately reflect their own style. This is important because of the attractive and comfortable design to use becomes focus of concern of the fashion products. The products offered at the Muslim Fashion store Jember are always up to date, which makes consumers want to buy them so that they can be seen as stylists.

The fourth indicator regarding the pleasure of fashion; the majority of respondents think that using fashion at the Muslim Fashion store Jember Clothing Store is enough to create pleasure, so consumers want to have fashion products offered at the store and buy them without looking at the quality of the materials but seeing the design side. The products offered at the Muslim Fashion store Jember are always up to date, which makes consumers want to purchase and keep stylists.

The fourth indicator regarding the pleasure of fashion; the majority of respondents think that using fashion at the Muslim Fashion store Jember Clothing Store will create pleasure. Accordingly, consumers interested to buy products offered at the store and creates buying based upon the design. The products offered at the Muslim Fashion store Jember are always up to date, which makes consumers seen as stylists. The fourth indicator regarding the pleasure of fashion; the majority of respondents think that using fashion at the Muslim Fashion store Jember Clothing Store is enough to create pleasure, so consumers want to have fashion products offered at the store and make a purchase

### 5.3. The Effect of Store Environment on Low quality of purchasing (LQP)

*Store environment* effect on low quality of purchasing on consumers of the Muslim Fashion store Jember clothing store is evidenced by the results of the t-statistics which shows t-statistics greater than the t-table ( $2.489 > 1.986$ )  $p\text{-value} \leq \alpha$ ,  $5\% = 5\%$  ( $0.015 < 0.05$ ). The relationship shown by the coefficient value is positive, indicating that the better the store environment is, the low quality of purchasing of consumers at the Muslim Fashion store Jember fashion store will increase. The results of this study are in line with research conducted by Tendai and Crispen (2009), Mohan et al., (2013), Saad and Metawi (2015), Wulandari (2018) and Raihani (2019) showing that the store environment has a significant effect on low quality of purchasing.

Based on the description of the research variables, information is obtained that consumers of the Muslim Fashion store Jember Clothing store have a fairly good store environment behavior, so the Low quality of purchasing that consumers will make will also be higher. The store environment in this study is measured through four indicators consisting of music

(X3.1), lighting (X3.2), layout (X3.3) and employees (X3.4).

The first indicator regarding music, the majority of respondents think that the music at the Muslim Fashion store in Jember Clothing Store is sufficient to generate interest in visiting; this encourages consumers to buy a fashion product that was not planned in advance. The Muslim Fashion store Jember fashion shop always plays songs to create comfort for consumers; this also indirectly makes consumers feel at home to linger in the store.

The second indicator is about lighting; most respondents think that the lighting at the Muslim Fashion store Jember Clothing Store is designed well enough to make it easier to shop and create a sense of comfort that makes consumers more likely to make purchases without strong effort. Lighting in a fashion store is certainly an important thing so that consumers can easily see in detail the products they are going to buy and make it easier for consumers to find the products they want.

The third indicator is about the layout; the majority of respondents think that fashion products in the Muslim Fashion store Jember Clothing Store are grouped by type so that it gives a pretty neat impression and makes consumers easy to choose the desired fashion product and is likely to buy the fashion product they like without looking ingredients of the product. The arrangement at the Muslim Fashion store Jember fashion store is done neatly and is grouped by type so that consumers will easily find the product they are looking for. The fourth indicator regarding employees; the majority of respondents think that employees at the Muslim Fashion store Jember Clothing Store provide quite a friendly service; this creates a comfortable impression when shopping and makes consumers willing to buy the fashion products offered without prior planning. Good employees will certainly make consumers feel comfortable and

enjoyable on finding the product they want.

## 6. Conclusion

Based on the analysis of hedonic shopping, fashion involvement, store environment and low quality of purchasing variables, the conclusions of this study are as follows.

- a. *Hedonic Shopping* effect on low quality of purchasing on consumers of the Muslim Fashion store Jember fashion store. The Muslim Fashion store Jember fashion store seeks to create hedonic shopping by building shopping emotions in consumers so that consumers are willing to do shopping and make low quality of purchasing.
- b. *Fashion involvement* effect on low quality of purchasing on consumers of the Jember muslim fashion store. The store provides a variety of fashion and is always updated so that consumers who see this new product will like it and want to buy it even though it was not planned beforehand.
- c. *Store environment* effect on low quality of purchasing on consumers of the Muslim Fashion store Jember fashion store. The store environment in this store were well managed so that consumers feel at home in the store; with a comfortable shop atmosphere, consumers will linger in the store and are likely to see fashion products on display which will create low quality of purchasing.

## 7. Research Limitations

Based on the results of this study, there are limitations of this study that are the consumers population are limited to

consumers who are in the Muslim Fashion store Jember Stores only. In addition, this study were using offline survey that are limitted number of sample reached during the periods of research.

## 8. Recommendation

Based on the results of this study, the suggestions that can be given to several parties include the following:

- a. For the owner of the Muslim Fashion store  
The owner of the Muslim Fashion store should pay attention regarding hedonic shopping on the fun indicator. The business owner can create a pleasant atmosphere by providing attractive sales promotion such as package discount. With regards to fashion involvement on the fun indicator for fashion, the owner expected to provide up-to-date fashion designs that always trendy in order to attack towards the product fashion offered. In connection with the store environment in oarticular layout indicator, the usiness owner needs to imprpve the layout of the fashion and easily looking out the clothes.
- b. For Further Researchers  
For future researchers, it is better if the research is more generalized by expanding the object of research in the Muslim Fashion store in other countries. Researchers are also encouraged to add aother variables to improve management strategies to reach consumer high quality of purchasing. Future researchers also need to use omni channels to make it paperless and to reduce errors in inputting research data.

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## A CASE STUDY ON THE SURVEY BASED RESEARCH OF CUSTOMER'S CHOICE OF TOOTHPASTE IN RAJASTHAN'S POPULATION

**Abstract:** *Toothpastes are essential part of dental hygiene and help prevent multiple and widespread tooth and gum diseases. The customer's choice of toothpaste sheds light on this knowledge of dental hygiene among the customers of various ages, sexes, ethnicity, financial statuses, geographical locations, etc. In present article, a survey was conducted among 300 people from different parts of Rajasthan. The questionnaire used was kept consistent and covered various aspects to generate ultimate customer satisfaction, while assessing future needs and satisfaction level of consumers. Results have been evaluated with the help of pie charts and further evaluation and studies on them have been done to give detailed conclusion. The information can help understand the type of oral hygiene methods that patients feel comfortable to approach and use. It can also help to understand the knowledge level of patients regarding dental hygiene.*

**Keywords:** *Toothpaste; Oral hygiene; Dental care; Oral hygiene aids; Dental carries*

### 1. Introduction

Although preventable, dental caries continues to be the most common non communicable disease worldwide. As much as 80% of caries incidence is experienced by only 20–25% of children, with 10% having untreated cavities, and those from low socioeconomic and minority groups experiencing significantly higher rates and at younger ages. [14]

Toothpastes are highly complex semisolid pastes that contain several active ingredients. Starting off with abrasives to remove dental plaque as effectively as possible. Many different abrasives are used in toothpastes, for example, hydrated silica, calcium carbonate, calcium phosphates, perlite,

alumina, and sodium bicarbonate. Different abrasives differ in relative hardness values and consequently in their cleaning efficacy and abrasion properties. In general, there is a trend of improvement to highly efficient abrasives, which show good plaque disruption or removal abilities, while having reduced radioactive dentin abrasion (RDA) values. [15]Fluoride has been identified as a potent caries preventive agent with significant benefits. Daily brushing with fluoride toothpaste is the most common topical fluoride application method. However, there are problems associated with fluoride applications, such as toxicity at high doses. The availability of fluoride over the past few decades has now led to the evolution of fluoride-resistant *S. mutans* and

other oral bacterial species; hence, its actions on acid-producing microbes may be diminishing. [18]

In addition to delivering therapeutic agents to combat caries and gingivitis, toothpastes are formulated to remove dental plaque, as well as stains, as effectively as possible while being gentle to teeth and gingiva. [15]

This survey discusses the factors that influence the customer's choice, this information can help understand the type of oral hygiene methods that patients feel comfortable to approach and use. It can also help to understand the knowledge level of patients regarding dental hygiene. [1] Prevention of oral disease is considered to be the most effective, acceptable and efficient method to attain oral health. The attitude of people toward their own teeth, and the attitude of dentists who provide dental care, play an important role in determining the oral health condition of the population. [2] There seems to be a lack of knowledge and awareness about how to choose a dentifrice and toothbrush, so education of people on the importance of oral hygiene maintenance, proper selection and method of use of oral hygiene products is needed. [3]

Consumer behavior is not exactly predicted one; somewhat it is predicted with the help of research activity. Starting and ending of the survey ends with only one statement 'consumer is king'. So the companies concentrate in analyzing the requirement of people thoroughly to satisfy and retaining the consumer. [4]

Previous experience seems to be a very strong factor in the choice of both the toothbrush and toothpaste in a study, which suggest that for as long as the respondents are satisfied with a particular product, they will stick to it. [5]

Another factor that may go a long way in determining the choice of toothpaste by a consumer is the content of the paste. Some consumers are concerned with the herbal contents, while others are concerned about

the fluoride content. Anecdotal reports have it that the majority of consumers of toothpaste in Nigeria are more concerned about the herbal content, while the dentists are those more concerned about the fluoride content. [6, 7]

Herbal tooth pastes have similar antibacterial effect as conventional tooth pastes. Tooth paste with multiple herbal ingredients is more efficient than the tooth pastes with fewer herbal ingredients in an anticariogenic property. [8] Although, homemade toothpaste seems dangerous, a study evaluating 84 homemade formulations stated that none of the formulas analysed contained any fluoride salts also highlighting that it is impossible to predict their abrasiveness and microbiological quality. [12]

There is a need for the dental professionals to be aware of the ever-increasing development and marketing of oral hygiene products from various databases. Hence, the education of people regarding the importance of oral hygiene maintenance, proper selection of oral hygiene products is essential. [9]

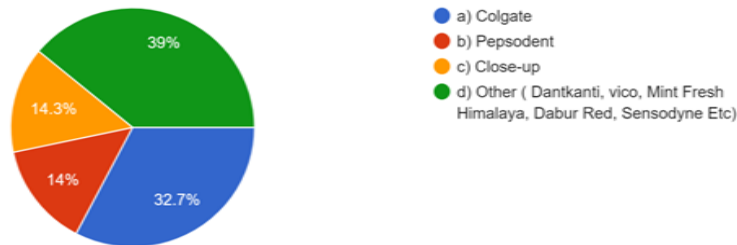
In present study, customer expectations, usage, attitude and brand comparison were studied for the toothpaste category, wherein the primary benefits that the consumer seeks while using a particular brand was analyzed with its purchasing pattern and behavior, and the core triggers to purchase their favorite brand. The effect of demographic factors like age, gender, occupation, income level was observed with respect to the purchase of toothpaste. Switching behavior between various brands was analyzed with the help of factors like offering attractive discounts, use of samples, price points and availability. [10]

## 2. Material & Methods

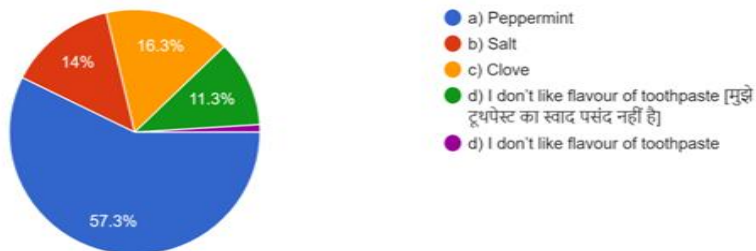
Problem formulation: The survey addresses only what the participants answered based on their personal experiences. The number is only limited to 300 people due to limited

reach of researchers involved, despite that the survey covers all regions of state widely. A cross sectional study was conducted among 300 people from different parts of India. Questionnaires were distributed to all subjects of various age groups, gender, ethnicities, financial backgrounds and geographical locations.

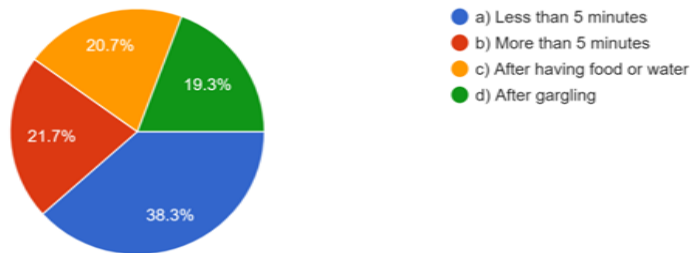
Consumers choose their options among the various choices given below the questionnaire. The following gives the list of questions and the respective answer depicted in the pie chart.



**Figure 1.** What is the brand of toothpaste that you are using at present?



**Figure 2.** Which flavour of toothpaste do you prefer?



**Figure 3.** After how long does the flavour of toothpaste recede from your mouth?

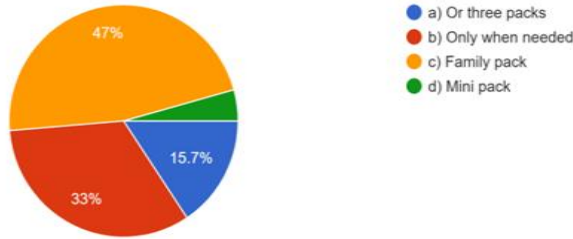


Figure 4. Do you buy toothpastes in stock or when needed?

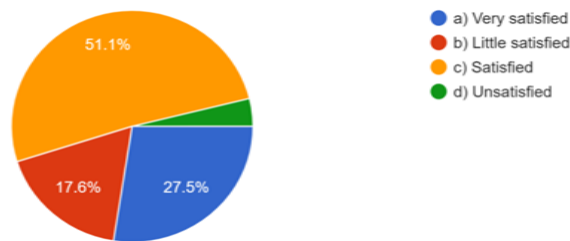


Figure 5. How satisfied are you with your current toothpaste?

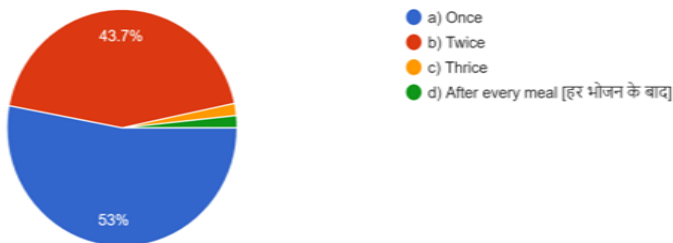


Figure 6. How many times do you brush your teeth a day?

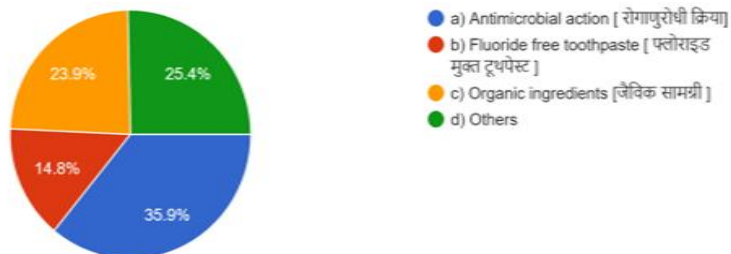
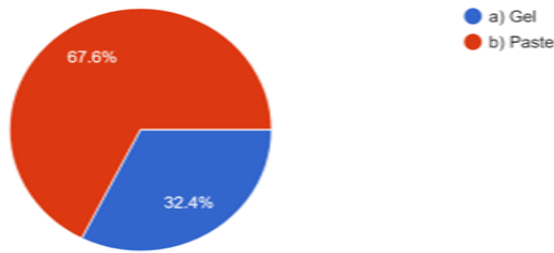
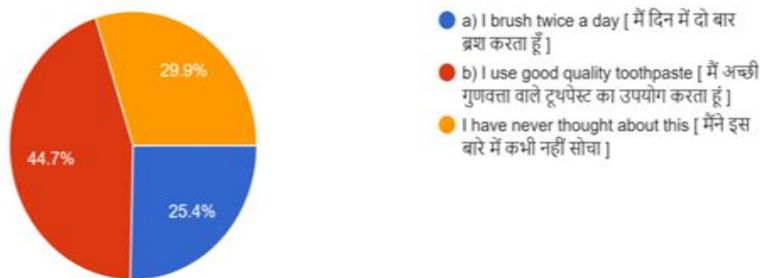


Figure 7. What additional features would you like to see in your toothpaste?



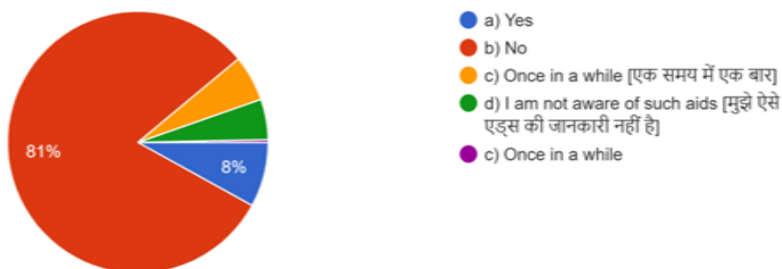
**Figure 8.** What texture do you desire in your toothpastes?



**Figure 9.** What actions are you considering to prevent tooth decay in future considering 1/3th of world population is affected by it each year?



**Figure 10.** What is the quantity of toothpaste you use?



**Figure 11.** Do you have the habit of using any other oral hygiene aids such as mouthwash?

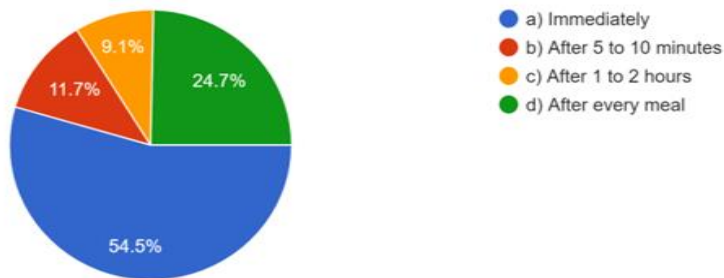


Figure 12. If Yes, How long after brushing do you use a mouthwash?

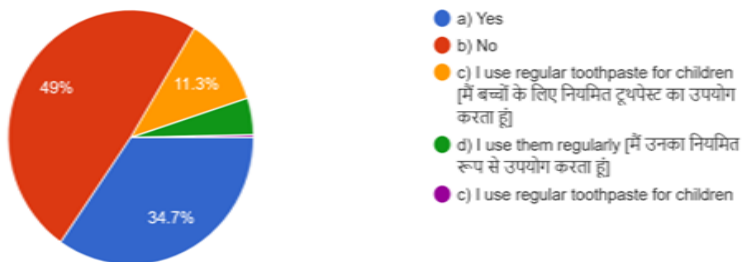


Figure 13. Do you know there are toothpastes specific for children?

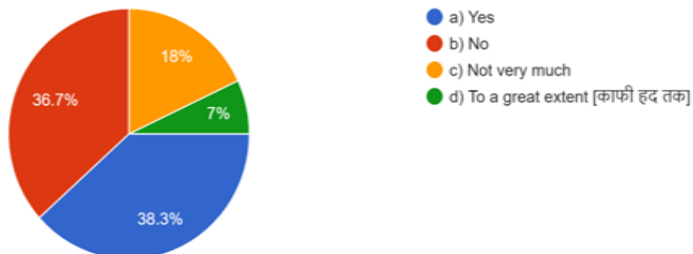


Figure 14. Does the taste of the toothpaste affect your choice of brand selection?

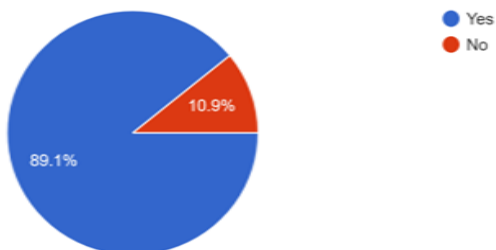
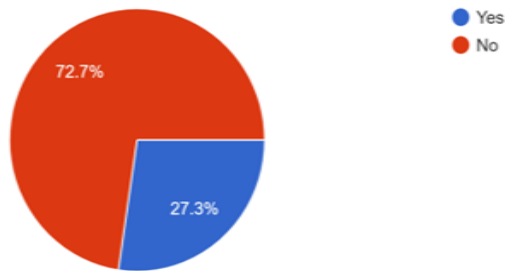
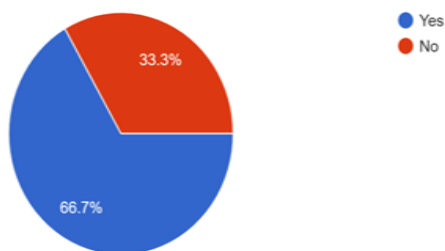


Figure 15. Do you feel like there is less awareness between people for oral hygiene?

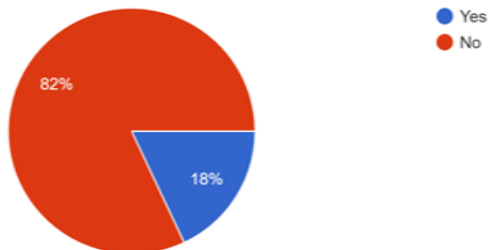




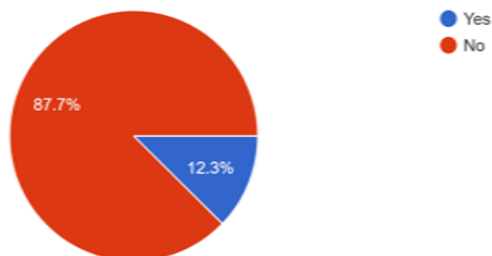
**Figure 16.** Have you tried using Herbal toothpaste?



**Figure 17.** Is your current brand prescribed by a dentist?



**Figure 18.** Have you used any natural brushing aids?



**Figure 19.** Do you change your toothpaste regularly?

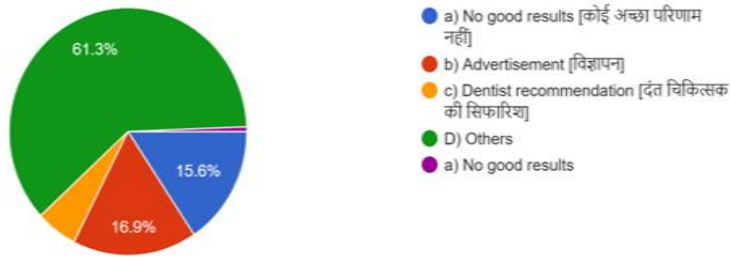


Figure 20. If Yes, why?

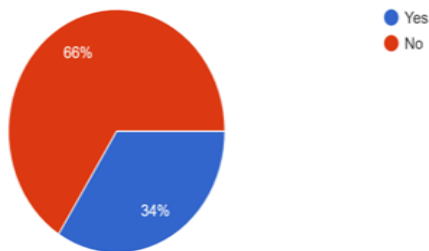


Figure 21. Does the cost of the toothpaste affect your selection?

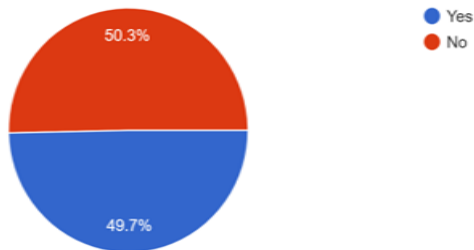


Figure 22. Do you believe packaging, advertisement or cost has nothing to do with the quality of the paste?

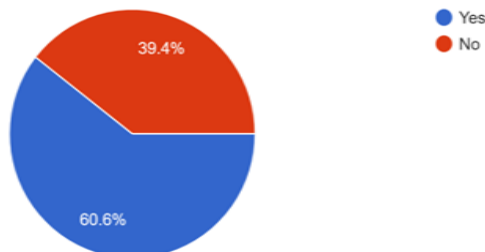


Figure 23. Does foaming action in your toothpaste affect your choices?

### 3. Result

A total of 23 questions were included in the survey. The first question addressed the brand being used at present by most customers and 39% customers agreed to using brands like Patanjali, Himalaya, Dabur, Sensodyne, Vico. The most common reason for choosing a brand was found to be Flavour as 62.3% of the population prioritises it. In another question, taste of toothpaste was not found to be a huge factor as 54.7% customers were either not affected by taste at all or it wasn't a significant factor for them, although peppermint holds the most preferred flavour spot with 57.3% votes. For about 38.3% of people, this taste recedes within 5 minutes of brushing.

Mouthwashes play an important role in dental hygiene, yet 81% of the population doesn't use them, moreover 5% of the population doesn't know of the presence of such aids in market. Similarly, toothpastes for children are unknown to 60.3% population. 89.1% need more awareness about dental hygiene as they find their current knowledge lacking. About 30% of the population has not given consideration to their dental health, and 44.7% use good quality toothpaste to prevent decay. Amount used commonly is as much as the length of their brush head for 46% people. For about 60% of the population brushing and whitening of teeth are not correlated and only 2 people in the entire population had undergone bleaching to whiten their teeth.

Herbal toothpastes have had more share in the market now than ever, it is seen as 66.7% of the population have used herbal toothpaste at least once. Yet natural brushing aids uses were limited to 18% of population. About 72.7% of the population doesn't consult a dentist for the choice of their toothpastes.

About 50% customers have been using the same brand since 1 to 2 years, and more than 37% have been using their brands for more

than 5 years. Brand loyalty again comes into play as 87.7% of the population doesn't change their toothpaste brands regularly. Out of 12.3% that actually do change, it's mostly for reasons other than dentist recommendations, advertisements and results of toothpastes. Only 15.6% of the population gives importance to results of toothpaste before changing brands and 16.9% value advertisement as a factor for brand switching.

About 66% of people were unconcerned with the price of their toothpastes. Only 12% have bought them as gifts or amenities. Packaging, advertisement or cost can have association with quality of product divided the population as 50% votes were for either option. About 67% population stocks up on one or other kind of packages, most popular ones being family packs with 47% votes. 53% people brush once a day.

Future trends suggest, antimicrobial action (35.9%), fluoride free nature (25%) and organic ingredients (25%). 67.6% customers wished for paste consistency over gel. Foaming action can affect brand selection too and about 60.6% customers agreed to foaming ability affecting their choices. Customer satisfaction is the ultimate goal, and 78.6% seem adequately satisfied with their current choices.

### 4. Conclusion & Future Aspect

Decreasing trust for various ingredients used in industry has led to development of a trend and consequently the herbal products demand started growing. Dabur has first mover advantage in market, after that came brands like Himalayas and Patanjali, who have gained unique position as well. With increasing acceptance of herbal products by consumers various MNE's like Colgate, HUL and P&G have realised the demand and have launched various herbal products for the same.

Excess fluoride consumption while teeth are developing can result in visibly detectable changes in enamel structure such as discoloration and pitting. Therefore, Centers for Disease Control and Prevention recommends that children should start using fluoride toothpaste at age 2 years. Children aged <3 years should use a just the size of a rice grain, and children aged >3 years should use no more than a pea-sized amount (0.25 g) until age 6 years. Although in an in vitro study the cleaning efficacy of medium-abrasive toothpaste showed that 1.00 g has a significantly higher cleaning efficacy than 0.25 g toothpaste and 0.125 g toothpaste. Rajasthan's population should be made aware of need for children specific toothpastes and amount they have been using. To solve the problem of excess fluoride content being used in toothpastes, 10% hydroxyapatite can provide comparable efficacy with in remineralizing initial caries

and preventing demineralization. Also incorporation of 2% arginine into fluoride toothpaste significantly increases its remineralization properties, as demonstrated by increased mineral gain, percent remineralization, surface Ca/P ratio with fluorine concentration, and enamel fluoride uptake.

Although the qualities like flavouring and foaming are important for consumer satisfaction but these should not be the whole and sole selling point for pastes. Proper advice from a trusted dentist should be taken before purchasing a tooth paste.

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Nusbantoro

## THE EFFECT OF PRODUCT QUALITY AND STORE ATMOSPHERE ON CUSTOMER LOYALTY THROUGH CUSTOMER SATISFACTION AT ALFAMART JEMBER

**Abstract:** This study aims to analyze and examine the effect of product quality and store atmosphere on customer loyalty on customer satisfaction at Alfamart Jember. The population in this study, all customers at Alfamart Summersari District, which are on Kalimantan Street and MT Haryono Street, and Alfamart Patrang District, which are chosen are Alfamart PB Sudirman Street and Alfamart Dr. Soebandi Street and Alfamart Kaliwates District, which are located at Ahmad Yani Street and at Basuki Rahmat Street. The results showed that product quality had a significant effect on customer satisfaction, product quality had a significant effect on customer loyalty, store atmosphere had a significant effect on customer satisfaction, and store atmosphere had a significant effect on customer loyalty. The findings of this study customer satisfaction have a significant effect on loyalty customer, product quality has a significant positive effect on customer loyalty through customer satisfaction and Store atmosphere has a significant positive effect on customer loyalty through customer satisfaction. Suggestions to add other variables, brand image, price, service quality, sales promotion, focused repurchase interest, and customer loyalty.

**Keywords:** Product Quality, Store Atmosphere, Customer Satisfaction, Customer Loyalty.

### 1. Introduction

The retail industry can be defined as an industry that sells products and directly provides services to end consumers (Berman and Evan, 2007:544). Most of the products sold are daily household needs using a self-service system, where consumers take their products or goods without being assisted by serving salespeople. The growth of retail business sales in Indonesia in the last few years from 2013-2021 has experienced quite an increase and decrease. Data in 2021 shows

retail sales growth in Indonesia by 9.8%. The record increased compared to the previous year, namely -14.6%. The data hit a record high of 15.2% in 2013 and a record low of -14.6% in 2020 (CEICdata.com). The growth of retail sales in Indonesia from 2013-2021 can be seen in Table 1. Table 1 shows that growth in Indonesia fluctuates every year. Seen in 2020 there was a very drastic decline in retail sales growth in Indonesia. The decline in retail growth in 2020 was due to the Covid-19 pandemic.

**Table 1.** Retail Growth in Indonesia in 2013 - 2021

No	Year	Retail Growth Each Year (%)
1	2013	15,2 %
2	2014	10 %
3	2015	5 %
4	2016	6,3 %
5	2017	-3,5 %
6	2018	-2,5 %
7	2019	-8 %
8	2020	-14,6 %
9	2021	9,8 %

Source: www.ceic data.com, 2021

The Indonesian Retail Entrepreneurs Association (APRINDO) said growth in 2020 only reached 3-3.5% or weakened compared to last year which ranged from 8%-8.5% (CEIC Data, 2020). The government's implementation of Large-Scale Social Restrictions (PSBB) has weakened retail growth. Even though shopping centers or malls have been opened, sales of modern retail stores have not met the expectations of business actors. The impact of the PSBB has also made people's purchasing power decline, thus holding back the pace of sales. The operational duration of several modern retail stores in Indonesia is also still limited to 6 hours from the previous 12 hours (<http://katadata.co.id>, 2020).

Alfamart is one of the retail companies that is experiencing fairly rapid development in Indonesia today. Alfamart is widely spread throughout Indonesia, one of which is Jember. Jember has 31 sub-districts, including Summersari District, Patrang District, and Kaliwates District, there are 131 retail units Alfamart in Jember Regency. The surge in modern retail in Jember has made competition between retail companies increasingly fierce, so retail entrepreneurs have their own ideas to find consumers so that they are interested in buying Alfamart products.

Alfamart retailers strive to increase competitiveness in the market by developing store brands. Alfamart is one of the retail outlets in Jember, making Alfamart the choice for people to shop for their daily needs at affordable prices and provide products from well-known companies, but also provide products with their brand Alfamart own, such as snacks, water, minerals, tissue, cooking oil, rice, and other household utensils. Alfamart realizes that a competitive advantage can be achieved by developing private label brands. Private labels are products marketed and developed by retailers that are only sold in stores retail (Levy and Weitz, 2007: 610). The advantage of having a private label is to strengthen customer loyalty, flexibility in pricing, and have control over the quality of goods.

Product quality is an important factor that is considered to obtain customer satisfaction after buying and using the product. Similarly, what Alfamart does to continue to capture market share by seeking customer satisfaction through the quality of products, private label among others, is the presentation of products private label that have attractive visual presentations so that they are appetizing, the arrangement of each product private label looks neat and in place, and the services provided by Alfamart employees are friendly and fast. The quality of these products will certainly affect consumer satisfaction. Research conducted by Nasirudin, Yulisetiari, and Suroso (2018) shows that product quality has a significant effect on customer satisfaction. According to Wirawan, Sjahrudin, and Razak (2019), that product quality has a significant effect on customer satisfaction. Syahmi, Colia, and Warman (2021) state that product quality has a significant effect on customer satisfaction. This means that the better the quality of the available products, the better the customer satisfaction. According to Ariescy, Yulisetiari, and Dimiyati (2017) who state that product quality has a positive effect on customer loyalty. Good product quality will



affect customer loyalty to the product. According to Wulandari, Hufron, and Basalamh (2020), Gunawan, Fathorrahman, and Handoko (2019) showed the same results that product quality had a significant effect on customer loyalty.

Store atmosphere plays an important role because of the environment that influences consumer behavior. Customers think that shopping is a form of recreation if a place makes them feel peaceful, comfortable and wants to linger in that place. Likewise, Alfamart, which makes a minimalist concept with a red display in almost all parts of Alfamart stores. The red color is believed to evoke feelings of pleasure and joy so that customers who come to Alfamart will not feel bored and feel at home in the store for a long time. Store atmosphere also has the same role to boost the customer in creating customer satisfaction. Research conducted by Winarjo and Japariato (2017) proves that store atmosphere has a significant effect on customer satisfaction, where the room design and layout are neatly arranged, lighting is very good, and access in and out that facilitates customer activities will make customers feel comfortable. In line with the research of Kumala, Hufron, and Khalikussabir (2020), Yulisetiari and Mawarni (2021) showed that the Store Atmosphere had a significant effect on customer satisfaction. In addition, according to Winarjo and Japariato (2017), the results show that store atmosphere has a significant effect on customer loyalty. In line with the research of Gunawan et al. (2019), Yulisetiari and Mawarni (2021) show the same result that Store Atmosphere has a significant effect on customer loyalty.

## 2. Literature Review

### 2.1 Product Quality

Product quality is something that has a good or bad level consisting of all the factors attached to the product, so that the product has the ability to be used as desired by consumers, therefore high product quality is needed so that satisfaction can be fulfilled (Kotler and Keller, 2012). According to, Orville, Larreche, Boyd (2005) formulate the dimensions of product quality are as follows.

1. Performance
2. Durability
3. Conformance to specification
4. Features
5. Reliability
6. Aesthetics
7. Perceived quality
8. Serviceability

### 2.2 Private Label

According to Keller (2007) private labels have become premium brands that have been known in European countries since 1990, so sometimes superior in terms of quality to the manufacturer's brand. Private labels are products that are marketed and developed by retailers and are only sold and available in stores retail (Levy and Weitz, 2007). Private label is divided into 4 product lines, namely personal care, food, nonfood, household (Beldona and Wyong, (2007).

### 2.3 Store Atmosphere

The store atmosphere is a combination of several elements of the store's physical characteristics such as coloring, temperature, architecture, sound, lighting, sign and layout, where all of these elements create a company image in the minds of customers or shop visitors (Berman and Evan, 2007). The store atmosphere is an environmental design through music, fragrances, visual communication, lighting, and colors to influence customers to buy an item and design

an emotional response to customer perception (Utami, 2010). Chatterjee, Berman, and Evans (2018), states that the store atmosphere is divided into 4 elements, namely.

1. Exterior Variable
2. Interior Variable
3. Store Layout
4. Interior Point of Purchase

### 2.4 Customer Satisfaction

According to Yulisetiari *et al.* (2020), customer satisfaction needs attention to the response of a product or service offered, basically, satisfaction is the goal of the company. Feelings of pleasure or disappointment from someone arising from comparing products (or results) against their expectations with perceived performance are called satisfaction (Kotler and Keller, 2009). Tjiptono (2007) says that the factors that influence consumer satisfaction are as follows.

1. Conformance of expectations
2. Ease of obtaining
3. Feelings after using

### 2.5 Customer Loyalty

Loyalty is a deeply held commitment to buy or re-support a preferred product or service in the future despite situational influences and marketing efforts that cause customers to switch (Kotler, 2016). Customer loyalty is a consumer who is strongly committed to buying or subscribing to a particular product or service in the future (Kotler and Keller, 2009b). According to Parasuraman, Zeithaml, and Berry (2009), indicators of strong loyalty are.

1. Say positive things about the company
2. Recommend the company to someone who seeks advice
3. Continue purchasing

## 3. Methodology

The population of this study, all customers at Alfamart Sumbersari District, namely Alfamart Jalan Kalimantan and Alfamart Jalan MT Haryono, Alfamart Kecamatan Patrang, namely Alfamart Jalan PB Sudirman and Alfamart Jalan Dr. Soebandi and Alfamart Kaliwates District, namely Alfamart Jalan Ahmad Yani and Alfamart Jalan Basuki Rahmat. The sampling technique used non-probability sampling with the purposive sampling method. The sample used was 120 respondents with a minimum age of 17 years who had visited, and made purchases and consumer products private label at least 2 times during the last month. The source of data in this study is primary data from data collection using a questionnaire via a google form. The analytical method used is path analysis.

## 4. Results and Discussion

### 4.1 Hypothesis Test

The following are the results of hypothesis testing in the study based on Table 2 below.

**Table 2.** Hypothesis Test Results

Hypothesis	Sig.	Description
$X_1 \rightarrow Z$	0,004	H <sub>1</sub> accepted
$X_2 \rightarrow Z$	0,000	H <sub>2</sub> accepted
$X_1 \rightarrow Y$	0,000	H <sub>3</sub> accepted
$X_2 \rightarrow Y$	0,011	H <sub>4</sub> accepted
$Z \rightarrow Y$	0,000	H <sub>5</sub> accepted

Source: Processed, 2021

- a. The effect of product quality on customer satisfaction

Based on Table 2 it can be seen that the results of testing the effect of product quality variables on customer satisfaction have a significance value of 0.004, then the value is smaller than 0.05 so it can be concluded that H<sub>0</sub> rejected and H<sub>1</sub> accepted which means that the quality product has a significant positive

effect on customer satisfaction at Alfamart Jember.

b. The effect of store atmosphere on customer satisfaction

Based on Table 2 it can be seen that the results of testing the influence of the variable store atmosphere on customer satisfaction have a significance value of 0.000, then the value is smaller than 0.05 so it can be concluded that  $H_0$  rejected and  $H_2$  accepted which means that the store atmosphere has a significant positive effect on customer satisfaction at Alfamart Jember.

c. Effect of product quality on customer loyalty

Based on Table 2 it can be seen that the results of testing the effect of variable quality products on customer loyalty have a significance value of 0.000, then the value is less than 0.05 so that we can conclude  $H_0$  rejected and  $H_3$  accepted, which means that the quality product has a significant positive effect on customer loyalty at Alfamart Jember.

d. The effect of store atmosphere on customer loyalty

Based on Table 2 it can be seen that the results of testing the influence of the variable store atmosphere on customer loyalty have a significance value of 0.011, then the value is smaller than 0.05 so it can be concluded that  $H_0$  rejected and  $H_4$  accepted which means that the store atmosphere has a significant positive effect on customer loyalty at Alfamart Jember.

e. The effect of customer satisfaction on customer loyalty

Based on Table 2 it can be seen that the results of testing the influence of the customer satisfaction variable on customer loyalty have a significance value of 0.000, then the value is smaller than 0.05 so it can be concluded that  $H_0$  rejected and  $H_5$  accepted which means that satisfied customers have a significant positive effect on customer loyalty at Alfamart Jember.

#### 4.2 Path Analysis

- 1) The indirect effect of product quality on customer loyalty through customer satisfaction is  $0.242 \times 0.393 = 0.095 = 9.5\%$
- 2) The indirect effect of store atmosphere on customer loyalty through customer satisfaction is equal to  $0.567 \times 0.393 = 0.222 = 22.2\%$

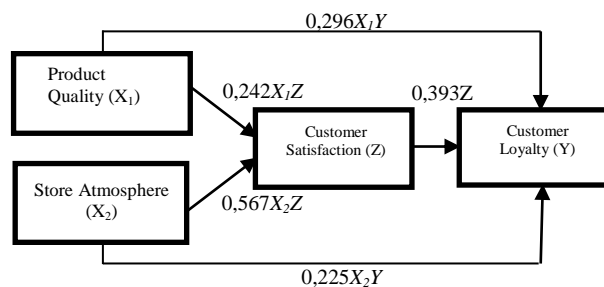


Figure 1. Path Analysis Results

Based on the calculation of the path coefficient, the results can be described as follows.

a. The effect of product quality on customer loyalty through customer satisfaction.

Based on the calculation results, it can be seen that the direct effect of product quality on

customer loyalty is 0.296 or 29.6%, greater than the indirect effect of 0.095 or 9.5%, which shows that if the value of direct influence > indirect effect, which means that indirectly product quality has a significant effect on customer loyalty through customer satisfaction. The value of the direct influence path coefficient is greater, then product quality has a greater effect on customer loyalty than having to go through customer satisfaction.

- b. The effect of store atmosphere on customer loyalty through customer satisfaction.

Based on the calculation results, it can be seen that the direct influence of store atmosphere on customer loyalty is 0.225 or 22.5%, greater than the indirect effect, which is 0.222 or 22.2%, which shows that if the value of direct influence > indirect effect, which means that indirectly store atmosphere has a significant effect on customer loyalty through customer satisfaction. However, because the value of the path coefficient of direct influence is greater, it can be concluded that the store atmosphere has a greater influence on customer loyalty than customer satisfaction.

Based on the results of path analysis and hypothesis testing that product quality has a significant positive effect on customer satisfaction at Alfamart Jember, so  $H_0$  was rejected and  $H_1$  accepted. Based on the results of the calculation of the direct influence of product quality on customer satisfaction, which is 24.2%, this means that the quality of the product provided is very good, despite the limitation of operating hours, but still does not reduce customer satisfaction shopping at Alfamart Jember. The results of this study support the research of Yulisetiari *et al.* (2018) states that product quality has a positive effect on customer satisfaction. Wirawan *et al.* (2019) state that product quality has a significant effect on customer satisfaction. This study supports Syahmi *et*

*al.* (2021) which states that product quality has a significant positive effect on customer satisfaction. The results of this study strengthen the theory that is consistent and proven product quality has an effect on customer satisfaction.

Based on the results of path analysis tests and hypothesis testing that store atmosphere has a significant positive effect on customer satisfaction at Alfamart Jember, so  $H_0$  was rejected and  $H_2$  accepted. Based on the results of the calculation of the direct influence of store atmosphere on customer satisfaction, which is 56.7%, this means store atmosphere that the available has made customers feel comfortable and happy to linger in the store, so it does not reduce customer satisfaction despite restrictions on operating hours. The results of this study are in line with and support the research conducted by Winarjo and Japarianto (2017), Kumala *et al.* (2020), Yulisetiari and Mawarni (2021) which state that store atmosphere has a significant effect on customer satisfaction. The results of this study strengthen the position of the theory that a consistent and proven store atmosphere has a significant effect on customer satisfaction.

Based on the results of the path analysis test and hypothesis testing that product quality has a significant positive effect on customer loyalty at Alfamart Jember, so  $H_0$  was rejected and  $H_3$  accepted. Based on the results of the calculation of the direct influence of product quality on customer loyalty, which is 29.6%, this means that the quality of the product provided is very good, despite the limitation of operating hours, but still does not reduce customer satisfaction shopping at Alfamart Jember, so that customers will become more satisfied. more loyal later. The results of this study are in line with the research conducted by Yulisetiari *et al.* (2017), Gunawan *et al.* (2019), and Wulandari *et al.* (2020) which shows that product quality has a positive effect on customer loyalty. The results of this study strengthen the position of the theory and can show consistency because it is proven that

product quality has a significant effect on customer loyalty.

Based on the results of path analysis tests and hypothesis testing that store atmosphere has a significant positive effect on customer loyalty at Alfamart Jember, so  $H_0$  was rejected and  $H_4$  accepted. Based on the results of the calculation of the direct influence of store atmosphere on customer loyalty, which is 22.5%, this means store atmosphere that a comfortable make customers enjoy the whole shopping process and feel at home in the store despite restrictions on operating hours, still making customers come back again in the future. The results of this study are in line with and support research conducted by Winarjo and Japariato (2017) showing that store atmosphere has a significant effect on customer loyalty. Subsequent research conducted by Gunawan *et al.* (2019); Yulisetiari and Mawarni (2021) stated that store atmosphere had a significant positive effect on customer loyalty. The results of this study strengthen the theoretical position and can show consistency because it is proven that store atmosphere has a significant effect on customer loyalty.

Based on the results of path analysis and hypothesis testing, customer satisfaction has a significant positive effect on customer loyalty at Alfamart Jember, so  $H_0$  was rejected and  $H_5$  accepted. used on the results of the calculation of the direct influence path of customer satisfaction on customer loyalty, which is 39.3%, this means that customers are satisfied, so that customers will enjoy the same product or service again and be loyal to the company despite limited operating hours. The results of this study are in line with and support the research conducted by Wardhana (2016), Wirawan *et al.* (2019), and Syahmi *et al.* (2021) which shows that customer satisfaction has a significant effect on customer loyalty. The results of this study

strengthen the theory and can show consistency because it is proven that customer satisfaction has a significant effect on customer loyalty.

### 4.3 Practical Implications

Based on the results of the analysis and discussion that have been described previously, it can be seen the practical implications in accordance with the benefits of the research are as follows.

#### a. For academics

This research can provide additional insight, knowledge and be used as reference material for further research related to product quality, store atmosphere, customer satisfaction, and customer loyalty.

#### b. For Alfamart

This research can be used as input for Alfamart Jember in determining strategies and what factors to continue to improve customer satisfaction so that it will also have an impact on customer loyalty.

### 4.4 Research Limitations

This research is in accordance with scientific procedures, but this research has limitations that are expected to be a reference material for further research to be better. The limitations of this study are as follows.

a. The data collection method in this study used a questionnaire distributed online through several social media, such as Instagram, Whatsapp, Facebook, Twitter, and telegram due to the Covid-19 pandemic which made face-to-face activities limited. Questionnaires distributed online also have limitations, such as respondents filling in the same answers, causing bias, incomplete answers from respondents because there was no assistance when filling out the

questionnaire so that there were some things that were not understood.

## 5. Conclusion

### 5.1 Conclusion

Product quality has a significant positive effect on customer satisfaction. The better the product quality which consists of performance, durability, features, reliability, aesthetics, and serviceability, the more customer satisfaction will also increase. Store atmosphere has a significant positive effect on customer satisfaction. The more comfortable the store atmosphere which consists of the marquee, parking facilities, sound, temperature, store personnel, cleanliness, classification of store offerings, and a straight traffic flow provided to customers, the customer satisfaction will also increase. Product quality has a significant positive effect on customer loyalty. The better the product quality which consists of performance, durability, features, reliability, aesthetics, and serviceability, the more customer loyalty will also increase. Store atmosphere has a significant positive effect on customer loyalty. The more comfortable the store atmosphere which consists of the marquee, parking facilities, sound, temperature, store personnel, cleanliness, classification of store offerings, and a straight traffic flow provided to customers, customer loyalty will also increase. Customer satisfaction has a significant positive effect on loyalty. customer. The higher the satisfaction felt by the customer, the more customer loyalty will increase. Product quality has a significant effect on customer loyalty through customer satisfaction. Store atmosphere has a significant effect on customer loyalty through customer satisfaction.

### 5.2 Suggestions

Based on the results of the tests that have been carried out, there are several suggestions that can be given, as follows.

- a. For Alfamart
  - 1) Product quality variable (X1) which is divided into 6 indicators at Alfamart Jember is already very good in the minds of customers. The statement item X1.1 has the highest mean value with indicators performance in it, this shows that respondents agree that customers feel that products private label Alfamart Jember Are ready to be used according to their functions. The statement item X1.4 has the lowest mean value with indicators reliability in it, this shows that respondents agree that customers feel that products private label sold at Alfamart Jember are in very good condition but still need to be improved.
  - 2) Variable store atmosphere (X2) which is divided into 8 indicators at Alfamart Jember is good and in accordance with the hearts of customers. The statement item X2.1 has the highest mean value with an indicator marquee in it, this shows that the respondents strongly agree that the shop signboard with the words "Alfamart" which is characterized by red color is very clear and easy to find by customers. The statement item X2.3 has the lowest mean value with an indicator sound in it, this shows that respondents agree that the music presented at Alfamart Jember is able to make customers not bored but still needs to be improved.
  - 3) The customer satisfaction variable (Z) which is divided into 3 indicators at Alfamart Jember has been very good in the hearts of customers. The statement item Z2 has the highest mean value with an indicator of ease of obtaining in it, this shows that respondents strongly agree that it is easy when shopping at Alfamart Jember. The statement item Z3 has the lowest mean value with indicators of customer feelings after using it, this shows

that respondents agree that customers are happy after making a purchase but still need to be improved.

- 4) Customer loyalty variable (Y) which is divided into 3 indicators at Alfamart Jember which is felt by customers is quite high. The statement item Y3 has the highest mean value with an indicator continue purchasing in it, this shows that respondents agree that customers will make repeat purchases at Alfamart Jember in the future. Statement items Y2 has the lowest mean value of the indicator recommending the company to someone who seeks advice in it, it shows the respondents strongly agree

that customers will recommend to shop in Jember Alfamart to those nearby but still needs to be improved.

b. For Academics

For further research, it is expected to use other analytical methods, such as structural equation modeling (SEM), partial least squares (PLS) and according to the results of the calculation of the coefficient of total determination, it is recommended to add other variables, such as brand image, price, service quality, promotion, sales, repurchase interest, and so on to customer satisfaction and customer loyalty at retail outlets.

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## A STUDY ON FACTORS INFLUENCING THE CONSUMER BUYING BEHAVIOR WITH REFERENCE TO ORGANIZED APPAREL RETAIL OUTLETS

**Abstract:** *The Indian Retail sector has come off age and has gone through major transformation over the last decade with a noticeable shift towards organized retailing. Modern retail formats, such as hypermarkets, superstores, supermarkets, discount and convenience stores are widely present in the developed world, whereas such forms of retail outlets have only just begun to spread to developing countries in recent years in Bangalore. Organized retail provides consumers with a wider choice of products, lower prices, and a pleasant shopping environment. Store atmospherics plays an important role in choice of the stores. The objective of this study is to identify the store related factors that have an influence on the consumers' decision process. Structured questionnaires were administered for a sample size of 400 customers who visited the shopping mall. There are several dimensions in a retail store. Hence, PL-SEM model has been used and three factors have been identified from the factor loadings analysis. The three factors under different parameters are-External Cues, Atmospherics and Merchandise.*

**Keywords:** *Consumer behavior, Retail, Store atmospherics, merchandise*

### 1. Introduction

The retail garment market scenario in India has gained a strong position as the third most attractive apparel retail market after Brazil and China. The retail clothing market contributed to the second turnover of the retail trade in India.

The apparel retail market has managed to take advantage of modern management concepts that lead to a better product offer, better customer management and scientific techniques for managing the supply chain retail. Apparel is expected to continue and experience greater retail penetration outside major urban groups and increased demand for branded products.

Retail stores create their own image in the minds of customers that have an impact on the purchases and perception of the products they carry from the stores. They also have self-respect, firmly connected with their behaviour. The various elements of the store image have an effect on the result of the customers.

The rationale behind this study was to spot store image features, sector-specific and evaluate the power and significant effect of each attribute on buyer buying decision. It also examined the effect of a range of demographic variables, on the buyer's evaluation of the different dimensions of the store perception.

**Retail Industry Scenario In India:**

Retail industry has transformed in a span of a decade, from traditional Kirana store to new formats such as department stores, hypermarkets, speciality stores, and malls. Modern formats have proliferated in metros and subways.

With rapid growth in the retail sector in the Indian market where it has reached the maturity phase, it has paved a way for the organised retail sector. India has been ranked on the fourth position as the most attractive countries among the global markets. Retailing in India is still in nascent stage. Organized retail represented only 7% of the

overall retail market in 2011-2012, and would reach 10.2% of the total retail sector in 2021-2022.

Retail sector is alienated into organized and unorganized sectors. Unorganized retailing includes Kirana or Mom and Pop stores. These retailers do not follow the government taxation norms. Unorganized retail is stores administered by owners without technical and accounting standardization. Unorganised retail refers to the local kirana retailers, convenience stores, corner hardware stores, small pharmacies etc. It is a family run business. Retailers of these stores are not so qualified, lack experience and visibility.

**Table 1.** Classification of store image components

Component	Details
Price of merchandise	Low prices Competitive or non-competitive prices
Quality of merchandise	Good or poor quality of merchandise Stock brand names
Assortment of merchandise	Breadth and depth of assortment Carries or not the brand the customer wants Carries or not elegant brands
Sales personnel	Attitude of sales personnel Knowledge of sales personnel Number of sales personnel Good or poor service
Location convenience	Location from home/work Access Good or poor location
Other convenience factors	Parking Hours store is open Convenience with regard to other stores Store lay-out with respect to convenience Convenience in general
Services	Credit Delivery Ease of return Self-service
Sales promotions	Special sales Stamps and other promotions Displays Symbols and colors
Advertising	Style and quality of advertising Media and vehicle used Reliability of advertising
Store atmosphere	Lay-out of store without respect to convenience External and internal décor of store Congestion Prestige of store Congeniality
Institutional	Reputation for fairness Conservative or modern
Clientele	Social class Self-image
Physical aspects	Facilities Architecture Shopping ease

## 2. Literature Review

1) Tripathi and Sinha (2008) in their document proposes to link the choice of the store, the choice of format and the demographic variables of the consumer, through a hierarchical logistic choice model in which consumers first choose a format of store and then a private store within that format. Empirical analysis was used. The result of the study was the number of members in the family, income and employment hours that can be captured. In the short term (for example, one year), these variables can also be stable, and the temporal aspect of the model can be really ignored for these variables. The identified research gap was a better model

2) Raghava Rao Gundala (2010) identified the image attributes of the store and assessed the strength and impact of each attribute on the purchase decision. It also analyzes the influence of demographic variables and on the consumer's assessment. Analysis was done using ANOVA and F test and it was found that the t-values of the attributes were not significant at the values of 0.05 and 0.01. There was a significant correlation between the demographic variables and the various images attributes of the business. The findings assist retailers to know the impact of the store image and its relationship to store patronage in this volatile market.

3) Krishna C.V (2011) in his article addresses the determinants that affect consumer preferences for private brands. In this study it was found that four aspects, namely the image of the brand, promotion offers, design and the store exteriors and interiors affect consumer priority for private-level brands. In addition, the study revealed that demographic aspects the consumer's occupation and the social class of the consumer, have no effect on consumer purchasing behaviour when selecting private brands. The research gap focused only on

private brands.

4) Narang Ritu (2011), the research was carried in the Tier II city. It included Indian youth and his goal was to recognize the role of psychographic characteristics in the selection of clothing stores. The methods of data collection consisted of in-depth interviews and group discussions of young people and retailers.

Both categories were determined by the environment, design, layout and accessibility to the newest designs and styles in the selection of the clothing store.

5) Khanna, Kesharwani and Rajput (2012) the intention was to determine the problems related to the purchasing decision, based on the gender point of view. The aim was to assess the importance of demographic profile of customers who make the decision to buy the brand attire. The result indicated that, there is no significant difference in purchase costs, brand awareness and regularity of purchase between men and women.

6) Rome, Siochi and Plaza (2017) In his study, he evaluated the factors that influence the impulse of consumer purchase in the supermarket environment. Quota sampling was used because the total sample size was evenly distributed to obtain a specific sample size for each supermarket. The convenience sampling technique was also used when the sponsor was already at the study site. The four external factors (store environment, store navigation, provider focus and promotion) with a positive regression coefficient indicate that they were statistically significant predictors of the study dependent variable (impulse buying behaviour). This study focused on evaluating factors associated with demographic factors, store characteristics and situational factors. Therefore, this study recommends that there is a scope for the researchers in future on factors that influence in stimulating the purchase of the consumer.

### **3. Research Methodology**

#### **3.1. Statement of the problem**

Retail industry is emerging at a very faster pace and growing day by day. There is a heterogeneous group of customers in the city of Bangalore since it is a metropolitan city. As the population grows, customer expectations increase.

Retailers should know the tastes and preferences of the consumers, to maintain their competitive advantage. The characteristics of the consumer, various components of the retail store, the image of the store, the selection of the store are key areas and have a fundamental role in the success of the retail sale. The marketing mix associated with the components of the store image contribute to overall image of the store.

As a growing percentage of clothing buyers prefer retail stores in metropolitan areas and cities, most organized clothing retailers will grow. The sector witnesses the integration of new national and international actors. However, clothing retailers face many challenges when they create new points of sale: location, store format, price, marketing, personnel, etc. These decisions entail huge predetermined costs that hinder the recovery of the investment if an error occurs in the location or format of the store. Customers expect maximum benefit for the price they pay. It is challenging to identify the factors that would attract and also retain the customers. Hence, marketers should be aware of the factors which influence the buying decision process while shopping at organized outlets.

Since very less research has been done on the attributes of the store image and the consumer's purchasing behaviour. Therefore, this study seeks to collect data about the research question If relationship exists between the attributes of the store's image

and the consumer's decision-making process.

#### **3.2. Objectives of study**

1. To explore the factors that influence the buying behavior of consumers while shopping of apparels in organized retail outlets,
2. To study the relationship between a stores' image and a consumer Satisfaction

#### **3.3. Scope of the study**

Proposed study is intended in order to take into account the attributes that influence consumer purchasing behaviour in organized retail apparel stores.

This study tried to discover and evaluate the relationship between store attributes and purchasing behaviour at the Shopping Malls Bangalore. It was important to assess the true drivers of shopping activities of the buyers. It also inspected the effect of a range of demographic variables like gender age and income on buyer,s assessment of different store image attributes. The present scope of the study was confined to organised clothing retail outlets.

### **4. Research design**

1. Descriptive research design has been used in this study. It involves studying the consumer characteristics. A descriptive research methodology was adopted because the objective of the study was to provide a systematic & factual description of the store image dimensions having an influence on their purchase decisions.
  2. Sources of Data Collection
    - i) Primary data: Primary data for this study has been gathered through the survey method.

The primary data was collected from the major apparel retail outlets in Bangalore, where respondents were customers who have finished their shopping in the store and ready to answer to the queries using the structured questionnaire.

ii)Secondary Data

Secondary data was composed from several consultancy and research organizations that on a regular basis develop and generate periodic reports on the retail sector in India, such as the retail details ICRIER, RNCOS, AT Kearney, BMI India Retail Report, Technopak, RAI, CII . Internet has been used to obtain relevant information for the study. The online libraries of Google, Google scholar, Ebsco, Springer and J-gate were also used to obtain relevant documentation for this purpose. Several books on market research, retail sales management, marketing management and consumer behaviour and professional journals were also used to obtain relevant information for the survey.

Sampling technique

The sample size corresponding to a population of 20,000 is 377 and for the population of 10, 00,000 it is 384. Based on sq.ft and zone wise stratified random sample is used, the given below table showed the sample proportion drawn.

HYPOTHESIS:

- $H_{a1}$ : There is relationship existing between Retail store and Overall Satisfaction of retailers consumers.
- $H_{a2}$ : The relation between Retail store and Overall satisfaction is higher for the retailers who opted to purchase decision while compared to retailers who does not opt

## 5. Data analysis and interpretation

Impact of Product and Store Attributes on the consumer purchase decisions at the retail

stores.

### 1. Product and Store based attributes

**Table 2.** Product and Store based Attributes

Product and Store based Attributes	Frequency	Percentage
Apparel factor Brand	167	41.75
Celebrity	10	2.50
Color	109	27.25
Design	83	20.75
Visual	31	7.75
Product Sensitivity Fabrication	203	50.75
Peer appreciation	32	8.00
Price	48	12.00
Social value	55	13.75
Touch	62	15.50
Apparel attribute Accessories	58	14.50
Brand Image	135	33.75
Newness	164	41.00
Style	43	10.75
Apparel type Celebrity Endorsed	113	28.25
Long Fashion Life Cycle	116	29.00
Premium Quality	30	7.50
Public Image Driving	141	35.25
Personalized apparel No	161	40.25
Yes	239	59.75
Factor of Store Brand to buy Customer Services	19	4.75
Personalization	111	27.75
Price	118	29.50
Store Image	152	38.00

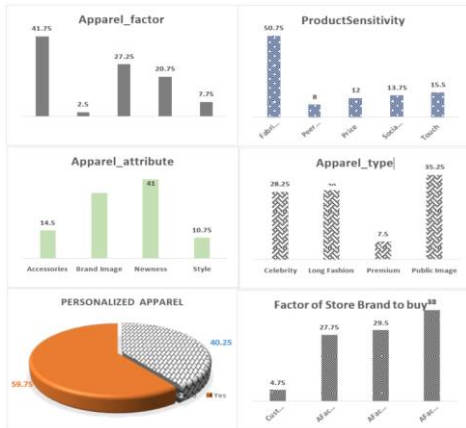


Figure 1. Product and Store based Attributes

With reference to Product and Store based Attributes,

A) Apparel factor

Brand attained maximum response of 41.75%, Colour attained response of 27.25%, Design attained response of 20.75%, Visuals attained response of 7.75% while Celebrity attained the minimum response of 2.50%. From the analysis, it implies that majority of the customers are more concerned with the brand when they are purchasing from the stores.

1. Product Sensitivity

Fabric attained maximum response of 50.75%, Price attained the response of 12%, Social value attained the response of 13.75%, Touch attained the response of 15.50% while Peer appreciation attained the minimum response of 8.00%. Thus, it reveals that quality of fabric of the apparel is an important aspect that has an influence on the buying behaviour.

2. Apparel attribute

Newness attained maximum response of 41%, Accessories attained the response of 14.50%, Brand Image attained the response of 33.75%, while Style attained the minimum response of 10.75%. Hence from the analysis of table 4.2.1 says that newness

of the apparel is the attractive factor that influences the customers to buy.

3. Apparel type

Public Image Driving attained maximum response of 35.25%, Celebrity Endorsed attained the response of 28.25%, Long Fashion Life Cycle attained the response of 29%, while Premium Quality attained the minimum response of 7.50%. Hence, public image is the major factor in the apparel type that has an influence on the purchases.

4. Personalized apparel

Majority 59.75% were yes while 40.25% of respondents were No.

5. Factor of Store Brand to buy

Store Image attained maximum response of 38%, Price attained the response of 29.50%, Personalization attained the response of 27.75% while Customer Services attained the minimum response of 4.75%. Image of the store is the one of the reason for consumers to buy at the stores.

Objective1 To explore the factors that influence the buying behavior of consumers while shopping of apparels in organized retail outlets.

EFA recognizes primary factor structure identifying the purchasing factors of Retail stores attributes.

Factors identified are named as External Cues, Store Atmospheric and Merchandise.

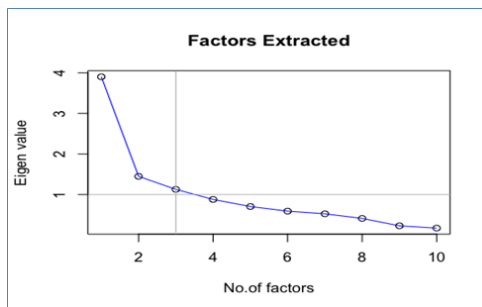
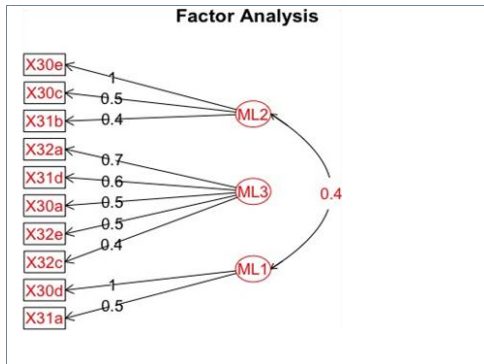


Figure 2. Store dimension factors extracted



The above graph depicted the Eigen value in Y axis, number of factors in X axis. Based on Eigen value is more than 1, number of factors determined is 3. The three factors identified are External cues, Atmospherics, and Merchandise.



**Figure 3.** Factor loadings to indicate the relation between atmospherics and Merchandise

The above Graph no. 4.42 showed that 3 factors with factor loadings, between Store Atmospherics (ML2) and Merchandise (ML1) the relation is .40. which indicate that the variance is less between the factors and there is an association between the two. Since there is an association between the two they can be considered for the study.

## 6. Summary of findings, suggestions & conclusions

The hypotheses framed are to test the association between demographic factors and consumer purchase decisions. To explore the relationship between store image dimensions, store atmospherics on the consumer purchase decisions.

**Table 3.**

Objectives of the study	Variables Used	Research Hypothesis	Statistica Techniques	Outcome of the Analysis
Objective 1 To explore the factors that influence the buying behavior of consumers while shopping of apparels in organized retail outlets	16 items [X30a through X32e] [Refer Descriptive stats]	Since model is exploratory, hypothesis is not required	Exploratory factor analysis Eigen > 1, KMO > .5, Estimation: ML Factor loadings > .4 Rotation: Oblimin	3 factor derived, factors names as External Cue, Atmospherics, and Merchandise. Total variance explained close to 50% [ 10 items are retained for further analysis]
			Descriptive statistics and graphs	Describing the dimension response
			Reliability test Cronbach alpha is more than .7 dimension wise	

2. The study reveals that, with reference to Product and store based attributes, in apparel factor brand is the most preferred attribute with a highest response of 41.75% followed by other attributes like colour, design, visual and the influence of celebrity endorsements.

- Also, the other attributes like fabrication was the most preferred attribute in product sensitivity with a response of 41.75%. Similarity in

the apparel attribute newness of the merchandise at the store attained a highest response with 41%.

- Public Image driving was the driving force for purchase which attained a highest response of 35.25% as compared to celebrity endorsements, long fashion life cycle and premium quality.
- Majority of respondents i.e.59.75% customers agree that they would like to purchase personalised apparels
- It was found from the study that, store image is the major factor which motivates respondents to shop only at particular branded apparel stores.

Suggestions:

- 1) Physical aspects and Store atmospherics were rated as vital predictor of store choice. The effect was more than all the other relationships explored. It suggests the interior of store must be clean, structured and well maintained.
- 2) In addition, the design should be optimized to maximize convenience to customers. Aesthetic factors must be enhanced by the retailers to ensure marketers exceed customer expectations and retain them.

## 7. Conclusion

Physical aspects were the main forecaster of store choice. This underlines the notion that

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the physical environment of store must be hygienic, well-structured and maintained. The customers prefer shopping in a store which is considered safe and healthy. Looking at changing behavioural occurrence retailers need to adapt themselves to the changing demands of the customers. Hence, it is important to understand the overall customer views regarding store image that influence customer store choice, purchase intention, store satisfaction and loyalty toward their ideal store. The store choice behaviour strongly influenced by location, convenience, store environments and reasonable price, merchandizing and sales assistance. Likewise, studies showed that purchase intention is stimulated by store image attributes like pleasant store environment and atmospheric indications, product variety and quality and price. However, complimentary store images make the customers revisit the store by augmenting store satisfaction. They can offer good service like people greeter at the entrances, checkout facilities by minimising queue hassles. Keeping this reality in mind, today's retailers are offering newer service dimensions to create unique shopping experiences for the customers. In the face of the increasing retail competition the marketing approach should assess consumer perception of store image for formulating effective marketing strategies to create and enhance appealing store image to influence the overall behavioural pattern of the customers".

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## THE EFFECT OF COMPANY SIZE AND CORPORATE GOVERNANCE MECHANISMS ON PROFIT MANAGEMENT ACTIVITIES IN INDUSTRY 4.0

**Abstract:** *The purpose of the research is to examine whether firm size, managerial ownership, institutional ownership, independent board of commissioners, and audit committee have an effect on earnings management. The population in this study is coal sub-sector mining companies listed on the Indonesia Stock Exchange for the 2019-2021 periods. The data used is secondary data. The data collection method used is the method of literature study and documentation. The analysis used is multiple regression analysis. The results showed that: 1) the size of the partial variables had no effect and had no significant effect on earnings management; 2) partial managerial ownership, institutional ownership and significant effect on Earnings Management in a positive direction; 3) the partial variable of the audit committee has no effect on Earnings Management.*

**Keywords:** *Good Corporate Governance, Size Of Company, Earnings Management.*

### 1. Introduction

Financial statements are a summary of the process of recording financial transactions that occurred during one financial year. Financial reporting becomes a medium where companies provide financial information, as a management responsibility, to meet the needs of external parties, namely to obtain information about company performance (Warren et al., 2017).

According to Statement of Financial Accounting Concept (SFAC) No. 1, profit information is a measure of the performance of management's responsibility in achieving predetermined business goals and helps owners estimate the future profitability of the company (Putro, 2016). Profit information is often the goal of engineering through the opportunistic behavior of

management to maximize its satisfaction (Arizal et al., 2021). Self-serving behavior (speculation) is through the selection of certain accounting policies, so that profits can be adjusted, increased or decreased according to one's own wishes (Fadilurrahman et al., 2021). Profit management according to its own wishes is called profit management is the result of agency problems arising from the misalignment of interests between shareholders (principal) and company management (agent) (Habibah et al., 2021). The relationship between the principal and the agent can be asymmetrical information, because within the company the agent has more information than the principal, so the agent can hide the information for his own benefit. Asymmetry between management (agent) and shareholders (principal) provides

an opportunity for managers to obtain personal profit opportunistically (Handayani et al., 2022), and in financial reporting, managers can mislead owners through the view of profit management (shareholders) towards the economy of the company. (Karina & Sutarti 2021). Therefore, profit management is actually a tool for managers to realize personal wills and desires (Hidayat et al., 2021). While financial statements are a medium for managers to express their will and desire (Sulistiyanto, 2018; Surti et al., 2022).

One of the profit management phenomena is the case that occurred at PT Garuda Indonesia (Persero) Tbk. According to Nuroniyah (2020) It was reported in the financial statements that PT Garuda Indonesia (Persero) Tbk in 2018 experienced a profit by scoring a net profit of US\$ 809.4 thousand. This is surprising because PT Garuda Indonesia (Persero) Tbk should have suffered a loss. In recent years, the company has continued to suffer losses, throughout the first nine months of 2018 the company recorded a loss of US\$ 114.08 million (Irpan et al., 2021). The loss decreased compared to 2017 of US\$ 222.03 million. However, surprisingly at the end of 2018 PT Garuda Indonesia (Persero) Tbk reported that it experienced gains instead of losses (Iyansyah et al., 2021). This made two commissioners of PT Garuda Indonesia (Persero) Tbk, namely Chairul Tanjung and Dony Oskaria, unwilling to sign Garuda's 2018 yearbook report (Joko et al., 2022). Therefore, one of the ways that can be done to monitor these problems is to implement corporate governance in the company (Kurniawan et al., 2021; Shaddiq et al., 2021).

Based on several financial reporting scandals, the effectiveness of the implementation of good corporate governance (GCG) in companies is questioned to minimize profit management (Bintara 2019). Good Corporate

Governance (GCG) is a system of controlling and regulating the company which can be seen from the relationship mechanism between various parties that manage the company (hard definition), as well as in terms of the "values" that contained from the management mechanism itself (soft definition) (Norrahmi et al., 2021). Based on the previous research above, there is a GAP from the research results, therefore researchers are interested in conducting further research, where this research is replication of the Bintara research (2019). The difference between Bintara (2019) research and this research lies in the object, where the previous research object lies in metal sub-sector manufacturing companies and the like, while this research lies in coal sub-sector mining companies. This study investigates the practice of profit management practices and retests the factors that influence them such as ownership concentration, company size, corporate governance mechanisms and audit committees (Wijaya et al., 2021; Norrahmiati et al., 2022).

## **2. Literature review and hypothesis development**

### **Agency Theory**

According to Hendrawaty (2017) Agency theory explains that agency relationships occur when principals hire other people (agents) to provide services and then delegate decision-making power to agents. So that agents can manipulate company reports to principals because each manager has great financial needs, including maximizing his compensation by implementing profit management (Putera et al., 2022).

### **Financial Statements**

According to Cashmere (2013) financial statements are reports that show the current or future financial condition of the company.

The purpose and objectives of the financial statements indicate the financial position of the company.

### Profit Management

According to Abbas et al. (2019) profit management is an accounting policy or specific action chosen by managers to influence the rate of increase or decrease in reported profits and losses to achieve desired goals. As the manager of the company, the management knows the real state of the company better than the shareholders.

### Company Size

Oktaviana et al. (2020) suggest that the size of the company is a scale where it can be classified as the size of the company measured by total assets, number of sales, value of shares and so on, while according to Novianty and May (2018) the size of the company is seen from the field of business being operated.

### Corporate Governance Mechanism

Corporate governance is a tool that is considered to be able to solve problems in managing and controlling the company (Ramadhani et al., 2021).

### Effect of Company Size on Profit Management

Prasetya (2016) found that company size has a negative impact on profit management. Large companies have fewer incentives for profit management than small companies, meaning that the larger the company's income the smaller the amount of profit management.

### The Effect of Managerial Ownership on Profit Management

According to Manossoh (2016), the practice of profit management can align the differences in interests between owners and management by increasing the company's share ownership by management

(managerial ownership).

### The Effect of Institutional Ownership on Profit Management

Institutional ownership has the ability to control management through an effective monitoring process, thereby reducing profit management (Rizal et al., 2020). Institutions that have a certain percentage of shares will affect the process of preparing financial statements, but do not rule out the possibility of accruals for the benefit of management (Rito & Azzahra, 2018).

### The Effect of the Audit Committee on Profit Management

Effendi (2016) the audit committee can influence the profit management practices that occur in the company. The audit committee at the enterprise may reduce the practice of profit management that is the result of opportunistic actions carried out by managers (Saputra et al., 2020).

### Research Models

From the background, literature review, and previous research, the following research model is stated.

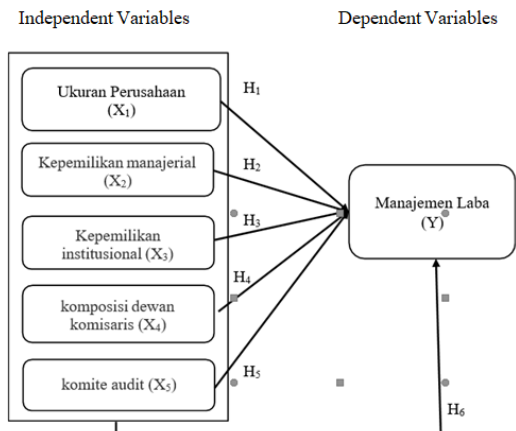


Figure 2.1 Research Model

### Hypothesis

Based on the framework of thought and research model discussed above, the hypothesis can be formulated as follows:

H1 : Company size affects Profit Management

H2 : Managerial ownership affects Profit Management

H3 : Institutional Ownership affects Profit Management

H4 : The composition of the Board of Commissioners affects Profit Management

H5 : Audit Committee affects Profit Management

H6 : Company Size, Managerial Ownership, Institutional Ownership, Composition of the Board of Commissioners of the Audit Committee simultaneously affect Profit

Management

### 3. Research methods

#### Population

This research is a quantitative study. The research focuses on secondary data, namely data obtained from annual reports. The population used in this study is all coal sub-sector mining companies listed on the Indonesia Stock Exchange (IDX) in 2019-2021, totaling 26 companies.

#### Sample

Based on the purposive sampling method, 13 companies were sampled in this study, with a total of 39 data. Details of the sample decline can be seen in the following table:

**Table 1.** Research Sample Criteria

No.	Sample Criteria	Total Samples
1	Mining Companies listed on the IDX for the period 2019-2021	29
2	Mining Companies that do not publish annual reports and complete research data for the period 2019-2021	3
3		13
4	<b>Total Data:</b> 13 × 3 years	39

Source: Processed Data (2022)

### Devinition of Research Variables

#### Profit Management (Y)

Profit management is the process by which management intervenes in the preparation of reports financial for external parties to balance, increase and reduce the condition of profit reporting. Profit management is measured using discretionary accruals (DACs). In this study, discretionary accruals were used as proxies because they are components that can be manipulated by managers such as credit sales. To measure the DAC, we will first measure the total accrual. Profit management (DAC) can be measured by discretionary accruals, which are calculated by differentiating between total accruals (TACs) and non-discretionary accruals (NDAs).

#### Company Size (X1)

The size of the company is measured by the total assets owned by the sample company, because the total assets reflect the size of the company, and the larger the assets owned by the company, the larger the company will be. Due to the high dispersion of total assets, natural logarithms are used to anticipate them (Sudiby, 2013).

#### Managerial Ownership (X2)

Managerial ownership is measured by the proportion of equity held by managers, directors, commissioners, and other parties actively involved in company decision-making, a variable used to determine the benefits of managerial ownership in reducing agency conflicts (Mutiasari, 2018).



### **Institutional Ownership (X3)**

Abdillah et al., (2015) state that institutional ownership is a percentage of the voting rights owned by the institution. The institutions referred to in this case include NGOs, governments and private companies. Higher institutional ownership will lead to tighter restrictions on managers' actions, thus hindering management's tendency to use discretionary accruals in financial statements.

### **Composition of independent Board of Commissioners (X4)**

Independent Commissioner is a member of the board of commissioners who has no financial, management, equity or family relationship or good relationship with other members of the board of commissioners, directors or controlling shareholders that may affect his ability to act independently. Non-executive directors (independent commissioners) may act as mediators in disputes between internal managers, oversee management policy and advise management. The greater the proportion of independent commissioners, the more it can reduce profit management practices (Abdillah et al., 2015).

### **Audit Committee**

The Audit Committee (AC) consists of at least 3 members, one of whom is an independent commissioner of a listed company who also serves as the chairman of the committee, and the other is an independent outsider, at least one of whom is competent in accounting and finance. The composition of the audit committee is measured using the indicator of the percentage of audit committee members from outside to all members of the audit committee (Fanani et al., 2020).

### **Data Retrieval Techniques**

The data collection technique used in this study was to use secondary data. The secondary data necessary for the study were

obtained by the method of documentation.

### **Data Analysis Techniques**

The data analysis method used in this study is multiple linear regression analysis. The tests carried out are descriptive statistical tests, normality tests, classical assumption tests, multiple regression analysis and hypothesis tests. The method of data analysis will be carried out with the help of the computer application program SPSS 26.

### **Hypothesis Testing**

#### *Partial Test (Statistical Test t)*

According to Ghozali (2013:98) the partial regression test (t) serves to find out whether the independent variable regression model partially has a significant effect on the dependent variable. Partial regression test (t) seen from the "Coefficient" table with a significance tolerance of 5%.

#### *Coefficient of Determination (R<sup>2</sup>)*

The Coefficient of Determination (R<sup>2</sup>) essentially measures how far the model is capable of explaining the variation of independent variables. The value of the coefficient of determination is between zero (0) and one (1). A small value (R<sup>2</sup>) means that the ability of independent variables to describe the variation of dependent variables is very limited. A value close to one (1) means that independent variables provide almost all the information needed to predict the variation of dependent variables (Ghozali, 2013:97).

## **4. Results of research and discussion**

### **Descriptive Statistical Analysis**

Descriptive statistical tests aim to provide an overview or description of a data that is visible from the number of samples, minimum values, maximum values, mean, and standard deviation of each variable. The following describes the statistics of the research data.

**Table 4.1** Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
UP	39	27.28	34.59	30.2190	1.77857
KM	39	0.00	0.12	0.0183	0.03439
KI	39	0.44	0.97	0.7813	0.15902
DKI	39	0.20	0.67	0.3836	0.09303
KA	39	3.00	5.00	3.2308	0.53614
ML	39	-0.30	2.25	0.7513	0.66537
Valid N (listwise)	39				

Source: Processed secondary data, 2022

**Multiple Linear Regression Test**

The testing of this study with multiple linear regression analysis aims to determine the influence of company size and corporate governance mechanisms on profit management activities in coal sub-sector

companies for the 2019-2021 period. Previously this model had already met the normality test and the classical assumption test. The following are the results of multiple linear regression analysis presented in the next table.

**Table 4.2** Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.014	1.783		0.008	0.994
	UP	-0.017	0.055	-0.046	-0.308	0.760
	KM	8.565	3.086	0.443	2.776	0.009
	KI	2.159	0.658	0.516	3.280	0.002
	DKI	-3.416	1.067	-0.478	-3.201	0.003
	KA	0.222	0.173	0.179	1.286	0.207

a. Dependent Variable: ML

Based on Table 4.2 to form a multiple linear regression equation can be seen in the Unstandardized Coefficient table of column B (Beta) which is 0.014 for constant values, -0.017 for company size values, 8.565 for managerial ownership, 2.159 for institutional ownership, -3.416 for independent boards, and 0.222 for audit committees. Therefore, from these values, a multiple linear regression equation can be formed as follows.

$$Y = 0.014 - 0.017X_1 + 8.565X_2 + 2.159X_3 - 3.416X_4 + 0.222X_5 + e$$

**Simultaneous Significance Test (statistical test F)**

Based on the table 4.3, it can be seen that the significant value is  $0.004 < 0.05$  (significance level) with a calculated F value of  $4.325 > F$  table 2.50. This shows that the variables of company size, managerial ownership, institutional ownership, independent board of commissioners, and audit committee simultaneously have a significant effect on profit management.

**Table 4.3 ANOVA**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.660	5	1.332	4.325	0.004 <sup>b</sup>
	Residual	10.163	33	0.308		
	Total	16.823	38			

a. Dependent Variable: ML

b. Predictors: (Constant), KA, DKI, KM, UP, KI

Source: Secondary data processed, 2022

### Discussion of Research Results

Based on hypothesis testing carried out both partially and simultaneously on the measurement of company size, the corporate governance mechanism for profit management activities can be explained as follows.

#### Effect of Company Size on Profit Management

The company size variable has a t-count of -0.308 and a t-table value of 2.034. Then the t-count value < t-table, which is  $-0.308 < 2.034$  with a significant value of  $0.760 > 0.05$ . It can be concluded that H1 is rejected meaning that the size of the company has no effect on profit management. The results of this study are not in accordance with Santi & Wardani, (2018) who argue that company size has a negative and significant effect on profit management. However, the results of this study are in accordance with the research of non-commissioned officers, (2019) which argues that the size of the company has no influence on profit management. This is because large companies have more assets and allow many assets that are not managed properly so that there is a possibility of errors in disclosing the total assets in the company.

#### The Effect of Managerial Ownership on Profit Management

The managerial ownership variable has a t-count value of 2.776 and a t-table value of 2.034. Then the calculated value > t-table, which is  $2.776 > 2.034$  with a significant

value of  $0.009 < 0.05$ . It can be concluded that H2 is accepted meaning that managerial ownership affects profit management. It can be interpreted that the existence of managerial ownership in coal sub-sector mining companies listed on the Indonesia Stock Exchange (IDX) for the 2019-2021 period has an influence on profit management activities. The results of this study are in accordance with Lestari et al. (2016) and Purwanti et al. (2021). That is, the greater the concentrated shareholding, the more shareholders can be in a strong position to effectively control management so as to be able to limit oportunis behavior by managers.

#### The Effect of Institutional Ownership on Profit Management

The institutional ownership variable has a t-count value of 3,280 and a t-table value of 2,034. Then the t-count value > t-table, which is  $3,280 > 2034$  with a significant value of  $0.002 < 0.05$ , then H3 is accepted meaning that institutional ownership has a positive and significant effect on profit management. It can be interpreted that the higher the number of institutional ownership shares, the lower the profit management action. The results of this study are in accordance with research conducted by L. Mamu & Eka Damayanthi, (2018) and Bintara, (2019). These institutional investors have the opportunity, resources and ability to monitor, adjust, and influence managers in terms of management opportunistic practices. This makes managers feel

burdened to adjust the profit targets that institutional investors want and as a result there is a tendency to profit management practices to satisfy institutional parties. This makes the manager's reason for short-term profit management practices, because the institution is a temporary shareholder and only focuses on short-term profit.

#### **Effect of Independent Board of Commissioners on Profit Management**

The independent board of commissioners variable has a t-count value of - 3.201 and a t-table value of 2.034. Then the value of t-count > t-table, which is  $-3.201 > 2.034$  with a significant value of  $0.003 < 0.05$ , therefore H4 is accepted meaning that the independent board of commissioners affects profit management. This shows that the number of independent boards of commissioners in coal sub-sector mining companies listed on the Indonesia Stock Exchange (IDX) for the 2019-2021 period in carrying out supervisory functions, independent commissioners can also supervise management policies in the preparation of financial statements, so the financial reporting supervision process carried out by the board of commissioners will be more effective so as to prevent profit management practices. The results of this study are in accordance with research conducted by Purwanti et al., (2021) which argues that an independent board of commissioners affects profit management.

#### **Effect of Audit Committee on Profit Management**

The audit committee variable has a calculation of 1.286 and a t-table value of 2.034. Then the t-count value < t-table, which is  $1.286 < 2.034$  with a significant value of  $0.207 > 0.05$ . It can be concluded that H5 is rejected, meaning that the size of the company has no effect on profit management. The results of this study state that the proportion of the number of audit

committees in coal sub-sector mining companies listed on the Indonesia Stock Exchange (IDX) for the 2019-2021 period has not been able to reduce profit management carried out by management in a company. This is allegedly caused because the appointment of the audit committee by the company is only carried out for regulatory compliance but not intended to uphold good corporate governance in the company.

#### **Effect of Company Size, Managerial Ownership, Institutional Ownership, Independent Board of Commissioners, and Audit Committee on Profit Management**

Variable company size, managerial ownership, institutional ownership, composition of the board of commissioners of the audit committee has an F-count of 4,325 and an F-table value of 2.50. Then the F-value is calculated > F-table, which is  $4.325 > 2.50$  with a significant value of  $0.004 < 0.05$ . Judging from the Adjusted R Square value of 0.304, it shows that it is 30.4%. It can be concluded that H6 is accepted meaning that the size of the company, managerial ownership, institutional ownership, the composition of the board of commissioners of the audit committee have a simultaneous effect on profit management. It can be interpreted that the size of the company, managerial ownership, institutional ownership, the composition of the board of commissioners of the audit committee in coal sub-sector mining companies listed on the Indonesia Stock Exchange (IDX) for the 2019-2021 period have a simultaneous influence on profit management activities. The results of this study are in line with Bintara, (2019) which states that together profit management is influenced by company size, managerial ownership, institutional ownership, composition of the board of commissioners of the audit committee.

## Coeffesient Determination Test

Based on the table 4.4, it can be seen that the Adjusted R Square value of 0.304 shows that 30.4% of the dependent variables, namely profit management, can be explained

by independent variables, namely company size, managerial ownership, institutional ownership, independent board of commissioners, and audit committees. While the remaining 69.6% is explained by other variables outside the regression model.

**Table 4.4** Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.629 <sup>a</sup>	0.396	0.304	0.55496

a. Predictors: (Constant), KA, DKI, KM, UP, KI

b. Dependent Variable: ML

Source: Secondary data processed, 2022

## 5. Conclusion

The results of simultaneous testing are known that there is a significant influence of independent variables on dependent variables, namely company size, managerial ownership, institutional ownership, independent board of commissioners and audit committees together it has a significant effect on profit management.

The results of partial testing with t-test show that managerial ownership, institutional ownership, and an independent Board of Commissioners have a significant effect on profit management, while the audit committee and company size have no significant effect on profit management.

This section presents research conclusions, research limitations, and suggestions for subsequent research. The Conclusion section is written in one chapter and there are no subtitles.

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# **14. International Quality Conference**



**SCIENTIFIC FOCUS 2**

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Enriko Ceko<sup>1</sup>

## ON THE RELATION BETWEEN ENTREPRENEURSHIP AND QUALITY MANAGEMENT

**Abstract:** *Healthy business ecosystems are necessary for competitive advantage, the major force of the trade economy, and free markets. Business sustainability requires entrepreneurship skills, knowledge, and competencies, as well as standardization of processes, procedures, etc., which relate to quality management patterns. Entrepreneurship can be measured, and so can quality management. Most international, regional, and local business organizations, individual businesses, as well as several researchers, assert that there is a connection between entrepreneurship and quality management, especially with ISO standards.*

*Therefore, it is necessary to research the relations between entrepreneurship and quality management to provide a clear insight into the issue. This study is based on a regression analysis between the Entrepreneurship Index (E Index) and ISO Standards Index to verify Hypothesis H1 (There is not any relation between E Index and ISO Standards Index) against Hypothesis H0 (There is a strong relation between E Index and ISO Standards Index). The results of the research show that entrepreneurship requires scientific management of factors of production, employing skills, knowledge, and competencies, as well as using quality management principles, to achieve a competitive advantage, so, a connection and relations between entrepreneurship and quality management (ISO standards), is indispensable. It can be stated from the conducted research that there is no relation between entrepreneurship and ISO standards yet, even though it is highly needed and should exist to promote sustainable entrepreneurship with no support at all.*

**Keywords:** *Entrepreneurship, business sustainability, competitive advantage, quality management, ISO standards, ISO standards Index*

### 1. Introduction

In this critical analysis, relations between entrepreneurship and International Standards of quality management are investigated, as they are important factors in healthy business ecosystems.

There is supposed to be a strong relationship between entrepreneurship and quality management principles, especially with ISO

standards, considering that disruption and uncertainty continue in multiple business sectors; but, as most entrepreneurs know well, with disruption comes opportunity and it is clear that entrepreneurs have been grasping pandemic-related opportunities and building resilience while living with the pandemic has certainly raised awareness of the business opportunities it brings in its wake (GEM (Global Entrepreneurship

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Monitor) (2022)).

This was the core issue to be investigated in this research, using quantitative methods, combined with a regression analysis on relations between the Entrepreneurship Index and ISO standards Index.

Also, there were have taken into account other sources to have thorough research such as classified existing data and materials about entrepreneurship, quality management, and ISO standards, the updated ones together with the previously published works and scholarly articles books, as well as online libraries.

There are strong and sustained relations between quality management / ISO standards and the climate of doing business (Ceko, 2016a). There are strong and sustained relations between the climate of doing business and life quality, which is already verified scientifically (Ceko, 2016b). Improving quality management systems / respecting ISO standards parallel with doing business regulations / doing business climate, can improve the life quality of citizens.

Worldwide countries recently are facing problems that affect the development and performance of businesses, entrepreneurship activity, development and economic growth, sustainable development, and life quality.

Establishing quality institutions, quality infrastructure, and doing business worldwide, using ISO standards, will have a positive impact on entrepreneurship activities and doing business as it leads to increasing economic growth and improving the quality of life of citizens in a wider perspective, as a part of long-term sustainable development.

## 2. Material and Methods

### 2.1. Entrepreneurship

Entrepreneurship is the creation or extraction

of economic value (Diochon et al., 2011; Gaddefors et al., 2017; Alvarez, and Busenitz, 2001). With this definition, entrepreneurship is viewed as change, generally entailing risk beyond what is normally encountered in starting a business, which may include other values than simply economic ones.

An entrepreneur is an individual who creates and/or invests in one or more businesses, bearing most of the risks and enjoying most of the rewards. The process of setting up a business is known as entrepreneurship. The entrepreneur is commonly seen as an innovator, a source of new ideas, goods, services, and business/or procedures. In the field of economics, the term entrepreneur is used for an entity that can translate inventions or technologies into products and services. In this sense, entrepreneurship describes activities on the part of both established firms and new businesses.

As an academic field, entrepreneurship accommodates different schools of thought. It has been studied within disciplines such as management, economics, sociology, and economic history (Lindgren, et al., 2009; Neergaard et al., 2007).

Entrepreneurship is the act of being an entrepreneur, or the owner or manager of a business enterprise who, by risk and initiative, attempts to make profits. Entrepreneurs act as managers and oversee the launch and growth of an enterprise. Entrepreneurship is the process by which either an individual or a team identifies a business opportunity and acquires and deploys the necessary resources required for its exploitation.

Regardless of the firm size, big or small, they can take part in entrepreneurship opportunities. The opportunity to become an entrepreneur requires four criteria. First, there must be opportunities or situations to recombine resources to generate profit. Second, entrepreneurship requires

differences between people, such as preferential access to certain individuals or the ability to recognize information about opportunities. Third, taking on risks is a necessity. Fourth, the entrepreneurial process requires the organization of people and resources (Shane, 2009).

The entrepreneur uses their time, energy, and resources into creating value for others. They are rewarded for this effort monetarily and therefore both the consumer of the value created and the entrepreneur benefit.

Strategies that entrepreneurs may use include:

- 1) Innovation of new products, services, or processes
- 2) Listen to customer feedback and adapt
- 3) Continuous process improvement (CPI)
- 4) Exploration of new business models
- 5) Finding solutions for problems
- 6) Use of technology
- 7) Use of business intelligence
- 8) Use of economic strategies
- 9) Development of future products and services
- 10) Optimized talent management
- 11) Entrepreneurial marketing strategies for interactive and innovative networking (Qureshi, 2015; Adel et al., 2020).

These strategies are part of the quality management subject too (Ceko and Mecalla, 2017).

For the period of pandemics and post-pandemics, several entrepreneurship challenges have been identified (GEM Report), including that in some countries one in two adults agreed their household income had decreased, comparing 2021 to 2019 (pre-pandemic), Total Early-stage Entrepreneurial Activity (TEA; GEM's most well-known indicator, representing the percentage of adults that are starting or running a new business) has typically decreased and this

has also been the case for levels of Established Business Ownership (EBO; the percentage of adults aged 18–64 owning or managing a business for more than 42 months), in a quarter of the GEM economies, over half of those starting or running a new business expect to employ no one but themselves in five years. This may be indicative of high levels of informal “survival” businesses, created during economic hardship when no other alternatives or social safety nets are available, and when people resort to entrepreneurship as their only fallback solution. Consistent with crises throughout history, the COVID-19 pandemic crisis surfaced new opportunities for entrepreneurs around the globe, however, despite positive perceptions of the ease of starting a business, self-confidence in their skills and abilities, and other factors, many entrepreneurs were constrained by the fear of failure (GEM (Global Entrepreneurship Monitor) (2022)).

## 2.2. Business Sustainable Management

Entrepreneurship and quality management are subjects of a discipline called Business sustainable management, which is concerned about:

- The global state, what needs to change, and how to bridge the sustainability gap through rewiring the economy.
- Why sustainability is good for business, and the importance of good leadership in achieving change.
- Policy instruments, international agreements, and the role of business and civil society in shaping a zero-carbon economy.
- The value chain: Implementing business models and processes for sourcing, producing, and consuming sustainably.
- The role of innovative design,

planning, and technology in facilitating sustainable business.

- How to effectively communicate sustainability strategies and goals to internal and external stakeholders.
- How businesses can work together with corporate, government, and non-profit actors to bring about large-scale change in the sustainability space (Business sustainability management course, 2022).

### 2.3. Entrepreneurship Index

The Entrepreneurship Index, compiled by the CEOWORLD magazine, evaluates a total of 100 economies that collectively account for 95 percent of the global gross domestic product. The overall ranking considers a wide range of factors to create an overall “best countries for entrepreneurship” index, including innovation, competitiveness, infrastructure, labor skills, access to capital, and openness for business.

Starting a business anywhere takes grit, determination, and a marketable idea, but certain economies make it just a little bit easier for entrepreneurs to get off the ground. If you’re looking for the best country to build a business, you may not have to look far.

To determine the rankings, researchers compiled, analyzed, and compared countries across 6 key categories: innovation, competitiveness, labor skills, infrastructure, access to capital, and openness for business.

To evaluate those dimensions, researchers looked at 18 indicators that fell into one of the 6 categories. An index has been created scoring the individual indicators on a scale of 1-100. Each indicator was given equal weighting within each of the 6 categories with some indicators being comprised of 2-3 sub-indicators that were also weighted equally.

The rankings are the result of a rigorous analytical exercise, incorporating multiple data sources, without relying on investment promotion agencies (IPA) and Government Industry trade data submissions.

The margin of sampling error for the full sample of 120,000 respondents is plus or minus 1.2 percentage points. In addition to sampling error, one should bear in mind that as in all survey research, there are possible sources of error, such as coverage, nonresponse, and measurement error, that could affect the results (Business sustainability management course, 2022).

### 2.4. International Standards Organization and Business Sustainability

The International Organization for Standardization (ISO) refers to Sustainability as the ability to maintain or develop performance in the long term. Looking at it through a different lens, sustainability has to do with maintaining businesses financially, socially, and environmentally. Sustainability broadly consists of three components:

- Business Sustainability (economic/financial);
- Environmental Sustainability; and
- Social Responsibility.

Two types of ISO Standards are helpful for the successful implementation of Sustainability practices:

- Certifiable standards
- Guidance standards.

### 2.5. International Standards Organization and Business Sustainability

According to ISO (World Most Entrepreneurial countries 2021 (2022)) governments, industry, consumers, the economy, society, environment, can benefit from using ISO standards as per below.

#### 2.5.1 Government

Regulators can rely on ISO standards as a solid base on which to create public policy that helps further Sustainable Development Goals (SDGs) such as human rights, water, and energy efficiency, public health, and more. Recognized the world over, International Standards also help governments achieve their national and international commitments (<https://www.iso.org/sdgs.html>).

### 2.5.2 Industry

Industry plays a key role in achieving all the SDGs and ISO standards help it do that by providing guidelines and frameworks on everything, from employee health and well-being to energy consumption, to resilient and eco-friendly infrastructures (<https://www.iso.org/sdgs.html>).

### 2.5.3 Consumers

While contributing to the SDGs ranks high on the agenda of business leaders and politicians, many of the benefits are felt at the local community level. Reduced poverty, improved health, cleaner and more abundant water, and safe and secure infrastructures are just some of the benefits to be gained from implementing ISO standards (<https://www.iso.org/sdgs.html>).

### 2.5.4 Economic

ISO International Standards promote economic sustainability by facilitating international trade, improving a country's national quality infrastructure, and supporting sustainable business practices (A quality infrastructure is a system contributing to governmental policy objectives in areas including industrial development, trade competitiveness in global markets, efficient use of natural and human resources, food safety, health, the environment, and climate change). They cover everything from efficient farming

methods to anti-bribery management systems (<https://www.iso.org/sdgs.html>).

### 2.5.5 Social

ISO International Standards promote social sustainability by helping countries and communities improve the health and well-being of their citizens. They cover all aspects of social welfare, from healthcare systems and related products to social inclusion and accessibility (<https://www.iso.org/sdgs.html>).

### 2.5.6 Environmental

ISO International Standards promote environmental sustainability by helping businesses and countries manage their environmental impact. They cover such aspects as implementing an environmental management system, measuring and reducing greenhouse gas emissions and energy consumption, and encouraging responsible consumption (<https://www.iso.org/sdgs.html>).

## 2.6. Quality Management, Doing Business, and Global Trends on ISO Certificates

Quality management is the act of overseeing all activities and tasks needed to maintain a desired level of excellence. This includes creating and implementing quality planning and assurance, as well as quality control and quality improvement. Quality management ensures that an organization, product, or service is consistent. It has four main components: quality planning, quality assurance, quality control, and quality improvement (Rose, 2005). Quality management is focused not only on product and service quality but also on the means to achieve it. Quality management, therefore, uses quality assurance and control of processes as well as products to achieve more consistent quality. Several means to

achieve quality management are between doing business regulations and rules, ISO certificates included, which are focused more on the quality of procedures private and public subjects follow, which at the end of the day brings a higher quality of products and services (Ceko, 2013c).

Because societies need regulation—and businesses, as part of society, are no exception, ISO certificates finally are part of business and trade regulations since they are the minimum requisites for characteristics of processes, products, and services to be used by private and public entities/subjects to be acceptable from their clients and markets. Without this standard,s modern private and public entities cannot exist. And where markets are s left without standards, they would produce poor outcomes and finally low life quality for citizens. When starting a new business, or entering a new phase of enterprise development, entrepreneurs need to establish certain procedures and standards, allowing the business to live beyond minimum frontiers, e, export, and import, participate in public procurement procedures, and finally attract as many as possible clients, for higher profits and

achieving other business objectives. Standards are the heart of all these issues, facilitating business transactions and allowing businesses to operate effectively. With 1 609 294 certificates issued worldwide in 2014, there is a slight up on the previous year, which demonstrates a moderate growth for almost all the ISO management systems standards around the world (<https://www.iso.org/sdgs.html>), confirming trends observed over the last two years. This market stabilization is, however, offset by three good performers exhibiting more sustained growth. Albeit less impressive than in previous years, ISO 50001 for energy management demonstrates a 40 % growth rate, led once again by Germany, responsible for 50 % of the 6 778 certificates reported. Similarly, food management standard ISO 22000 continues to deliver reliable performance with a 14 % growth rate, while ISO 16949 for the automotive sector shows accelerated progression with a commendable 8 %, signaling that economic recovery in the auto industry is holding up (ISO Survey Executive Summary, 2014).

**Table 1.** ISO Survey Executive Summary. 2020 [19]

ISO standards	Total valid certificates	Total number of sites
ISO 9001 – QMS	916,842	1,299,837
ISO 14001 – EP	348,473	568,798
ISO 45001 – HSW	190,481	251,191
ISO/IEC 27001 – ISM	44,499	84,181
ISO 22000 – QSGF	33,741	39,894
ISO 13485 – H	25,656	34,954
ISO 50001 – EE	19,731	45,092
ISO 20000-1 – IT	7,846	9,927
ISO 22301 – BC	2,205	4,662
ISO 37001 – ABMS	2,065	5,946
ISO 39001 – RTS	972	2,341
ISO 28000 - SRMS	520	968

When compared with the 2019 edition, the results are consistent when looking at the overall figures for most of the countries. The overall results show an increase, from 2019,

of 18% in the total number of valid certificates for the 12 management system standards covered in the survey. Part of this significant increase is due to the important



growth in the certification to ISO 45001; this standard was published in 2018 and consequently had a limited number of certifications in the previous edition of the survey. The rate of increase for ISO 9001 and ISO 14001 has been greater compared to previous years with +4% for ISO 9001 and +12% for ISO 14001 mainly due to an important increase in China. Similarly, to the previous editions of the survey, the results show some fluctuations at the country level that are explained by factors related to the participants such as the non-participation of some certification bodies for those specific countries. In the 2020 survey, this is the case particularly for ISO 9001 and ISO 14001 for Belgium, Korea, Mexico, Ireland, and the Philippines and for ISO 28000, China (ISO Survey Executive Summary, 2020).

The most important thing related to this paper is the declaration of the International Standards Organization that the ISO Survey is not a database, but just a list of ISO certificates issued and a list of countries based on alphabetic order, neither based on the number of certificates issued per country ISO (Survey Executive Summary, 2020).

## 2.7. How ISO Standards Help Companies and Bring Benefits to their Clients

As it is stated in the GEM Report Policymakers could allay much of this fear by drawing greater attention to entrepreneurial success stories both large and small and implementing risk-mitigating initiatives that reduce real and perceived impediments for startups (GEM (Global Entrepreneurship Monitor) (2022)), besides other factors, ISO standards help on this issue.

ISO standards have helped various companies and our clients have benefited because of:

Reduced risk: The underlying reason for ISO compliance is that entrepreneurial companies are at a greater risk than established

organizations – and thus have a more compelling case for minimizing risk. If a young company doesn't have policies, processes, and procedures that are standardized, it risks wasting its precious resources. And that doesn't result in just missing the numbers – it can mean going out of business.

**Builds in consistency:** It isn't enough for fledglings to operate with a "general knowledge" of the details involved in turning out first-rate products or services. Typically the founders and a few employees have the needed knowledge but it is not communicated consistently across the organization. ISO standards, by contrast, put policies, processes, and procedures in writing so that everyone is aware and able to work within common directives.

**Measures ROI:** In addition, ISO standards serve as a checklist against which a young company, whose financial talent and systems might not yet be up to par, can measure critical entrepreneurial objectives, namely return on investment or ROI.

**Builds credibility:** Finally, standards function as an imprimatur, convincing partners to engage with, and customers net to buy from, an untested entity (Leo et al., 2003).

## 2.8 Methodology and methods (Research framework, the purpose of the case study)

The framework of the research was the relationship between Entrepreneurship Index (E Index) and the ISO standards Index from a global perspective and global ecosystem. Given the lack of numerical, statistical, and algebraic arguments on relations between the E Index and the ISO Standards Index, this study adopts a building mode theory and aims to investigate the following research questions:

- 1) Ho: There is a strong connection/relation between E Index and the ISO standards Index.

- 2) H1: There is not a strong connection/relation between E Index and the ISO standards Index.

... considering that there is little research on relations between the E Index and ISO standards Index, listed in the literature review of this paper research, and considering that theoretical approaches on relations between entrepreneurship and ISO standards, and specifically between E Index and ISO standards Index, as well as numerical, statistical and algebraic arguments on relations between them, doesn't exist.

Specifically, while acknowledging the importance of connections/reasons between entrepreneurship and ISO standards, prior empirical research impresses with declarations that this connection exists, but does not explain statistically if there is any connection/relation between them, thus, a theory was needed, supported by analysis and evidence. Therefore, with this critical analysis, an exploratory approach was adopted, using a single in-depth case study approach, appropriate for building an in-depth understanding of a phenomenon and allowing closer investigation of theoretical constructs.

### **2.8.1 Case selection**

The case was selected based on three main criteria: a theoretical approach, suitability of relations, and practical positive impacts on relations between the E Index and ISO standards Index.

The case project ran in stages: (1) identifying needs for entrepreneurship, (2) identifying needs for quality management, and ISO standards certification, and (3) identifying the rank of the countries for Entrepreneurship and the Rank of countries for ISO standards Index.

### **2.8.2 Data collection**

Data for E Index has been gathered from Entrepreneurship Report 2021, an annual ranking of countries by their achievement on the subject, compiled by the CEOWORLD magazine (The world's most entrepreneurial countries. 2022).

Data for the number of businesses registered worldwide has been gathered from HitHorizon (<https://www.hithorizons.com/>).

Data for the ISO standards Index has been gathered from the ISO certificates Report 2022 (<https://www.quality.org/article/2020-iso-survey-management-system-standards-reveals-17-increase-certifications>).

To prepare the ISO standards Index I have divided the number of ISO certificates issued per country by the number of businesses registered in the country, resulting in the ISO standards Index per country, preparing the list of countries based on this Index.

### **2.8.3 Data analysis**

A correlation and regressive analysis (inferential statistics) between these Indexes for 91 countries worldwide were performed. In the table below, 91 countries are listed for the E Index, and ISO Standards Index (prepared by the author of this article as per the explanation given in the paragraph above).

Based on these data and information from secondary resources, a regression between E Index and ISO certificates issued per country was built. Data from ISO about ISO standards certificates issued worldwide (taken from ISO report) didn't help directly, because an Index was needed, so the Index divided the number of ISO standards certificates issued per country by the number of business entities in the country, finding the ISO standards Index, as explained above.

### 3. Results

After listing countries per this Index, regression analysis between the E Index and ISO Standards Index was drafted, based on which, it can be stated that the relations between the E Index and ISO Standards Index are not high, verifying the H1 hypothesis which was: “There is no relation between E Index and ISO Standards Index, against Ho that was: “There is a strong relation between E Index and ISO Standards Index”, which is a hypothesis that comes from the highly estimated situation from international organizations and believes of people who work on these subjects, which could never prove this hypothesis statistically.

In table 2, countries are listed as per the E Index, which served as the “Y” at the regression procedures, and ISO standard Index which served as the “X” at regression procedures, handled in an excel program.

**Table 2.** List of countries based on the E Index (CEOWORLD) and the ISO Standards Index (drawn from the author of this paper)

No	Country	E Index	ISO standards Index
1.	USA	42.88	0.00095
2.	Germany	41.05	0.021
3.	UK	35.8	0.00884
4.	Israel	34.25	0.018
5.	UAE	31.01	0.01185
6.	Poland	29.75	0.00656
7.	Spain	29.01	0.0146
8.	Sweden	28.16	0.00575
9.	India	25.47	0.00082
10.	France	25.34	0.0054
11.	Australia	25.05	0.00576
12.	Estonia	24.64	0.0071
13.	Ireland	24.37	0.0136
14.	Malaysia	23.6	0.011497
15.	S. Arabia	22.98	0.003433
16.	Canada	21.8	0.0052
17.	Philippines	21.62	0.00544
18.	Denmark	21.42	0.0071

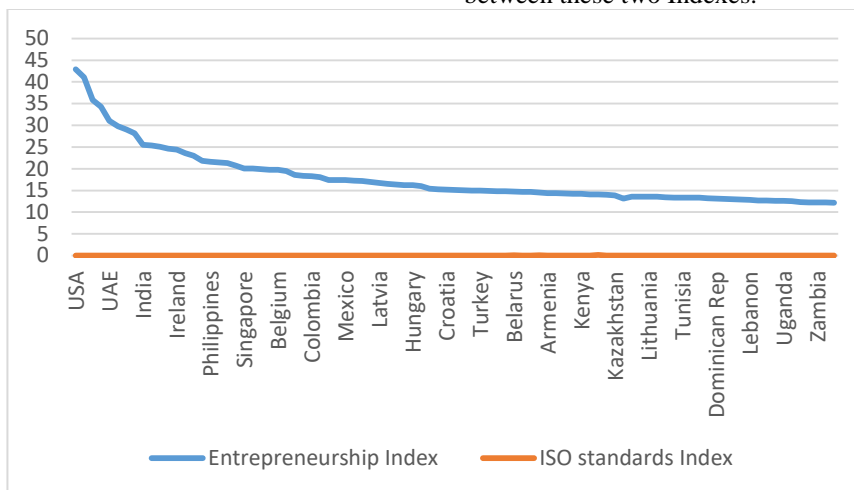
19.	Switzerland	21.34	0.022
20.	Japan	20.71	0.011234
21.	Singapore	20.05	0.0153
22.	China	20.04	0.004338
23.	Austria	19.92	0.0173
24.	Portugal	19.73	0.0114
25.	Belgium	19.72	0.00467
26.	Italy	19.46	0.021
27.	New Zealand	18.55	0.00321
28.	Thailand	18.32	0.00505
29.	Colombia	18.25	0.00558
30.	Bulgaria	18.05	0.0129
31.	Chile	17.41	0.0293
32.	Czech Rep	17.37	0.0207
33.	Mexico	17.37	0.00209
34.	Norway	17.22	0.00695
35.	Cyprus	17.16	0.0053
36.	Argentina	16.96	0.00951
37.	Latvia	16.76	0.01173
38.	Serbia	16.55	0.0189
39.	Brazil	16.4	0.003433
40.	Romania	16.25	0.0144
41.	Hungary	16.19	0.009254
42.	Netherlands	16	0.0072
43.	Indonesia	15.42	0.000018
44.	Greece	15.23	0.034
45.	Croatia	15.2	0.0149
46.	S. Africa	15.12	0.00196
47.	Luxembourg	15.05	0.00231
48.	Rwanda	14.96	0.000389
49.	Turkey	14.95	0.00132
50.	Slovenia	14.86	0.0127
51.	Slovakia	14.8	0.0166
52.	Russia	14.79	0.001895
53.	Belarus	14.71	0.0494
54.	Iceland	14.65	0.0136
55.	Peru	14.65	0.00162
56.	Qatar	14.54	0.078
57.	Armenia	14.41	0.00124
58.	Malta	14.4	0.00596
59.	Morocco	14.32	0.01886
60.	Moldova	14.23	0.001201
61.	Kenya	14.2	0.000219
62.	Nigeria	14.11	0.000014
63.	Azerbaijan	14.07	0.144
64.	Finland	14	0.0082
65.	Kazakhstan	13.87	0.001995
66.	Albania	13.16	0.0043
67.	N.R.Macedonia	13.59	0.0191
68.	Georgia	13.57	0.011355

69.	Lithuania	13.55	0.0099
70.	Ukraine	13.53	0.001213
71.	Vietnam	13.44	0.0131
72.	Jordan	13.38	0.00282
73.	Tunisia	13.38	0.00212
74.	Ghana	13.35	0.00317
75.	Bahrain	13.34	0.0093
76.	Sri Lanka	13.18	0.001904
77.	Dominican Rep	13.16	0.00311
78.	Costa Rica	13.06	0.00428
79.	Bangladesh	12.99	0.00126
80.	Jamaica	12.91	0.00406
81.	Lebanon	12.8	0.00354
82.	Iran	12.66	0.0288
83.	Cameroon	12.65	0.00046
84.	Egypt	12.59	0.00094
85.	Uganda	12.59	0.000144

86.	Trind&Tob.	12.52	0.0048
87.	Algeria	12.28	0.000343
88.	Ethiopia	12.27	0.00113
89.	Zambia	12.27	0.00004
90.	Pakistan	12.24	0.022
91.	El Salvador	12.18	0.00147

In figure 1 a correlation analysis, in a graphical mode is given, where is shown there is no connection/relation between E Index and the ISO standards Index.

In the three tables below, tables 2, 3, and 4, statistical results about missing connections/relations between E Index and ISO Standards Index are given, where  $R^2 = 0.248363$  shows a weak connection/relation between these two Indexes.



**Figure 1.** Missing relations between E Index and ISO standards Index (graphic is drawn from the author of this paper).

**Table 2.** Summary Output

<b>SUMMARY OUTPUT</b>	
<b>REGRESSION STATISTICS</b>	
Multiple R	0.49836
R Square	0.248363
Adjusted R Square	0.237127
Standard Error	16.04706
Observations	90

**Table 3.** Anova

ANOVA					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	7572.848	7572.848	29.4082	5.08E-07
Residual	89	22918.21	257.508		
Total	90	30491.06			

**Table 4.** Coefficients

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
0.00095	434.2485	80.07633	5.422933	4.98E-07	275.1386	593.3585	275.1386	593.3585

With these results, it has been verified in practice there is no connection/relation between E Index and ISO Standards Index.

## 4. Discussion

In this study, by making use of a regressive analysis, it was verified statistically that there is no relation between E Index and ISO Standards Index, but this doesn't mean the relations are not needed, or they can't be achieved in the future. The question is when these relations will be achieved and verified, and what is needed next.

It is true and we all, World Bank, United Nations, and ISO including, do believe that entrepreneurship is important for economic growth and there is an improving ISO standard certification process all around the globe, but the question is how we can better match and adopt the entrepreneurship activity with ISO standards.

Scientific management of factors of production creates opportunities for improving entrepreneurship climate and business activity, applying quality management principles and ISO standards, as efficient and effective tools, and this is needed, immediately, but scientific management of factors of production requires ISO standards application in a wider approach and not only for private subjects which are looking to participate in public

procurements as well as for exporting goods accompanied with ISO certificates, so, a real connection and relations between the E Index and ISO standards should exist.

### 4.1 Implications for Theory and Practice

About the theory, based on the final results of this research, a new window has been opened for further research in the field of relations between entrepreneurship and quality management, and especially between E Index and ISO Standards Index, considering them as a tool for a life quality improvement all around the world.

#### *Contribution*

The contribution of this paper, mostly on the field of relations between entrepreneurship and ISO standards, shows that international organizations, those mentioned in this paper, should carefully investigate the issue of building research relations between concepts, especially between important concepts and principles like those of Entrepreneurship and Quality management principles too.

This critical analysis article emphasizes the economic and social importance of Entrepreneurship and ISO standards, for current and future generations.

**Limitations and Further Research**

This research has been undertaken using plenty of data about the E Index and offering for the first time information about the ISO Standards Index for the period of 2020.

Further research is needed to verify these relations, which must be stronger in the future, to make Entrepreneurship Index and ISO Standards Index real tools for life quality improvement all around the world.

**5. Conclusion and Recommendations**

Scientific management of factors of production creates opportunities for entrepreneurship activities, applying quality management principles and ISO standards, as efficient and effective tools, and this is needed, immediately.

Scientific management of factors of production requires ISO standards application; so, a connection and relations between the Entrepreneurship Index (E Index) and ISO standards should exist, for healthier business ecosystems.

The general outcome of the research is looking forward to achieving and maintaining entrepreneurship activities, applying quality management principles and ISO standards, as efficient and effective tools, as an immediate need, all parties should look forward to making sure building relations and connections between Entrepreneurship Index and ISO Standards Index, which currently doesn't exist.

There are no strong and sustained relations between sustainable development and quality management/ISO standards.

Improving quality management system / respecting ISO standards parallel with working on improving the business climate and strengthening entrepreneurship activities, shall have a real indication of life quality improvement all around the globe.

There is no relation between entrepreneurship and ISO standards, even though it is assumed that it should exist to promote sustainable entrepreneurship with no support at all.

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## AN INVESTIGATION INTO TQM IN A RETAIL BANK IN THE KINGDOM OF BAHRAIN

**Abstract:** *TQM is a must if you want to improve policies and procedures and make customers happier. The paper investigates total quality management (TQM) implementation in a retail bank in Bahrain. The study distributed 131 questionnaires, of which 120 have been returned. The results showed that TQM improves operations and functions by involving and training employees. TQM was perceived as a strategic technique to enhance the bank's profitability. Employee involvement, training, strategic planning, and top management commitment correlated positively with TQM. The study suggests that retail bank employees keep quality standards and get regular training and education to help provide good care.*

**Keywords:** *Total quality management, retail bank, management development, banking sector, and Bahrain*

### 1. Introduction

Quality has become one of the best ways for all organizations to stay in business and do well [1]. To excel in quality, firms must add value to their customer service. TQM is a strategic system for customer satisfaction in today's dynamic and competitive environment that assists managers in evaluating external environments. The concept of total quality management (TQM) meets the organization's goals by facilitating customer satisfaction at the most economical level. The former name of TQM was quality control. TQM refers to the philosophy of business management that helps recognize the customers' needs and the organization's inseparable goals [2]. In today's dynamic and competitive environment, strategic management is critical to assisting managers in evaluating external environments. An effective TQM strategy allows organizations to optimize resources to extract opportunities

and limit threats to achieve competitive advantage [3].

TQM is the way of thinking and acting needed to give customers a good product and meet their needs. TQM described quality as the giving force behind guidance, preparation, and enhancement. Communication among all employees is necessary to ensure proper and efficient management of quality issues and measures, whether at a lower, middle, or higher management level. Padhi [4] categorized TQM into eight elements: the binding mortar, building bricks, foundation, and roof. Critical, or communication, refers to understanding the sender and receiver. A successful TQM requires active communication between employees, customers, and suppliers.

The building blocks category includes teamwork, training, and leadership. Collaboration ensures the smooth running of the organization. People feel free to bring

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challenges, and the management gets the operators' help finding the solution. Successful companies in the future will encourage teamwork, cooperation, and employee connections to their business partners and clients, as well as greater employee inclusion in the company's development activities. Similarly, training is essential to increase the productivity of the employees. It helps employees improve their skills, such as problem-solving, decision-making, etc. The learning or training curve can be improved using a short creation period, seminars and courses, co-working space, divided teams, cohort peers, and mentorship. Leadership is one of the essential elements in TQM. The supervisor led the employee to understand the strategic direction of the company. The leader understands the concept of TQM and teaches the employees through their daily practices.

Under the foundation come integrity, ethics, and trust. Integrity specifically discusses or includes factors such as morale, value, and honesty. On the other hand, ethics are related to the discipline maintained in excellent or harmful situations. Personnel decisions are related to standards. Trust is the output of integrity and trust. The framework of the TQM is built on faith. It encourages ownership and commitment. Trust ensures customer participation and makes the company environment suitable for work. Acceptance or recognition is the final step in the complete system. It provides individual and group recommendations, recognition, and acceptance to the employees trying to receive credit for their group and themselves. Recognizing individual contributors is the supervisor's responsibility.

Putting a QM theory that has already been tested in a new situation adds to its theoretical value [5], especially in developing economies. This research aims to bridge this literature gap on the role of TQM in a developing country's setting. The main goal was to examine the relationship

between employee involvement, employee training, strategic planning, top management commitment, and TQM in a local retail bank in Bahrain. The study investigated many issues concerning the valuation of quality. The study has been extended to include collecting primary data and statistical analysis so that practitioners can use actual and accurate materials.

## **2. Methodology**

### **A. Instrument**

The five-point Likert scale questionnaires were electronically distributed to the respondents through Google Forms. The web link was distributed to the randomly selected employees by email.

### **B. Sampling Method**

The study used a simple random sampling technique to collect data, where every subject had the same chance of being selected [6]. Simple random sampling necessitates little prior knowledge of the population [6], and telephone interviews have been used to follow up with respondents.

### **C. Sample Size**

The respondents were managers, executives, and middle-level employees. Out of these 131 distributed questionnaires, 120 were returned. Thus, the response rate for this study was 91.60 percent.

### **D. Research Variables**

**Employee involvement:** All employees must participate for organization members to participate in the quality control process. It will result in the assurance of a proper TQM process.

**Strategic planning-** Adequate physical resources are also essential for reasonable quality control assurance. To correctly manage the quality within organizations, there must be sufficient material resources to ensure quality control and management

strategies.

Employee training helps employees understand the need to maintain the organization's quality issues. Training has always been an important tool to motivate employees to control and manage quality problems and factors. It makes the employees responsible enough to accomplish their duties to assure quality control and leadership within the organizational aspects.

The commitment of top management- Top management is primarily responsible for maintaining and overseeing all quality management issues. They must govern all other members to ensure proper administration of the organization's TQM. The organization's top administration can make the other employees indulge and be motivated towards the appropriate management and control of all the quality issues.

### 3. Results

Most respondents were employees for more than seven years, 43.33%. Most employees had 5-7 years of experience (24.17%), followed by employees with 3-5 years (20%). The minority employees had less working experience (less than three years, 12.50%). The most significant demographic feature was that most of the respondents had a total work experience of more than seven years.

#### A. Reliability and Internal Consistency

Table 1 provides Cronbach's alpha test results for 120 participants using SPSS version 20. According to Tavakol and Dennick [7], as Cronbach's alpha is more significant than 0.7, it is considered acceptable. Table I demonstrates that Cronbach's alpha minimum value was 0.733 and the maximum was 0.953, along with Cronbach's alpha value for the whole questionnaire being 0.975.

**Table 1.** Reliability and internal consistency

Construct	No. of Questions	Items	Cronbach's Alpha (Reliability)
TQM	4	Q1-Q4	0.808
Employee Involvement	4	Q5-Q8	0.733
Employee Training	4	Q9-Q12	0.953
Strategic Planning	4	Q13-Q16	0.952
The Commitment of Top Management	4	Q17-Q20	0.951

#### B. Perceptions of TQM

The general perception of TQM had a mean of 3.08. The statement "All the bank employees strive to meet their needs and expectations" had a mean score of 3.55. The statement "Quality is the key strategic factor in achieving business success" had an arithmetic mean of 3.30. The statement "TQM is the procedure or technique for improving the bank's reliability, efficiency, and quality," with an arithmetic average equal to 2.99. Finally, "TQM is the management approach the entire bank follows" equals 2.48.

As for the perceptions of employee involvement, the mean score of the statement "Employees of the bank are always involved in offering a high quality of work" was 4.53, followed by "Participation of all the organization members determines high quality in the group," with a mean of 4.50. Then "the involvement of employees is also the primary element of TQM" had a mean of 3.27. Lastly, "employees are the main way to keep and ensure quality in the organization," which got a mean score of 2.96, got the lowest score.

The general mean score of the perception of employee training was 3.82. The mean average of the statement "Training will also make them aware of the need for quality control for ensuring proper organizational proceedings" was 4.25. Then "Training and development programs help the employees to know about their goals and objectives in the organization," with a mean of 4.18. Then, "Training that can make employees understand the need to manage quality within the organization" with a mean score of 3.94. Finally, "All the bank employees are provided with training for showing high-quality performance," with a mean of 2.91. The section was rated 4.09 by the general mean of strategic planning perception. The mean average was 4.58 for the statement "TQM is the strategic planning that involves continuous improvement of product quality to achieve customer satisfaction," followed by a mean of 4.53 for the sentence "TQM is the strategic planning of the organization." Then, "Strategic planning accomplishes the primary task or duty of maintaining quality issues within the organization," with a mean of 3.69. Finally, "To ensure the proper TQM process in the organization, it is vital to synchronize TQM and strategic planning,"

with a mean of 3.55. Table 5 shows that the arithmetic mean of the section was 3.32.

The general mean of the perception of top management commitment was 3.32. The mean score for "Top-level management of the organization arranges for organizational innovation to ensure high-quality work" was 3.69, followed by a mean score of 3.46 for "Top-level management of the organization arranges for organizational innovation to ensure high-quality work." The statement "A bank follows TQM programs with the help of top management support" had a mean score of 3.18. Finally, "All the organization members are responsible for maintaining high-quality products and services to gain customer satisfaction" had a mean score of 2.96.

**C. Correlation Coefficient Results**

Table II documents the Spearman correlation coefficient results. The correlation coefficients exceeded 0.7, referring to high relationships between the study variables and the p-values, which were less than 0.05. The results showed significant associations between employee involvement and training, strategic planning, and top management commitment to TQM.

**Table 2.** Spearman's correlation coefficient results

		Correlations				
		TQM	Employee Involvement	Employee Training	Strategic Planning	Top Management Commitment
TQM	Spearman's $\rho$	1.000				
Employee Involvement	Spearman's $\rho$	.894**	1.000			
Employee Training	Spearman's $\rho$	.916**	.871**	1.000		
Strategic Planning	Spearman's $\rho$	.917**	.858**	.921**	1.000	
Top Management Commitment	Spearman's $\rho$	.935**	.902**	.968**	.934**	1.000

**4. DISCUSSIONS**

TQM became a critical way to improve and enforce policies and procedures so that customers could get value-added benefits. Employees' satisfaction with TQM as a

strategic management technique was consistent with the findings of Hosseini et al. [8] regarding achieving long-term competitiveness.

The results indicated a positive and significant correlation between employee involvement and TQM. This result is similar to that of Fotopoulos and Psomas [9], who explained that employees are the primary determinant that helps maintain quality issues and control the maintenance of products or services.

The relationship between employee training and TQM provided a positive result. Providing proper employee training and development programs is a significant responsibility for the bank and higher-level managers. This result was consistent with Padhi [4], Salamzadeh et al. [3], and Salamzadehand Radovic-Markovic [11], who explained that training is crucial to increasing employees' productivity. Training helps employees improve their skills, such as problem-solving, decision-making, etc. Management competencies and skills help to oversee TQM issues with the proper skills and knowledge. Knowledge development and human resource capabilities are essential because increasing human resource capabilities play a significant role in achieving strategic objectives and public satisfaction.

The correlation between strategic planning and TQM provided a positive relationship between these two variables: strategic planning and TQM. Strategic planning is essential to ensuring and handling all the quality problems in the bank. According to Sallis [12], TQM is a management strategy incorporating quality elements into the organization's management process. The concept of TQM needs to be nurtured within the culture of organizations. The organization needs specific plans to raise its standards in the policies and procedures related to its quality issues.

The correlation between top management and TQM commitment again provided a positive result, indicating that top management and TQM commitment variables had a positive and significant

relationship. The top management's commitment to quality management cases is as fundamental as their participation in quality control issues. It is the highest required duty that needs to be accomplished by the top managers in the maintenance of quality control, which will again motivate the other employees of similar banks to take the initiative in maintaining quality issues. Furash [13] also found that top management had a unique role in maintaining and managing the TQM programs.

## 5. Conclusion

In the banking sector, service quality is an important aspect. The business's success depends on effective ways to improve the organization's performance. When the TQM is defined and implemented, it provides the marketer with an unobstructed view of the bank's elements as the first choice for new and existing customers.

Quality needs to be the top priority of the administration. To build a service-quality culture in any organization, the leadership and participation of the management play a crucial role. Thus, this study produced the combined result that TQM issues need to take particular concern over factors such as employee involvement, training of the employees, strategic planning, and the commitment level of the bank's top management. Considering the competitive environment in the banking sector, there is a great need to develop TQM programs in operations and functions.

The retail bank's management needs to ensure that the staff learns more about TQM's importance to the bank's long-term competitive advantage. Employees need regular training and education on TQM practices that can change their beliefs, attitudes, and actions. Employees must know about human resource development projects and be encouraged to participate. There also needs to be a system of rewards and praise

for employees who work to improve quality. regularly evaluated and constantly improved.  
The TQM practices of the bank need to be

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## INTEGRATING CONSTRUCTS OF THE TECHNOLOGY ACCEPTANCE MODEL AND TOTAL QUALITY MANAGEMENT TO IMPROVE DOCUMENT MANAGEMENT PERFORMANCE

**Abstract:** Document management processes represent a key consideration in business success and quality management. There is ongoing pressure for the public sector to embrace these tools to increase efficiencies, reduce cost, waste and more significantly upholding their mandate of improved services to its citizenry. An exploratory sequential mixed method comparative case study design described the study's methodology. The study relied on the combination of a desktop review; semi-structured exploratory individual interviews (n=45) with municipality executive and strategic managers; focus group discussions (n=2) comprising 5 and 7 participants each and a quantitative online survey (n=186), in which executive/strategic municipal employee participants provided experiential insights into the range of factors that influenced technology acceptance of differing document management systems, whilst simultaneously offering their insights on the range of impacts on "total quality" that they experienced and observed. This study reports on the quantitative part of the study. The South African context creates a unique dynamic and, for that reason, traditional models related to technology acceptance were found inadequate. The recommendations borne out of the findings can contribute substantially towards a more in depth and incremental understanding towards the successful, implementation and adoption of a customised, purpose-built document management system for the public sectors.

**Keywords:** Document management processes, increase efficiencies, reduce cost, waste, exploratory sequential mixed method, TQM and TAM, South Africa

### 1. Introduction

A range of document management system alternatives have been widely introduced globally (ranging from print-based, hybrid and paperless) but their success and usage patterns is varied because of the differing

conditions under which each has been implemented. Global reports of business running costs suggest that poorly evidenced document management systems can increase running cost wastage for companies by anything from 15 percent to 65 percent of the total business running cost when compared to evidenced options and in the

main, these cost differences can be the fine-line between the survival or demise of a business entity (Helmer 2012). By the same token, environmental sustainability of different document management processes represents an important consideration in business success and quality management. Some, including Jones (2012) and Marton & Choo (2012) suggest that strategic decisions related to, choice, usage and overall quality contribution of document management systems within business have its historical roots, in the total quality management discourse and constructs related to technology acceptance. Coined in 1985 by the USA navy, the theory of Total Quality management (TQM) is conceptualised.

## **2. Research problem**

Documents represent the single most universally utilised form of communication within businesses and their management is identified by some, as one of the top sources of financial wastage (Welsh, 2007) and (Department of Health and Hunt, 2013). Some, including Ugale, Patil and Musande, (2017) and David, Ngulube and Dube, (2013) have presented studies that show that up to 15% of fruitless expenditure within business is attributable to the mismanagement of document management systems especially within publicly run enterprises. Evidence has been consistent in illustrating a need for more evidence-based understanding of the problems associated with paper/document management systems as part of the wider agenda of increasing efficiencies and driving down operational costs. This is especially important within public entities because government reports from various contexts globally, show a growing lack of funds for the necessary operations and service provision that have direct impact on the wellbeing and the health of populations (McGrath, Griffin & Mundy 2016) and (McMullen 2011). The use of

paper within industry has been equated to millions of tons of deforestation and beyond the search for efficient document management options., there is a need for seeking out options that are not harmful to the environment. This unresolved challenge represents a significant problem for the public service, one that is deserving of empirical study.

## **3. Literature review**

Documents represent the single most universally utilised form of communication within businesses and their management is identified by some, as one of the top sources of financial wastage (Welsh, 2007) and (Hunt, 2013). Some, including Ugale, Patil and Musande, (2017) and David, Ngulube and Dube, (2013) have presented studies that show that up to 15% of fruitless expenditure within business is attributable to the mismanagement of document management systems especially within publicly run enterprises. a growing lack of funds for the necessary operations and service provision that have direct impact on the wellbeing and the health of populations (McGrath, Griffin & Mundy 2016) and (McMullen 2011). Beyond the wasteful expenditure and efficiency imperatives, the attention given to more effective management of documents has been equalled by growing concerns related to the environmental sustainability of paper-based document management systems. The use of paper within industry has been equated to millions of tons of deforestation and beyond the search for efficient document management options., there is a need for seeking out options that are not harmful to the environment. With this imperative clearly accepted by many including Al-Yahya and Panuwatwanich (2018), there have been significant efforts and debates across industry to determine how businesses can bring about greater efficiencies in the workplace, particularly with respect to the



management of documents.

### **3.1. An overview of the value of electronic document management systems – debates about paper-based and electronic options**

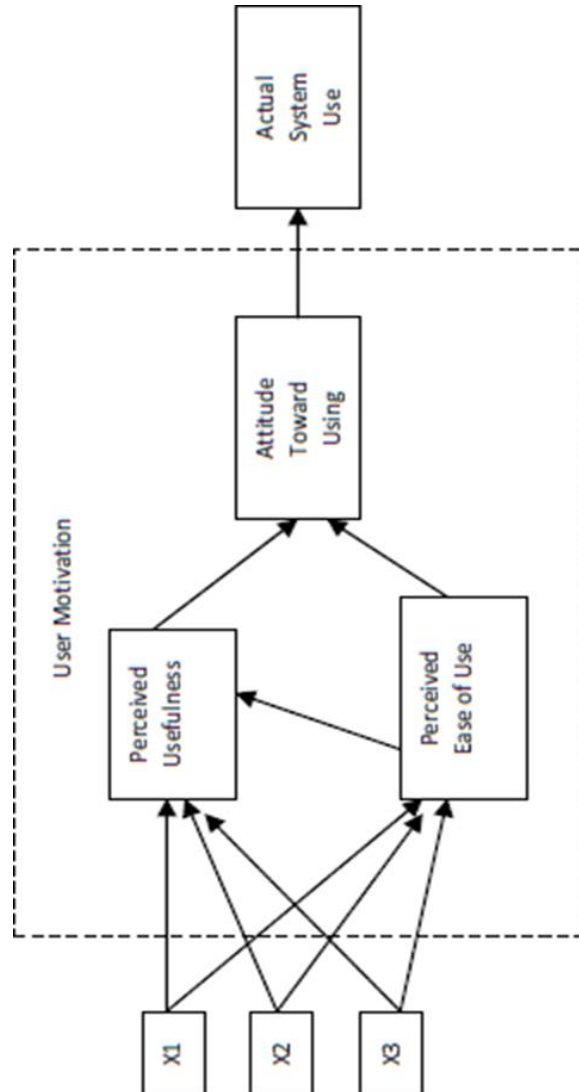
Firstly, there appears to be some contradictory evidence about the benefits and limits of electronic systems, for example, Igbaria et al., (1997) show EDMS to be disproportionately expensive at the point of initiation, that many services and organisations often do not possess the material resources to effectively oversee their introduction. As much as this is not a distinct disadvantage, it represents a critical acceptance factor that can dissuade use of newly introduced innovations. Furthermore, others including Hsu & Chiu (2006) show that the introduction of new technologies is usually problematic because potential users are inadequately trained and as such, the full potential of the new technology is never realised. As noteworthy as these summations are, Horst et al. (2007) put forward the view that these shortcomings are not specifically about EDMS but rather speak to poor implementation readiness issues. Others including Featherman and Pavlou (2003); Grandon and Pearson (2003) and Heinze and Hu (2007) identify the benefits of EDMS over traditional manual methods of paper management. Notably, Gilani (2009:16) and Kunis (2007:31) argue that, within public services, the debates about the acceptance of different document management systems have noted the specific benefits of EDMS as ranging across several issues including – cost efficiency, environmental sustainability, quality management and efficient business function. With respect to cost efficiency, Liu and Stork (2000:24) and Vallis (2009:71) argue that, the adoption of electronic document management options can result in anything from 10 percent to 50 percent of total cost reductions.

### **3.2. Theoretical contribution to understanding technology acceptance model – A brief overview of seminal contributions**

The Technology acceptance model (TAM) specifically and critically explores the role that identified factors such as the perceived ease of use, the perceived usefulness ended the probability of system use, all play in determining the likelihood of full implementation of the newly introduced Information Systems. Critically, the TAM prioritises the tracing of the impact of external factors on internal cognitions, beliefs, attitudes and intentions. As a basis of its application, the TAM was derived from earlier work by Azjen& Fishbein (1969) in which they proposed the theory of reasoned action (TRA) (Azjen& Fishbein 1980). The theory of reasoned action offers insights to understanding the voluntary behaviour of individuals. It argues that intention to perform a certain behaviour precedes the actual behaviour and results from a belief that performing the behaviour may lead to particular (often beneficial) outcome. Therefore, stronger intentions lead to an increased likelihood that the behaviour of interest will be performed.

Together, the TRA and the TAM offer a widely accepted viewpoint, which centres on stating that external factors play an indirect role in influencing attitudes, perceived boundaries of normality and how these psychological factors have a significant impact on individual decisions to take up new technologies. Legris et al. (2003) specifically test the application value of these two theories combined together. In their review of literature, Legris et al. (2003), consult over 80 Scientific publications (published between 1980 and 2001) as the basis for identifying the empirical value of the TAM and the TRA. For example, the TAM has been integrated with the Theory of Reasoned Action (TRA))

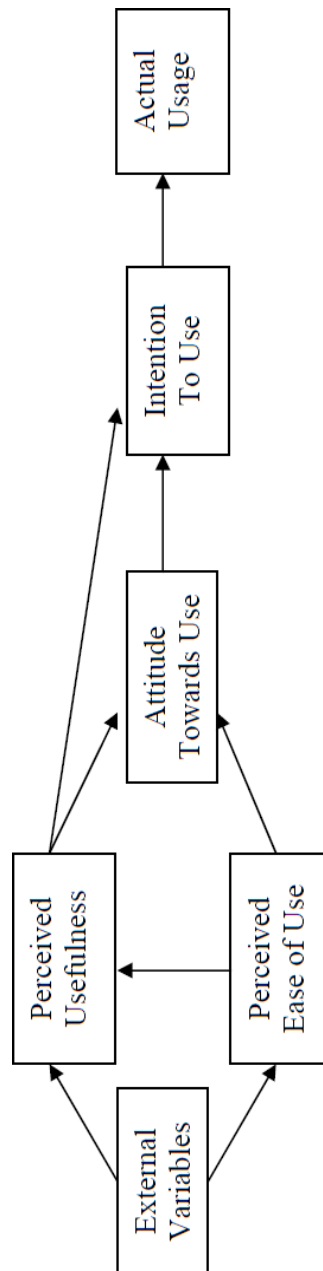
successfully as a basis for expanding current theories about the factors that impact technology usage.



**Figure 1.** Davis' Original Theory of Technology Acceptance Source: Davis, 1986

Davis' original conception of the TAM has been revised by himself and others over the course of time with the most current version

showing inclusion of wider determining variables as indicated below in Figure 2.



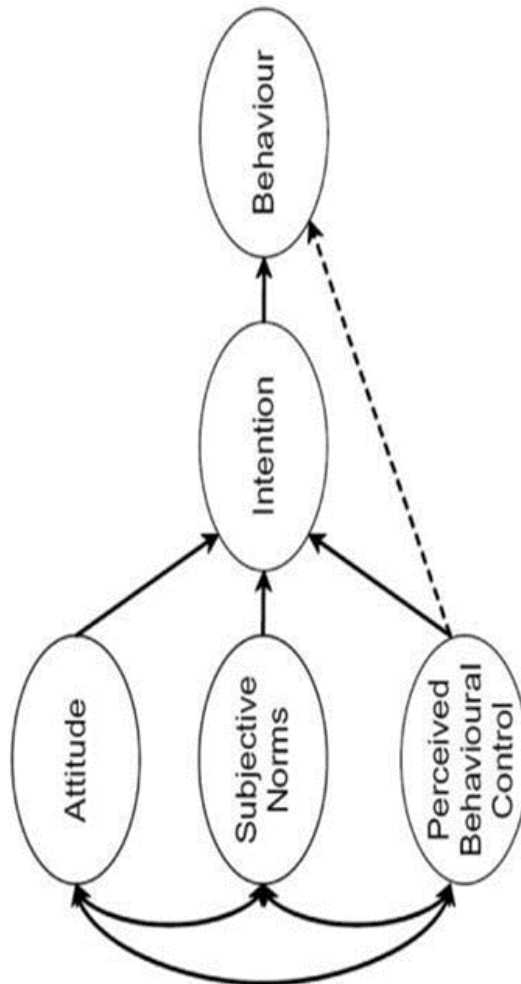
**Figure 2.** Davis' revised Theory of Technology Acceptance Source: Davis, 1986

It should be noted that Davis (1985) attributes the genesis of his TAM to the Theory of Reasoned Action by Fishbein and Ajzen (1975) which identifies that primarily,

an individual's intention to adopt a behaviour is the single most important predicting factor in their decision to act. Fishbein and Ajzen (1975, 1991) importantly

highlighted that the determination of behavioural intention is a result of the combined interplay between a person's attitudes toward that behaviour; their perceived control of the behaviour and any

subjective norms that they would have assumed with respect to the behaviour or in this case, the adoption of a new technology. The TRA is depicted below in Figure 3.



**Figure 3.** Theory of Reasoned Action (TRA) (Source: Fishbein & Ajzen, 1975)

Some researchers, including Silva et al. (2014) suggest that strategic decisions related to choice, usage and overall quality contribution of document management systems within business have their historical roots, in the total quality management discourse and constructs related to

technology acceptance. As such, the theoretical grounding of the study refers both to theory related to total quality management and technology acceptance theoretical areas. The former i.e. total quality management theory is particularly important because it confirms the widely held view that much of

the changes that are introduced in industry are a result of the competitive pressures and the need to satisfy the range of customers that any service has to satisfy. In this regard, Total Quality management represents an important strategy for ensuring stakeholder satisfaction. For the purposes of the current study, it is important that a sound understanding of founding philosophies, concepts and primary principles is elicited.

### **3.3. Total quality management theory: A conceptual overview**

Some researchers, including Silva et al., (2014) suggest that strategic decisions related to choose, usage and overall quality contribution of document management systems within business have their historical roots, in the total quality management discourse and constructs related to technology acceptance. As such, the theoretical grounding of the study refers both to theory related to total quality management and technology acceptance theoretical areas. The former i.e. total quality management theory is particularly important because it confirms the widely held view that much of the changes that are introduced in industry are a result of the competitive pressures and the need to satisfy the range of customers that any service has to satisfy. In this regard, Total Quality management represents an important strategy for ensuring stakeholder satisfaction. For the purposes of the current study, it is important that a sound understanding of founding philosophies, concepts and primary principles is elicited. Although a long-standing issue, the importance of TQM as a strategic focal point is a recent emergence and some, including Jung and Wang (2006) see it as a reaction to the growing customer demands for quality

‘fit-for-purpose’ products. With regard to the development of document management systems, total quality management is the primary motivation for effecting any change in the choice of system that an organisation that uses.

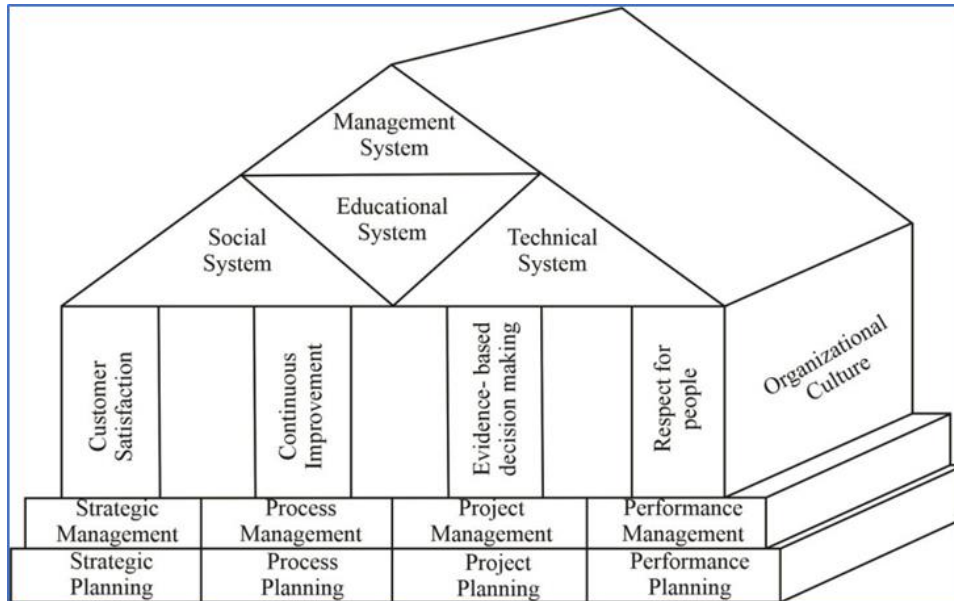
### **3.4. A summative overview of key elements of TQM**

Literature on Total Quality management has been collated and reviewed by a number of theorists including (Excellence 2001) and Holmes and McElwee, (1995) with the primary aim of providing a conceptual overview of what its key elements are. Some including Zbaracki (1998) suggests that there are six major components to TQM;

- Management commitment and leadership
- Employee involvement
- Continuous improvement
- Supplier Quality assurance and management.
- Customer focus
- Education and training

### **3.5. An integrated model for TQM**

The above discussions provide an overview of the different concepts and/or elements of TQM. Geraedts, Montenarie and Van Rijk (2001) and Tapiero (1990) acknowledge that TQM is, by its very nature, a complex phenomenon because of the many considerations that should be made in understanding what quality is and who it is who is defining it. Deming (2001) cited in Swinton, (2004) proposes a building-block theory of TQM which attempts to collate the differing aspects of TQM into a diagrammatic representation below.



**Figure 4.** The House of Total Quality Model (Source: Voehl, 1992)

The above “House of Total Quality Model was initially posited by F. Voehl in 1992 and is made up of six elements that combine house and architectural metaphors with important quality concepts to describe the different aspects that should be considered within any quality discussions. Voehl’s six elements include:

1. Subsystems of the organisation, such as management system, education, social and technical subsystems (roof).
2. Continuous improvement of customer satisfaction, basing decisions on facts and respect for people (pillars of quality).
3. Strategic management, processes, projects and tasks (base).
4. Strategic planning of processes, projects and tasks (benches).
5. Development of organization (mortar).
6. Corporate culture (the wall).

The above-identified House of Total Quality model shows the wholly inclusive approach to quality management and any

implementation of any quality management process should be centred on the operationalisation of key organisational processes, methods and techniques. This wide-encompassing view has been used within the current study to inform that way in which quality issues have been explored.

### **3.6. Application of the theoretical framework in this study**

As indicated earlier, the combined exploration of concepts related to technology acceptance and total quality management is used as a basis to guide both the data collection and analysis processes. To that end, the resulting data collection procedures are designed to ensure inclusion of each of the factors/influences and variables that the theories highlighted. Furthermore, the decision to collect data from the varied perspectives of different stakeholders within the document management sphere was largely informed by explorations of relevant theoretical framings of the subject under study.

## 4. Methodology

### 4.1. Research paradigm

Polit & Becker (2014) define epistemology as the philosophical study of the nature, origin, and limits of human knowledge. Within the current study, a number of research paradigms were deemed relevant and as such, each is discussed;

Interpretivism is a paradigm that maintains that all human beings are engaged in the process of making sense of their worlds and continuously interpret, create, give meaning, define, justify and rationalise daily actions (Babbie & Mouton 2001:28). Hermeneutics has a partial resonance with the current study because some of the focus is on how individuals' experience changes upon the introduction of a new technology and that understanding of the phenomena should be based on the lived experience.

### 4.2. Population and sampling

The total target population for the current study was 364 potential participants ("Integrated Development Plan Annual Review", 2016/2017). Parent /source population = 23,000 employees employed by the municipality and who utilize the services of the administration unit. The epi-info sampling calculator ([www.epi-info.com](http://www.epi-info.com)) was used to calculate the sample size and calculations were carried out using the following population parameters:- Target Population = 364 respondents comprised of Mayor (n=1); Executive Committee (EXCO) (n=10); Councillors (n=206); City Manager (n=1); Deputy City Managers (n=6); Heads Of Departments (n=80) and operational staff (n=20). This is a total of 364 respondents within the target population.

A confidence level of 95% and a confidence interval of 5%, were used and based on these, the predicted sample size was 168 respondents. To allow for attrition, a further

10% was added to the sample size i.e. 17 respondents, culminating in a total of 186 respondents being recruited to take part in the survey.

The research study was carried out over four phases, which included focus groups, semi structured interviews and a survey questionnaire. This study will focus on the quantitative analysis only.

## 5. Data Presentation:

The final data collection phase of the study was a questionnaire-based survey in which identified respondent groups were represented.

As per sampling plan, a total of 186 respondents took part in the survey aspect of the study.

The sampling plan for the survey (Phase 3) was based on a Parent/Source Population = 23,000 employees employed by eThekweni and who utilize the services of the administration unit.

The target population was made up of 344 respondents comprised of Mayor (n=1); Executive Committee (Exco) (n=10); Councillors (n=206); City Manager (n=1); deputy city managers (n=6); Heads of departments (n=40) and Deputy Heads of Departments (n=80).

Through simple randomized sampling, a total of 186 survey respondents from the parent or source population took part in the survey.

The survey focused on eliciting feedback from respondents about the factors that respondents believed to be influential in determining their selection, uptake, and consequential utilization of an electronic DMS.

The replication of this inquiry within a quantitative survey was intended to assess the extent to which findings from previous phases of the study could be generalizable to

wider population groups.

### 5.1. Data Analysis and Interpretation:

The sample of management respondents who took part in the online survey had the highest representation of 30-39-year-old (n=43; 23.19%) followed by those aged between 50-59 years old (n=36; 19.35%).

Notably, the cohort included three respondents who are under the age of 19 years old, and a significant proportion were aged between 59 and 65 years old (n=31, 16.67%).

Respondents were asked to provide information about their highest educational level attained, and from this process, more than half of the respondents (n=96; 52%) indicated that they had reached or attained at least a secondary school level of education.

Those with at least a tertiary education qualification represented 32% (n=59) of the respondent.

Most of the respondents had been employed within their current positions for at least three years and, as such, were expected to have sound awareness of their role expectations and most importantly what the key document management system requirements were.

The findings from the current study suggest that respondents were adequately experienced in their respective positions and therefore could offer meaningful insight into the barriers and motivating factors for their decisions to use (or not use) electronic document management systems.

Data was collected from respondents about their self-assessed competence in information technology (IT). This variable was identified as a factor of interest as predecessor research (Ammar and Ahmed,

2016) has shown that perceived competence in IT can have an influence on motivation to uptake a new technology.

Over half (n=94; 51%) of the respondents identified themselves as having "basic-user" competencies in IT. 34% (n=64) and 15% (n=28) of the respondents indicated intermediate and advanced user status, respectively.

The current study's developed conceptual framework is a combination of the modified Technology Acceptance Model (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris & Davis, 2003), and the Total Quality Management Theory (TQM) (Silva et al., 2014). These frameworks directed the researcher to a number of variables of interest, including attitude towards use, perceived cost, perceived ease of use, perceived usefulness, satisfaction and enjoyment, subjective norms, behavioral control, perceived security, perceived risk, perceived compatibilities, individual mobility, and personal innovativeness.

To collect feedback on these variables, respondents were asked to provide their opinions, ranging from strongly disagree to strongly agree, on a number of statements related to the above-specified themes. The responses offered by the survey participants for each investigated theme are presented below.

For the theme of "attitude towards use," 147 (79%) of the respondents either strongly disagreed, disagreed, or had neutral opinions regarding the influence of attitude towards use and its impact on whether it influenced their choice to use a specific Document Management System (DMS). The complete overview of the respondent responses for this theme is presented in the table below.



**Table 1.** Attitude towards use

Question (Theme: Attitude Towards Use)	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
My pre-existing attitudes towards any document management system plays an important role in deciding whether I use it.	20	102	25	24	15
The attitudes of colleagues towards any document management system are likely to influence me in similar ways and will drive my decision to accept this technology	33	73	40	29	11
I accept that my attitude towards any document management system does not have any bearing on whether or not I decide to use it.	10	8	47	86	35
Using the latest document management system will earn me support and favour from my peers and my management.	29	59	55	23	20
My attitude toward accepting a new document management system may affect my performance and that of the rest of the department in which I work.	10	30	40	60	46

One close assessment, respondents feedback on the five domains that are related to attitudes towards use, broadly indicated that individuals felt that their attitude had limited influence on the decision about whether to use the newly introduced document management system. In summation, individual attitude towards a specified document management system was seen as having minimal influence on the ultimate decision on whether or not to use that specific alternative. Perceived costs will feature next.

## 5.2. Perceived cost

The rationale here was to attempt to measure the impact of the perceived cost on participants' behaviors with regard to using and adopting new innovation and technology. TAM is extensively accepted as a guide to understanding user's acceptance behavior. Perceived usefulness and Perceived ease of use are the core determinants of individuals' intention to accept or reject new technology. While TAM is used as the baseline model, perceived cost is viewed as an additional independent variable (Rind, Hyder, Saand, Alzabi, Nawazi & Ujan, 2017).

The table that follows is indicative of the respondent's behaviors with regards to acceptance or rejection of new innovation or technology.

**Table 2.** Perceived Cost

Question (Theme: Perceived Cost)	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
My perception about the fairness of the cost of the proposed document management system is an important consideration in whether or not I decide to accept and adopt that system.	48	75	48	10	5
The perceived cost of any document management system has no influence on my decision to accept and/or adopt this system.	7	4	12	98	65
Cost of a newly introduced document management system represents one of the most important determining factors that influences acceptance of that system.	59	65	40	15	7
The cost of any new system determines its quality.	24	66	53	10	33

With regard to the fairness of the cost impacting their decision to accept or adopt the innovation, participants 75 (n=40%) disagreed, with a further 48 (n=26%) strongly disagreeing with the statement with regard to their acceptance or rejection of the innovation. Participants 48 (n=26%) remained non-committal. In summation, the

majority of respondents 123 (n=66%) held the view that the fairness of the cost is not a consideration when adopting new innovation. The next determinant to be discussed will be Perceived Ease of Use.

### 5.3. Perceived ease of use

The Technology Acceptance Model (Davis et al. 1989) is a measure of the relationships of Perceived Ease of Use (PEOU), Perceived Usefulness (PU) and Attitudes aligned to Behavioural Intention (BI).

PEOU is one of the determinants that participants must embrace for the adoption and acceptance of new technology. Understanding the participants' perceptions may help to increase the sustained use and adoption of new innovation. The following table is a numerical summary of their Perceptions regarding Perceived Ease of Use.

**Table 3.** Perceived ease of use

Question (Perceived Ease of Use)	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
I will not use a system that I view as difficult to use regardless of how much it is likely to improve job performance.	37	80	32	23	14
I am not deterred from using a DMS by its apparent difficulty in use.	16	23	40	72	35
I accept that all new systems will be difficult to use.	17	30	38	65	36
I believe that perceived-ease-of-use is one of the key most important determining factors which influence my decision to use any DMS.	14	13	28	82	49
Difficulty in using a DMS is often a result of computer literacy more than anything.	29	43	71	33	10

Five position statements were included to test the Participants perceptions with regard to Perceived Ease of Use. With regard to the first position statement about not using a difficult system irrespective of job performance improvement, 80 (n=43%) disagreed with the statement. Simply put,

these participants were of the opinion that the improvement in job performance or ease of use far outweighs that of a difficult system or invention. A further 37 (n=20%) held the view that they too will also accept the system irrespective of the difficulty factor by strongly disagreeing with the

position statement. The next determinant to be discussed is Perceived Usefulness.

**5.4. Perceived usefulness**

Initially informed by the technology acceptance model (TAM), perceptions

related to the usefulness of any new innovation were seen as having some relevance on whether or not individuals take up the innovation. The table below offers a numeric summation of the responses in relation to the theme of perceived usefulness.

**Table 4.** Summation of perceived usefulness

<b>Question (Theme: Perceived usefulness)</b>	<b>Strongly disagree (1)</b>	<b>Disagree (2)</b>	<b>Neutral (3)</b>	<b>Agree (4)</b>	<b>Strongly agree (5)</b>
The fact that a DMS does what it promises to achieve is the most important factor to consider when deciding whether to accept and adopt new technology.	13	31	21	65	56
Usefulness of a DMS means that it will make the job less difficult to do.	13	23	35	62	53
Usefulness of a system strongly influences how employees perceive it	17	26	30	60	53
Usefulness can only be measured by whether the system makes important performance improvements for clients of the service.	10	9	11	105	51
Thereal usefulness of a system can only be determined after it has been fully implemented.	11	7	16	112	40

## 5.5. Satisfaction and enjoyment

Apart from an assessment of the appropriateness of a system to the task at hand, the researcher carried out a specific

evaluation of the role that satisfaction and enjoyment of the system had on decisions on whether to use it. A detailed analysis of areas included in this theme is provided in the table below.

**Table 5.** Satisfaction and enjoyment

Question (Theme: Satisfaction and Enjoyment)	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
My satisfaction in using a DMS will influence my support of its continued use.	21	30	42	54	39
Satisfaction and enjoyment of using a DMS have limited or insignificant influence in determining whether or not the system will be consistently utilised.	20	41	30	60	35
User satisfaction is primarily a result of how well the DMS performs identified job-tasks.	14	20	29	73	50
Large workstations will have limited influence in determining my satisfaction and enjoyment	16	40	50	48	32
The ergonomic design will play a huge role in my continued utilisation of the DMS	12	30	40	70	34

According to the feedback received, 46% (n=86) of the participants in the study perceived satisfaction in using a DMS as a highly influential factor. The respondents also believed that user satisfaction with the system was related to higher system performance, which was reflected in survey findings. Specifically, 152 (81%) of the

participants believed that the more satisfactory and enjoyable their experience was in using a DMS, the more likely they were to perform well. The following table offers an item-by-item summary of the responses obtained regarding subjective norms.

**Table 6.** Responses on subjective norms

<b>Question (Theme: Subjective Norms)</b>	<b>Strongly disagree(1)</b>	<b>Disagree(2)</b>	<b>Neutral(3)</b>	<b>Agree(4)</b>	<b>Strongly agree(5)</b>
My peers' opinions about the newly introduced DMS influence my own motivation towards using it.	30	41	52	43	20
Industry reputation as it relates to a DMS influences my willingness to accept and adopt it.	30	58	36	29	33
My decision(s) about whether to utilise a newly introduced DMS are entirely based on my own self-assessment of benefits with little influence from others.	14	21	30	64	42
The reputation of the DMS held by senior colleagues is an important influence in my own beliefs about the system.	20	39	55	41	42
Locally developed DMS can deliver an equally efficient service than those developed in more developed countries in the northern hemisphere.	32	42	42	42	42

In summary, respondents believed that the opinions of their peers, both at the same level and those who were superior, had a significant impact on their motivation to adopt a new DMS.

Behavioural control, as introduced by Azjen (1988) in his theory of planned behavior, is explained in the table below.

**Table 7.** Responses on behavioural control

Question (Theme: Behavioural Control)	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
It is important for me to be able to contribute to the development of a DMS as an intended user.	16	33	30	61	46
Being involved in the development and regular evaluation of a DMS provides important motivation to me to accept and adopt it.	20	35	23	50	58
Development of a DMS is for IT experts and there is no need for my involvement as a potential user.	16	30	54	50	36
Being asked to adopt a DMS that was decided on by my management without my involvement negatively influences my motivation to use the system.	14	25	60	59	28
The most important contributors for determining the design of an intended DMS must be the potential users rather than the IT developers.	28	13	43	64	38

In the context of the study, the construct of Perceived Security was investigated using the TAM framework. It was found that a significant number of respondents (74%, n = 137) believed that they should play a

contributory role in the development of the particular DMS as intended users, emphasizing the importance of Perceived Security in the adoption and usage of new technology.

**Table 8.** Responses on perceived security

<b>Question (Theme: Perceived Security)</b>	<b>Strongly disagree (1)</b>	<b>Disagree (2)</b>	<b>Neutral (3)</b>	<b>Agree (4)</b>	<b>Strongly agree (5)</b>
The assessed security of a DMS is of paramount and critical importance in deciding whether to accept and/or adopt it.	17	25	23	69	52
As an end-user, the security of a DMS is not my concern but rather, that of senior management who decided on its procurement.	30	60	70	14	12
System security is primarily related to system-user behaviour's and can be individually determined by different users.	16	40	53	41	36
Security concerns of a system should be balanced against potential usefulness of the system in achieving performance requirements.	10	22	36	63	66
Systems with limited security but high usefulness can be adopted with precautionary measures e.g. using an Electronic –DMS (EDMS) with a paper-based alternative to protect against potential security shortcomings of the newly introduced EDMS	8	14	57	56	51



Categorically, 77% of the participants (n=144) stated that security is of critical importance and agreed with the statement. Perceived risk is an important construct in the Technology Acceptance Model as it

relates to the potential negative consequences of adopting a new technology. The table below summarizes the responses from participants regarding their perceived risks associated with the new DMS.

**Table 9.** Assessing perceived risk

Question (Theme: Perceived Risk)	Strongly disagree(1)	Disagree(2)	Neutral(3)	Agree(4)	Strongly agree(5)
New technology always poses more risks than any comparable existing systems.	32	41	43	43	27
Perceived risk is the single most important reason for not utilising a newly suggested DMS.	22	33	35	60	36
My assessment of a system's risk is influenced by the views of peers	43	60	39	30	14
Perceived risk of a system can be locally managed by training potential users to be more security literate.	10	19	31	72	54
Assessment of a system's risk should be undertaken by strategic managers who procure new DMS and is not a concern for potential users.	17	22	58	51	38

Of the 186 respondents, 131 (70%) agreed with the statement that perceived risk is the most significant factor for not using a new DMS. Perceived compatibility is a measure of how relevant individuals perceive the

technology to be to their job. The table below shows the responses of the respondents regarding four domains related to perceived compatibility.

**Table 10.** Perceived compatibility

<b>Question (Theme: Perceived Compatibility)</b>	<b>Strongly disagree(1)</b>	<b>Disagree(2)</b>	<b>Neutral(3)</b>	<b>Agree(4)</b>	<b>Strongly agree(5)</b>
Compatibility between DMS capabilities and the requirements of the service are a critical deciding factor in my decision to take / accept and/or adopt a new technology.	9	24	28	79	46
Determinations about a DMS are outside the locus of control of end-point users and do not play a role on an individual's motivation to use a newly introduced system.	8	22	60	57	39
End-point users of a DMS do not possess the in-depth expertise about a system to make accurate judgments about its compatibility with the job requirements.	13	30	32	66	45
Compatibility of a DMS with the job requirements can be assessed after an agreed trial period (e.g. of 6 months) and I am willing to fully utilise the system in its trial period even if it means duplicating systems with the pre-existing alternative(s).	19	33	43	49	42

A significant number of respondents, 153 (n=82%), strongly agreed, agreed or were neutral to the posited statement that there must be alignment between the DMS capabilities and the relevance of their job.

Individual mobility:

TAM has undergone numerous modifications and extensions in order to

include additional variables to facilitate its ever-increasing predictive power. Technologies have increased mobility of human interactions both in social spheres and professional domains. The table below presents the four domains in relation to individual mobility, incorporating the participants' responses.

**Table 11.** Individual mobility

Question (Theme: Individual Mobility)	Strongly disagree(1)	Disagree(2)	Neutral(3)	Agree(4)	Strongly agree(5)
The ability for me to personally customise my user functionalities plays an important role in influencing my decision(s) to accept and/or adopt a DMS.	29	54	39	47	17
Systems that allow individual customisation to provide more efficient performance with regard to core job expectations.	20	40	29	54	43
Being able to customise my functionalities is not a necessary pre-requisite to me using a system.	17	35	40	55	39
Flexibility of a system is one of the most important aspects that influence my motivation to accept and/or use it.	12	14	10	77	73

With regard to personal customisation of user functionalities in relation to acceptance or adoption of the DMS, 67% (n= 122) of the respondents were neutral, disagreed or strongly disagreed, while 55% (n=103) affirmed their stance with the statement.

Personal innovativeness is potentially crucial and a significant driver in the adoption and

acceptance of new technological innovations. The following table comprises the participants' responses with regard to personal innovativeness.

There appears to be a stalemate from respondents with regard newly introduced systems being at the “cutting edge” of technology.

**6. Overview of key findings**

The responses from the online survey were in agreement with the general themes that emerged from the individual interviews and the focus group discussions. Importantly, themes were statistically substantiated by

virtue of the fact that the survey had statistically significant representation with 186 respondents. In summation, findings identified offered a basis for the development of theory on what factors have noteworthy influence in document management system choice.

**Table 12.** Responses to personal innovativeness (Source: Author’s own, 2019)

<b>Question (Theme: Personal Innovativeness)</b>	<b>Stronglydisagree(1)</b>	<b>Disagree(2)</b>	<b>Neutral(3)</b>	<b>Agree(4)</b>	<b>Stronglyagree(5)</b>
I believe that any newlyintroduced system should be atthe “cutting edge” of innovationand should surpass systemsutilised by similar serviceproviders.	23	40	58	33	32
Innovativenessis notasimportant to me as the system’sability to perform to identifiedwork and taskexpectations.	18	27	40	52	49
The future of documentmanagemen t systems will be IT-based, and it is important that allinnovative approaches make useofthat aboveall.	16	30	35	60	45
The security risks associatedwith using innovative IT DMSoptions are a minorconsideration and should not bethe basis for decision whether ornot a new system should beintroduced.	31	45	50	34	26

### 7. Recommendations

The recommendations borne out of the findings can contribute substantially towards a more in-depth and incremental understanding towards the successful implementation and adoption of a customised, purpose-built document management system for the public sectors. The eThekweni Municipality has no doubt made and is making huge strides in trying to provide basic services to the citizenry, but the opportunity to embrace technologies increasingly in their strategic endeavors will go a long way in better servicing the community. The time is now.

### 8. Conclusions

The current study adopted and embraced the exploratory sequential mixed method design as this was best suited to answering the key

objectives. Data analysis, presentation, and interpretation was then expounded, and this ultimately culminated in the proposed framework being developed. The model is so designed that further testing will facilitate a better understanding of the technology acceptance behaviors and also contributes to the understanding of the dynamic nature of the technology acceptance process. The recent surge in technology in creating competitive advantages are at the vanguard of opportunity, but as we note almost daily, it is a formidable challenge for management and organizations. The degree of technocratization and enabling a facilitating environment is a huge challenge for public sectors. However, with a concerted effort, strategic orientation, and armed with a better understanding of the factors that contribute to successful implementation and adoption of technology, the level of success is raised.

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## **INDEX SCALE OF TOTAL QUALITY MANAGEMENT IMPLEMENTATION ON THE PERFORMANCE OF MSMEs PRODUCERS OF GRC**

***Abstract:** MSME Manufacturing sector is always interesting to research, for this reason, this research will be carried out in MSMEs in the GRC manufacturing sector in the East Jakarta and West Bekasi areas. This study aims to develop a study on the application of the Total Quality Management (TQM) method that has been implemented on SMEs, precisely to find out what percentage of TQM implementation that has been implemented in product quality control and improvement as well as to propose an alternative quality management system that is better for using TQM approach. This study uses a qualitative descriptive approach that combines direct observation in the field with literature studies from previous studies. As a basis for discussion, the authors use the basic concepts of TQM that have been developed by experts, which the authors modify for the purposes of this study. The results showed that the application of TQM principles to MSMEs had only reached about 60% of the ideal target which should have been 100%. There needs to be serious efforts and support so that MSMEs are able to fully TQM in order to improve the performance of MSMEs as a whole.*

***Keywords:** MSMEs, TQM, Improve, Performance*

### **1. Introduction**

Deputy for Business Restructuring of the Ministry of Cooperatives and Micro, Small and Medium Enterprises (MSMEs)), Eddy Satriya at the Scale Up With Whatsapp event, on Tuesday, 7/21/2020 stated that currently there are around 64.19 million MSMEs or 99.9% of the total business units in Indonesia with a contribution of 97% (employment), 60% (national GDP), 58% (national investment), 14% (national exports) (Arizal et al., 2021). This shows that small and medium enterprises are the foundation of the Indonesian economy,

which absorbs a lot of labor, but their performance needs to be continuously developed (Fadilurrahman et al., 2021).

SMEs in the manufacturing sector, especially the business of making Glass Reinforced Concrete (GRC) or also known as Glass Fiber Reinforced Concrete (GFRC) is one of MSMEs businesses that is interesting to study because its products are widely used in construction projects today (Habibah et al., 2021). For this reason, this research will be carried out in SMEs in the GRC manufacturing sector in the East Jakarta and West Bekasi areas where this location is one of the centers for GRC

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manufacturing in Indonesia, especially DKI Jakarta (Handayani et al., 2022).

This study aims to develop a study on the application of the Total Quality Management (TQM) method that has been implemented on MSMEs, precisely to find out what percentage of TQM implementation that has been implemented in product quality control and improvement as well as to propose an alternative quality management system that is better for using TQM approach (Hidayat et al., 2021).

Descriptive qualitative methods will be the approach in this study where the discussion is focused on determining alternatives to improve quality management. Leaders and employees of 4 MSMEs in the GRC manufacturing sector will be the main informants of the research in addition to direct observations on processes in the field, document studies and discussions with experts (Irpan et al., 2021).

There have been many studies on the application of TQM to MSMEs, but no one has explicitly stated what percentage of TQM applications are to MSMEs, only almost all studies conclude that the application of TQM has a positive effect on company performance. For this reason, it is necessary to further deepen the extent to which the application of TQM has a positive effect on company performance and what recommendations should be given to MSMEs when they implement TQM in their companies.

The paper is to be written in two-column format. Paper size should be 19cm width and 26cm height. Text should be right and left justified, using single spacing (Times New Roman 10 pt) and 3pt spacing after each paragraph. The width of top margin is 2.85cm, left 2.5cm, right is 3cm, and bottom margin is to be 3cm. The width of each column is to be 6.4cm, and the gap between columns should be 0.7cm.

## **2. Literature review**

### **2.1. Micro, Small and Medium Enterprises (MSMEs)**

In general, the definition of MSMEs is a trading business managed by individuals or business entities and in accordance with the criteria for small or micro businesses (Iyansyah et al., 2021). So, in accordance with the definition of MSMEs, the criteria for MSMEs are distinguished individually, which include micro, small and medium enterprises. In addition to this classification, the government hopes that MSMEs can play a role in building the national economy, including the development of regional potential-based and market-oriented businesses (Kusuma et al., 2016; Joko et al., 2022). So, so that you understand more about the meaning of MSMEs, just take a look at the following reviews that have been reported from various sources (Mahfuzah et al., 2021; Kurniawan et al., 2021). Government Regulation No. 7 of 2021 concerning the Ease, Protection, and Empowerment of Cooperatives and Micro, Small and Medium Enterprises has been issued by the government along with 48 other implementing regulations from Law No. 11 of 2020 concerning Job Creation (UU Cipta Kerja) on 16 February 2021 (Norrahmi et al., 2021). The government regulations changed several provisions that had previously been regulated in Law no. 20 of 2008 concerning Micro, Small and Medium Enterprises (UU UMKM) (Norrahmiati et al., 2022). One of them is the rules related to the criteria for SMEs themselves. MSMEs are grouped based on the criteria for working capital or annual sales results (Putera et al., 2022). The criteria for working capital are used for the establishment or registration of MSME activities established after the government regulation comes into effect (Ramadhani et al., 2021). So now the stipulation is that Micro Business has a

business capital of up to a maximum of Rp. 1,000,000,000.00 (one billion rupiah) excluding land and building for business premises, Small Business has a business capital of more than Rp. 1,000,000,000.00 (one billion rupiah) up to a maximum of Rp. 5,000,000,000.00 (five billion rupiah) excluding land and buildings for business premises and Medium Enterprises have a business capital of more than Rp.5,000,000,000.00 (five billion rupiah) up to a maximum of Rp.10,000,000,000.00 (ten billion rupiah) excluding land and buildings for business premises.

## 2.2. The Basic Concept of TQM

Total Quality Management (TQM) is basically a quality management system that focuses on the customer aspect (customer focused), by involving all employees at various levels within the company to make continuous improvements (Rizal et al., 2021). Total Quality Management is essentially the continuous improvement of people, processes, products (including services), and the environment. With total quality anything and everything that affects quality is a target for continuous improvement. When the concept of total quality is applied effectively, the end result can include organizational excellence, superior value, and global competitiveness (Goetsch & Davis, 2014; Rahmadani et al., 2021). Improve customer satisfaction and other stakeholders through effective goal dissemination, cost reduction, process improvement, people involvement, and supply chain development has proven essential for organizations to exist in the 21st century, TQM is a way of managing the future because if you ignore products and quality of service can have disastrous consequences, damage to a company's reputation has consequences deeper and faster than ever before as information, opinions and ultimately consumer choices,

are affected by the scale and nature of modern communication technology and of course, TQM is much broader in its application than ensure the quality of a product or service, it is a way of managing an organization to improve every aspect of performance, either internally and externally (Oakland, 2014).

TQM implementation areas, such as supplier relations, benchmarking, commitment top management, and customer focus are critical factors in quality management (Rizani et al., 2022). Some researchers found a relationship that top management commitment, customer focus, satisfaction customers, human resource management, training, and education is the most important TQM practice for manufacturing and service companies (Saputra et al., 2022). Process management and commitment top management represents the elements of TQM with influence the biggest on organizational performance in the industry (Aziz, 2019).

There are many basic concepts of TQM that have been put forward by experts which we can synthesize that TQM is basically customer-focused quality management, carried out by all elements of the organization and carried out continuously and efficiently (Shaddiq et al., 2021).

## 2.3. TQM Implementation on MSMEs

Until now, large companies still dominate the discussion about TQM and the continuous improvement process, this is in contrast to small and medium enterprises which have not paid much attention to the implementation of TQM even though MSMEs are one of the pillars of a country's economy (Surti et al., 2022). In fact, large companies that have used TQM establish business relationships with MSMEs as distributors of raw materials or other services, this forces MSMEs to meet a number of quality standards in order to

support the successful implementation of TQM in large companies (Wagiono et al., 2022).

The application of TQM can increase the competitiveness of SMEs through long-term commitment, continuous improvement, education & training and unity of purpose. All of this is the responsibility of top management because the success of TQM in MSMEs is strongly influenced by the awareness of top management which will have a direct impact on the overall performance of the company (Sari & Firdaus, 2018).

TQM is significant on managerial performance and has no effect on profits, but in other studies it is stated that the application of TQM in the company will increase company profits, is a human resource issue (Ch & Aji, 2020).

The level of implementation of traditional MSME quality management is still low because TQM has only been carried out in the production aspect with the trend of production volume and the number of customers increasing, increasing production volume by increasing human resources and company management in order to obtain optimal revenue (Bremanti, Hubeis & Palupi, 2018).

Of the many studies on the application of TQM in MSMEs, the three research results above can represent all of them, which in essence is the application of TQM in MSMEs has given good results even though

the level of application is different so the results are different. Further studies are needed that can provide recommendations on how TQM should be carried out in MSMEs). For this reason, the research will be deepened again how the level of application of TQM in MSMEs so that later it can provide recommendations for the application of TQM to similar MSMEs and in situations and conditions similar to the object of this research (Wijaya et al., 2021). Literature review is the survey of scholarly sources on a specific topic. It analyzes and synthesizes and critically evaluate to give a clear picture of the state knowledge on the subject.

### 3. Method

This study uses a qualitative descriptive approach that combines direct observation in the field with literature studies from previous studies within a maximum period of 5 years on a national and international scale in order to obtain a connecting line between this research and previous research. The literature study used is research that has been published through digital searches with online-based academic index media. As a basis for discussion, the authors use the basic concepts of TQM that have been developed by experts, which the authors modify for the purposes of this study.

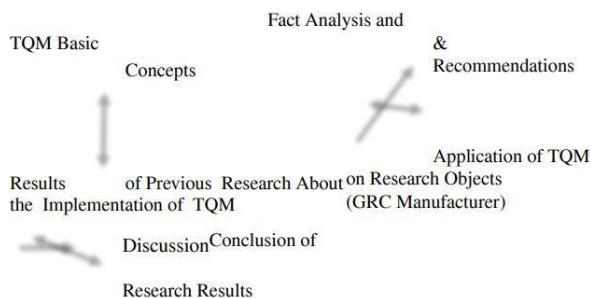
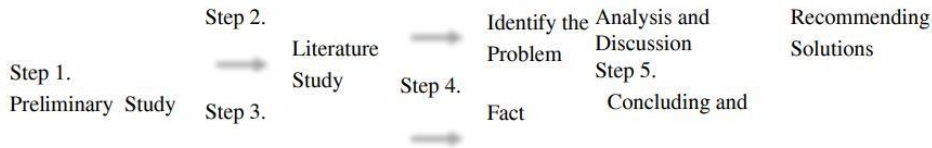


Figure 1. Research Thinking Framework

Based on the research framework in Figure 1 above, the steps involved in conducting this

research are as follows:



**Figure 2.** Research Thinking Framework

**Step 1. Preliminary Study:** to find out the extent of the implementation of TQM in MSMEs in 4 MSMEs that produce GRC to obtain the information needed for the next stages of research, carried out by direct observation of all processes regarding the products they produce, namely GRC starting from implementation tender, supplier selection, production process, distribution to consumers and installation of GRC in places that have been determined by consumers.

**Step 2. Literature Study:** This is done in order to better understand the technical problems faced, in this case are scientific journals related to the application of TQM as well as TQM theory books and other fields of science that are relevant to the problems at hand so that they can support problem solving.

**Step 3. Problem Identification:** carried out by observing directly in the field and also interviews with related MSME actors to find out how far the effectiveness of the application of TQM on MSMEs in improving product quality that aims to meet customer satisfaction, where there are several main problems that must be corrected from each process. All processes that have been observed will be compared with previous literature studies.

**Step 4. Fact Analysis and Discussion:** after direct observations and interviews with MSME actors are carried out, the next step is to analyze the information and facts obtained. The analysis carried out is by using the Total Quality Management method approach and then a discussion of the results

of the analysis is carried out.

**Step 5. Concluding and Recommending Solutions:** after the research stages have been carried out as a whole, conclusions will be drawn on all these stages in accordance with the research objectives that have been set and then provide recommendations in the form of proposals as useful contributions.

## 4. Results and discussion

### 4.1. Results

Field observations and interviews were conducted based on the research focus which consisted of 6 key elements of TQM which the authors developed into 19 observations and interview questions as a sub-focus of the research. the results of direct observations and interviews will then be given an assessment. The values obtained are then compared with the theory of TQM principles. In order to facilitate the analysis and understanding, the researchers grouped the results of the analysis into a value scale as shown in the following table:

**Table 1.** TQM Process Ideal Value Scale

Score	Implementation Percentage
1	1% – 20%
2	21% - 40%
3	41% - 60%
4	61% - 80%
5	81% - 100%

Source: Processed data (researcher provisions), 2021

#### 4.2. Discussion

Based on study results, the average score is 3 (rounded score of 3.26), and if based on the scale of the ideal value of the TQM process in table 1, it means that the application of TQM principles in MSMEs has only reached about 60% of the ideal target which should be 100%. From the table of observations, it can be seen in what parts the low value is 2, which means that it has only been applied around 21% - 40%, namely. That is in the context of question Number 13: Are MSMEs ready to release the root cause of the problem or do you just firefight over the symptoms?

Things that weaken these aspects are:

1. Lack of Customer Focus: Quality leadership requires a focus on the customer. This means that the main goal of the organization is to meet or exceed customer expectations through something that provides lasting value to customers, both internal and external customers.
2. Lack of Obsession with Quality: Lack of obsession with quality greatly affects employees regarding the achievement of quality in order to exceed the expectations of internal and external customers.
3. Lack of Understanding of Work Structure: The work process should be further analyzed to determine the appropriate structure arrangement (organization, work order SOP (Standard Operation Procedure), tools used, and others). When the optimum structure has been achieved, the work process must be analyzed, evaluated, and studied continuously in order to improve it.
4. Uncontrolled Freedom: Control in the sense of TQM is human control of work methods and processes.

Leaders must ensure that managers and employees control work processes and methods by standardizing them together. The goal is to reduce variations in output by reducing variations in work processes.

5. Lack of Unity of Purpose: In this case, a leader is responsible for determining and conveying the organization's mission clearly and carefully so that all employees understand, believe, and are responsible for the mission. With the unity of purpose, all employees work related to the system.
6. Likes to find system errors: In order to prevent employees' liking for system errors, it is necessary to change the focus or emphasis on error assessment due to a problem becoming a system assessment in order to find and analyze problems related to the system.
7. Lack of Teamwork: In order for strong teamwork, a principle must be needed, which is based on the belief that working together will be able to give much better results than working individually.
8. Lack of Continuing Education and Training: Continuous education and training in the technological era is very necessary because the most important machine in the work environment is the human mind. Therefore, continuous learning is a fundamental element in TQM.

#### 5. Conclusion

Based on the introduction, problem identification, findings and research analysis described above, the conclusions in this study are as follows:

1. This research produces some information about the process carried out by MSMEs

starting from the tender process, production, distribution to product installation at consumer locations. Information obtained through direct field observations and interviews with GRC production managers obtained complete information about the processes that occur starting from the GRC production project tender process followed by the production scheduling process, raw material purchasing, production process, tidying process, distribution and installation process of GRC products. the place specified by the customer and after-sales service.

2. The results showed several management methods as tools used by MSMEs to control and improve product quality and quality. Based on the data from the research conducted, it was found that MSMEs have not fully applied the TQM method 100% but have only applied about 60%, so there are still some MSME potentials that have not been explored and utilized optimally for the advancement of MSMEs.

3. From the results of the research that the researchers plotted into the analysis table, it was found that the values of the process stages could be improved and improved. These stages can be seen from a technical point of view as well as from a management perspective. The TQM method describes several methods or good ways to improve performance. With the application of this method, it is hoped that better MSME performance will be obtained.

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Suggestions/recommendations that researchers can convey based on the results of this study are:

1. That the TQM method if applied seriously and seriously, will be able to improve the quality and quality of the product. Through overall quality management and the responsibility for product quality is not only borne by the Quality Control department, but all parts of the organization have the same responsibility so that it is hoped that

product quality will be maintained and the overall performance of MSMEs will increase.

2. The theory of TQM principles does not absolutely have to be done directly and carried out in a short time. But it would be nice to implement TQM principles in stages and start from the smallest and simplest things. The implementation of TQM principles must also be adapted to the existing conditions of MSMEs.

3. MSMEs should apply the TQM method in carrying out all their operational activities, because applying the TQM method as a whole is expected to increase work efficiency and is expected to improve the overall performance of MSMEs.

4. For further researchers, it is recommended that they research on different objects and expand the sub-focus of the research so that more comprehensive and in-depth research can be produced.

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## HOW DO TQM PRACTICES AFFECT EMPLOYEE EFFECTIVENESS IN TUNISIAN SMEs?

**Abstract:** Total Quality Management (TQM) is a key strategy used by human resources to maintain a competitive advantage. Indeed, TQM is essentially based on the strategy and culture of the company as well as on the maturity and awareness of the managers. Therefore, TQM has a strong relationship with Employee Effectiveness to ensure the improvement of all company performance. Thus, the purpose of this study is to show the nature of the relationship between TQM and employee effectiveness and to judge whether TQM affects employee effectiveness or not. In this context, we have used the survey method to study the behavior of Tunisian companies. 206 responses were collected and analyzed using the software "SPSS". Then, structural equation modeling was used to validate the work's hypotheses. The obtained results show that TQM has a positive impact on employee effectiveness and that all TQM practices affect positively employee effectiveness.

**Keywords:** Total quality management, Employee effectiveness, SEM; Empirical research.

### 1. Introduction

Total Quality Management (TQM) is a management philosophy that focuses on the continuous improvement of products, services, and processes to meet or exceed customer expectations (Banuro et al., 2017). It encourages employees to take ownership of their work and to participate in continuous improvement efforts. This can lead to increased job satisfaction, motivation, and engagement, which in turn can lead to higher levels of productivity and performance.

TQM also emphasizes the importance of training and development, which can help employees acquire new skills and knowledge and improve their effectiveness on the job. By investing in employee development, organizations can create a culture of

continuous learning and improvement.

Another key aspect of TQM is teamwork and collaboration. By working together to identify and solve problems, employees can build stronger relationships and improve communication and coordination. This can lead to a more efficient and effective workplace, as well as higher levels of job satisfaction and engagement.

In this context, TQM start to be adopted in Tunisia, especially in manufacturing companies, as a means of enhancing efficiency and competitiveness. However, there can be a problem between employee effectiveness and TQM implementation in Tunisia. This is because some employees may resist the changes that come with TQM implementation. They may feel threatened by the changes or may not understand the

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need for them, leading to a lack of commitment to TQM initiatives. Another issue is the lack of effective communication and training on TQM principles and methods, which can make it difficult for employees to understand their role in the implementation process. In addition, there may be cultural barriers that need to be addressed to successfully implement TQM in Tunisia, such as a reluctance to question authority or challenge established ways of doing things.

Companies that seek to enhance their chances of survival have implemented TQM practices, which prioritize quality and continuous improvement as part of their strategic objectives. These practices involve utilizing management concepts and tools to engage both managers and employees in the pursuit of ongoing performance enhancement. Success factors and TQM practices have been identified by numerous authors (Alawag et al., 2023; Hchaichi, 2023). Lehyani et al. (2018) have identified the six most crucial TQM practices in scientific literature which are: leadership, customer focus, Human Resources Management (HRM), process management, information analysis, and continuous improvement.

In this framework, Lehyani et al. (2022) have studied the application of TQM practices in Tunisia. The results indicate that over 90% of SMEs in the "Petrochemical," "Manufacturing," "Agri-food," and "Textile" sectors apply TQM, while only SMEs in the "Construction" sector apply TQM at a rate between 80 and 90%. Furthermore, between 70 and 80% of SMEs in the "Electric & Electronic," "Telecommunication," "Automotive," and "Service" sectors responded positively to the application of TQM. SMEs in the "Transportation & Distribution" and "Materials" fields responded equally with 66.7%, while those in the "Training" and "Healthcare" sectors had an equal rate of 50%. Furthermore, in

the first category, all TQMP practices, except "Information analysis", are frequently applied in more than 70% of cases in the "Materials" and "Agri-food" sectors. In the "Training" field, only "Leadership" has a 66.67% application rate. Similarly, in the "Textile" sector, only "Customer focus" and "HRM" have a 66.67% application rate. Among the industrial domains, the "Telecommunication" sector had the highest rate of TQMP application, with three practices applied commonly in more than 70% of cases, and two practices, "Customer focus" and "Process management," applied in 62.5% of cases.

Based on related works such as (Israfilov et al., 2020; Rombaut & Guerry, 2020; Enenifa & Akintokunbo, 2020) The employee effectiveness practices are: employee expertise, continuous employee learning, employee involvement & commitment, integration/ interaction with employees, employee performance, use of technological resources.

The impact of TQM on employee effectiveness has been widely studied in many countries. In this vein, Khan et al., (2019) have found that TQM practices positively influenced employee job satisfaction, which in turn positively influenced employee creativity and proactive behaviors. In addition, Ali et al., 2020 have claimed that TQM practices positively influenced employee job satisfaction, organizational commitment, and employee performance. Moreover, Ababneh (2021) has affirmed that TQM practices positively influenced employee job satisfaction and employee engagement, which in turn positively influenced employee performance. Also, Galeazzo et al., (2021) have argued that TQM practices positively influenced employee job satisfaction, employee commitment, and employee performance, and that employee involvement in TQM activities was a significant mediator in these relationships. Regarding healthcare field,

Dagasan et al. (2023) pointed out that TQM principles produce different performance outcomes like the job performance of employees. Furthermore, Lehyani et al. (2023) studied the impact of knowledge management and TQM impact on employee effectiveness in Emerging Industries in the case of Tunisian Small and Medium enterprises (SMEs) and they confirmed that there is a positive and significant relation between TQM practices application and employee effectiveness determinants.

In summary, it is remarkable that TQM and staff effectiveness have mutual relationships based on the intersection of their practices. Hence, the aim of this research is to answer the following question: is there an impact between TQM and employee effectiveness in Tunisian companies?

In this circumstance, the aim of this study is to investigate the feasibility of implementing TQM practices in small and medium-sized Tunisian enterprises, and to determine their impact on the effectiveness of employees. To achieve this objective, the survey method was employed and the data gathered were analyzed using SPSS software. Then, the Principal Component Analysis (PCA) method was used and the hypotheses of the model were validated by applying the SEM method. Thus, the significance of this research lies in its examination of the relevance of TQM practices in the context of Tunisian SMEs and their potential effects on employee effectiveness.

## 2. Research methodology

### 2.1. Data collection method and Measurement instrument

This work is based on a survey designed to study TQM's impact on staff effectiveness in Tunisian SMEs. The survey was divided into two sections. Section 1 contains questions related to the descriptive details of

enterprises. Section 2 consists of open-ended questions that respondents can answer using a Likert scale ranging from 1 to 5, from very low impact to very high impact.

The survey was distributed in two ways: direct contact with 125 companies and sending emails to approximately 3000 companies from several fields. With this strategy, the percentage of responses obtained by direct contact is around 80%, and by sending emails is about 3.5%. Hence, the total number of obtained responses was 206. However, questionnaire validation was carried out by academic and non-academic experts who checked the nature of the questions, their understanding, consistency, etc. The instrument had a Cronbach's Alpha of 0.986, which is considered reliable (Azizi et al., 2016). Indeed, survey questions were coded to be processed by "SPSS" software version 24.

### 2.2. Reliability

For Gandhare et al. (2018), reliability analysis is a correlation-based procedure estimated using the Chronbach Alpha " $\alpha$ " reliability coefficient. This coefficient varies between 0.00 and 1.00 and its generally acceptable minimum value is 0.7. Similarly, Katiyar et al. (2018) assert that the acceptable reliability of the indicators must exceed the recommended threshold of 0.70. However, Zaied et al. (2012) states that if the test shows that the  $\alpha$  value is equal to or greater than 0.80, this means that the collected data are consistent.

### 2.3. Validity

Convergent Validity is assessed using Item Loading, Composite Reliability (CR), and Average Variance Extracted (AVE). To accept convergent validity, the values of all these measurements must be greater than 0.5. In contrast, Lu et al. (2019) argue that the CR and AVE are adopted to measure

convergent validity and that the CR must be greater than 0.7 and the AVE must be greater than 0.5. However, the discriminant validity specifies to what extent a given construction is different from all other constructions of the same measurement model. It can be examined by comparing values with the diagonal square root of the AVE with correlations between reflective constructions (Katiyar et al., 2018).

## **2.4. Exploratory Factor Analysis**

Exploratory Factor Analysis (EFA) is performed using the maximum probability of rotation "Varimax" to verify that validity and reliability criteria of variables are satisfactory and correlated (Singh et al., 2018). According to Qasrawi et al. (2017), for the AFE to be carried out, the data must satisfy the following conditions: 1) Kaiser-Meyer-Olkin (KMO) measurement must be greater than 0.5. 2) the eigenvalue of each factor must be at least 1. 3) a minimum load factor of 0.40 for the preservation of each element must be achieved. For our empirical study, we chose the PCA method to verify the validity of the factor adjustment test since it provides the correlation between the factors with the unique variance of the elements.

## **2.5. Confirmatory Factor Analysis**

For the model to be accepted and sampling to be adequate, KMO must be greater than 0.6 (Singh et al., 2018). However, Bartlett's sphericity test is significant if  $p=0.00$  (i.e. the null hypothesis of the correlation matrix being an identity matrix must be rejected). In this case, the sample can reduce the factors and is suitable for factor analysis (Qasrawi et al., 2017).

After the exploratory analyses are performed, Confirmatory Factor Analyses (CFA) are used to define and represent one

or more hypothetical models of factor structure. Each suggests a set of unobserved variables to account for covariance in a set of observed variables (Zhang & Min, 2022). Depending on Dissanayake & Cross (2018), Structural Equation Modeling (SEM) follows certain hypotheses of statistical distribution, since it is assumed that the observations are independent of each other and that the exogenous variables have a multivariate normal distribution. Indeed, several adjustment indices are considered to judge the adequacy of the model. In our case, our model was assessed by examining the goodness-of-fit statistics indices: ratio of  $\chi^2$  to degree of freedom, Root Mean Square Error of Approximation (RMSEA), Parsimony Goodness of Fit Index (PGFI), Akaike's Information Criterion (CAIC), Parsimony Normed Fit Index (PNFI), and Comparative Fit Index (CFI).

## **2.6. Structural Equation Modeling**

In order to test the causal links between KM elements, TQM factors, personnel effectiveness practices and SCP dimensions, we applied the SEM. This method is a methodological approach that tests complex causality models incorporating latent variables. The set of causal relationships between latent, dependent and independent variables of our model compose our study hypotheses. The method application will be developed by the software AMOS 24 and the method that will be used for the data estimation is the Maximum Likelihood (ML) method.

# **3. Results and discussions**

## **3.1. Sample demographics**

A summary of the participating companies and respondents is presented in Table 1.

**Table 1.** Summary of participated companies and respondents

Relevant Dimension	Profiles in percentages	Relevant Dimension	Profiles in percentages
Localisation	37.4% Sfax	Activity field	18.9% Service
	17% Tunis		5.8% Petro-chemical industry
	7.3% Nabeul		6.8% Electric & Electronic
	4.4% Ariana		2.9% Training
	4.9% Ben arous		1.9% Health
	4.9% Sousse		7.8% Construction
	4.4% Mahdia		5.8% Transport & distribution
	3.4% Bizerte		17% Agri-Food
	3.4% Monastir		5.3% Automotive
	2.9% Gabes		13.6% Manufacturing
	2.4% Medenine		5.8% Textile
	2.4% Zaghouan		4.4% Materials
	1% Beja		3.9% Telecommunication
	1% Jendouba		15.5% less than 9
	0.5% Gafsa		25.7% between 10 and 49
	0.5% Kairouan		26.7% between 50 and 249
	1.5% Manouba		32% More than 250
0.5% Sidi bouzid	24.8% Quality Manager		
0.5% Tataouine	17.5% Human Resources Manager		
Certification	51.5% QMS	Respondent function	16% Logistics Manager
	16.8% EMS		6.8% Production Responsible
	9.9% OHSMS		4.4% Purchasing & Supply Manager
	5% FSMS		6.8% Sales & Marketing Manager
	3% SMS		7.3% Technical Manager
	2% Others		2.9% Financial Officer
	9.9% Not certified		3.4% Administrative Officer
	2% In progress		10.2% General Manager

### 3.2. Exploratory Factor Analysis results

The measurement of KMO and Bartlett sphericity results show that they are well accepted in our analysis, see table 2. Therefore, it can be concluded that the data show a suitability and homogeneity conducive to PCA application.

**Table 2.** KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.894
Bartlett's Test of Sphericity	Approx. Chi-Square	1443.009
	df	66
	Sig.	.000

Based on the results presented in table 3, two factors have been selected, with an eigenvalue greater than 1. These factors provide a cumulative percent variance of 64.78%. The 1st factor provides 51.93% of the total variance and the 2nd factor brings 12.84%. This allowed us to conclude that the mass of information retained by these two factors is quite significant. Then, we calculated the correlations between these factors, the retained measurement variables, the corresponding standardized factor loadings, and t values resulting from testing the items' coefficients in CFA, see table 3.

**3.3. Tests for reliability and validity of the constructs**

Cronbach’s alpha was used to measure the reliability of the multi-item scale to assess internal consistency. Also, it was used to ensure that the scale items are free of measurement errors and that they quantify the corresponding latent variables (Masa'deh et al., 2019). However, structural reliability will not increase significantly if elements are removed from the analysis.

Table 4 exposes descriptive statistics, Cronbach’s alpha values, and variables Pearson correlations in our research model. In this regard, it is noted that the reliability analysis of TQM practices was 0.884 and the reliability analysis of employee efficiency practices was 0.896. According to Wang et al. (2019), if the alpha values of all variables exceed the threshold of 0.70, we can conclude that this is an excellent reliability, which is the case for our work.

**3.4. Test results of the structural model**

The results for the adjustment of the structural model are shown in Table 5. Based on these results, we can conclude that the index values are acceptable and satisfactory and that our structural model shows a good quality of adjustment.

**Table 5.** Results of structural model

Goodness-of fit statistics	Structural model	Recommended values
$\chi^2/df$	2.798	<3
Root mean square error of approximation (RMSEA)	0.094	<0.08
Parsimony goodness-of-fit index (PGFI)	0.612	>0.5
Parsimony normed fit index (PNFI)	0.722	>0.5
Comparative fit index (CFI)	0.933	>0.9
Goodness of Fit Index (GFI)	0.900	>0.8
Adjusted Goodness of Fit Index (AGFI)	0.853	>0.8
Root-mean-square residual (RMR)	0.034	≤0.05

According to Zhang & Min (2022), to support a tested hypothesis, it is necessary to examine the Coefficient Ratio (CR) which should be greater than 1.96. Also, the probability of release of H0 must be less than 0.05 ( $p \leq 0.05$ ). Table 6 presents the path models estimating, direct and indirect effects of TQM practices on employee effectiveness from the structural model. It shows that the model not needs modification to be used for the further analysis and that all the relationships have significant regression weight.

**Table 3.** Rotated factor matrix of the TQM practices and employee effectiveness

	Measure/construct	Factor loadings		Eigenvalue	Percentage variance explained by factor	Percentage total variance explained	t-value
		Component 1	Component 2				
Employee Effectiveness	Employee expertise	-	.793	6.23	51.93	51.93	62.558
	Continuous employee learning	-	.792				58.303
	Employee involvement & commitment	-	.786				61.213



	Integration/ interaction with employees	-	.779				56.017
	Employee performance	-	.775				61.847
	Use of technological resources	-	.678				60.484
TQM practices	Leadership	.795	-	1.54	12.84	64.78	61.133
	Customer focus	.785	-				57.299
	HRM	.782	-				57.111
	Process management	.755	-				57.278
	Information management	.741	-				57.729
	Continuous improvement	.661	-				60.719

**Table 4.** Descriptive statistics, Cronbach’s alpha, and bivariate correlations for the variables in the research model\*

Measure/construct	1	2	3	4	5	6	7	8	9	10	11	12	Mean	S.D	Alpha value
EE1	1.000												3.68	.845	0.896
EE2	.657	1.000											3.51	.865	
EE3	.575	.630	1.000										3.58	.839	
EE4	.545	.601	.636	1.000									3.58	.917	
EE5	.418	.639	.600	.639	1.000								3.57	.828	
EE6	.484	.556	.609	.577	.667	1.000							3.52	.836	
TQM <sub>1</sub>	.377	.378	.428	.351	.399	.360	1.000						3.84	.903	0.884
TQM <sub>2</sub>	.286	.367	.307	.281	.333	.308	.517	1.000					3.73	.934	
TQM <sub>3</sub>	.407	.379	.430	.416	.433	.321	.590	.525	1.000				3.74	.941	
TQM <sub>4</sub>	.394	.462	.411	.404	.419	.363	.471	.520	.637	1.000			3.74	.937	
TQM <sub>5</sub>	.444	.428	.522	.461	.394	.327	.563	.369	.641	.620	1.000		3.77	.938	
TQM <sub>6</sub>	.424	.439	.445	.367	.393	.380	.604	.392	.557	.698	.677	1.000	3.95	.933	

\* N =206. all correlations are significant at the P<0.001

**Table 6.** Results of the structural model

			Estimate	S.E	C.R	P	Direct effects	Indirect effects
TQM	<---	EE	.863	.110	7.868	***	.863	-
EE	<---	TQM1	.856	.079	10.872	***	.856	.739
EE	<---	TQM2	.728	.085	8.597	***	.728	.628
EE	<---	TQM3	.975	.080	12.178	***	.975	.842
EE	<---	TQM4	.996	.079	12.579	***	.996	.860
EE	<---	TQM5	.994	.079	12.524	***	.994	.858
EE	<---	TQM6	1.000	-	-	***	1.000	.863

Note. \* p < 0.01; \*\* p < 0.001

## 4. Discussion and study implications

### 4.1. Managerial implications

The proposed model can serve as a valuable tool and strategic plan for managers, allowing them to understand the connections between TQM practices and staff effectiveness. However, the model is not set in stone and can be customized to suit the specific needs of the organization. By utilizing the results obtained from our study, managers can accurately gauge the impact of TQM practices on staff effectiveness and make informed decisions to enhance employee productivity. Furthermore, establishing positive relationships between staff effectiveness and TQM practices can motivate leaders to prioritize the well-being of their employees by fostering a positive work environment and encouraging their active participation in decision-making processes. Ultimately, the commitment of managers to implementing TQM practices and promoting employee effectiveness can directly influence overall employee performance.

### 4.2. Research limitations

Although our study produced noteworthy results, it is important to acknowledge the limitations that need to be addressed in

future research. One of the limitations is the difficulty in obtaining cooperation from industrial managers, which may have influenced the sample size. Furthermore, the number of companies that participated in the study was limited. Additionally, although we collected data from various industrial sectors, we did not perform a sector-specific analysis as the sample size was not representative of most industries. Addressing these limitations could help provide a more comprehensive understanding of the relationship between TQM practices and staff effectiveness in different industries.

### 4.3. Implications for future research

We have identified several potential research directions based on the findings of our study. First, we suggest the use of alternative data collection methods such as direct access to company data to overcome the challenges of confidentiality and to enable the identification and analysis of barriers to TQM implementation in Tunisian companies. This would also allow for an investigation of the reasons behind the application of some TQM elements and staff effectiveness practices while neglecting others. Additionally, we propose conducting a comparative study by disseminating the survey to companies in other developed and/or developing countries. This could provide valuable insights into how TQM

practices and staff effectiveness differ across countries and industries. Overall, these research directions could contribute to a deeper understanding of how TQM practices can be effectively implemented and the factors that contribute to staff effectiveness.

### 5. Conclusion

In this study, the primary objective was to examine the impact of TQM practices on staff effectiveness in Tunisian companies. The results indicate that TQM practices have a positive effect on staff effectiveness, particularly in the areas of leadership, customer focus, human resources management, process management, information analysis, and continuous improvement. The findings suggest that companies that prioritize effective

management approaches are more likely to attain higher levels of employee effectiveness. This can be achieved through evidence-based decision-making, quality programs, and training, as well as creating a motivating and balanced work environment, among other strategies. Based on the findings, it is recommended that managers in Tunisian companies lead by example by sharing their knowledge and experiences with their employees and by adhering to all quality procedures and guidelines established by the company. It is also important for managers to not only focus on what they are paying their employees, but also on what benefits they can provide to them.

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## DEVELOPMENT OF A FRAMEWORK FOR DEFINING THE CONCEPT OF QUALITY 4.0

**Abstract:** Industry 4.0, better known as the Fourth Industrial Revolution, is a concept that refers to the application of high technologies, such as the Internet of Things (IoT), cybernetics, machine learning, automation of production and the entire business. This concept aims to improve efficiency, productivity, and flexibility and reduce costs. On the other hand, Quality 4.0 is the integration of smart technologies and digitalization into the manufacturing process to improve quality control and increase efficiency. It involves using IoT devices, machine learning, and big data analytics to monitor and optimize production processes in real time, resulting in reduced defects, increased productivity, and improved product traceability. By using these technologies, manufacturers can reduce the risk of defects and downtime, increase productivity, and improve product traceability. Quality 4.0 is an essential aspect of Industry 4.0. It represents the integration of digital technologies into the quality control process. The main objective is to achieve higher quality products, reduce defects, and optimize production processes using real-time data analytics. This approach emphasizes the importance of data-driven decision-making in manufacturing and highlights the benefits of integrating data analysis into quality control processes. Overall, Quality 4.0 focuses on improving the quality of products and processes using modern technology, resulting in increased efficiency, productivity and flexibility.

**Keywords:** Quality 4.0, Industry 4.0, Quality Management; Competencies, Knowledge Management

### 1. Introduction

The world has experienced three industrial revolutions. The first one, which occurred in the late 1700s and early 1800s, was fueled by innovations in steam and water power, which enabled factories to expand their production capacities and potential locations. Before this, factories were situated near

rivers to harness water wheel energy. Later, the discovery of electric power and infrastructure developments led to the mass production of machines and the expansion of iron ore production. The expansion of railways facilitated the procurement of supplies and delivery of finished products in the US. The widespread availability of energy sparked the development of digital computing, with the emergence of

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mainframe and client-server computers, the Internet, and e-commerce. The third industrial revolution emerged in the late 1960s with the programmable logic controller, which brought about process automation through the control of tank filling, motor starting and stopping, and sequencing control events.

Just 20 years ago, companies could barely redirect phone calls within departments or sell through websites. Today, it is an integral part of the workday. Mobile devices and cloud computing have led to an expansion of services, as different communication channels (phone, web, tablets) have fully shifted towards customers.

The first industrial revolution was characterized by the invention of steam-powered machinery, followed by the use of electric power and assembly line production in the second. The third industrial revolution saw innovations in computing and industrial automation. The fourth industrial revolution is defined by the integration of machine intelligence, pervasive computing, accessible storage, and robust connectivity. It builds on the foundation of the previous industrial revolution, including digitalization, computer networks, robotics, artificial intelligence, smart machines, smart factories, modelling and simulation, nanotechnology, transportation, and other smart components of development (Zonnenshain&Kenett, 2020). Accompanying Industry 4.0 is Quality 4.0.

Quality 4.0 represents the knowledge and philosophy of understanding the aspects and trends of Industry 4.0 and its fundamental characteristics, such as virtual system, real-time work, modularity, and the ability to be preventive, simulate, and understand the relationships that Industry 4.0 establishes. Improving any process in an organization contributes to the development of the organization's competitiveness. Therefore, it is necessary to manage quality properly in Industry 4.0. Quality is imperative in

business.

The concept of Quality 4.0 has emerged as a response to the demands of Industry 4.0, where digitalization and automation have transformed the way we work and produce goods. To define Quality 4.0, it is necessary to develop a framework that takes into account the specific characteristics of this new industrial revolution. The first step in developing such a framework is to identify the key features of Quality 4.0. These may include, among others, the use of big data and analytics, the integration of advanced technologies such as artificial intelligence and machine learning, and the implementation of continuous improvement processes that are data-driven and agile. Once the key features have been identified, the next step is to define the scope of Quality 4.0. This may involve identifying the industries or sectors that are most likely to benefit from Quality 4.0, as well as the specific quality metrics that will be used to measure the effectiveness of Quality 4.0 processes.

Another important aspect of developing a framework for Quality 4.0 is to identify the stakeholders who will be involved in the process. This may include manufacturers, suppliers, customers, regulators, and other relevant parties, and it will be important to ensure that their needs and requirements are taken into account when defining the concept of Quality 4.0.

Finally, the framework for Quality 4.0 should include a roadmap for implementation, which outlines the steps that will be taken to achieve the desired outcomes. This may involve the adoption of new technologies and processes, the training of employees, and the establishment of new partnerships and collaborations.

In summary, the development of a framework for defining the concept of Quality 4.0 requires a thorough understanding of the key features, scope,



stakeholders, and implementation roadmap. By taking these factors into account, it is possible to create a comprehensive and effective framework that can help organizations to achieve the full benefits of Quality 4.0.

However, Quality 4.0 requires more than just technological advancements. It raises the bar for stakeholder requirements by elevating them to a new level. New technology becomes one of the foundational components of the Quality 4.0 approach.

This paper focuses on the significance of Quality 4.0, highlighting the knowledge required by managers to keep pace with the rapid changes that Industry 4.0 brings.

## 2. Literature review

Quality 4.0 refers to the fourth generation of quality management, which is based on modern technologies such as artificial intelligence (AI), the Internet of Things (IoT), and cloud computing to ensure greater efficiency and precision in quality management (Carvalho et al., 2021). In this context, AI can be used to predict quality by analyzing data and predicting potential quality problems before they occur (Sader et al., 2022). Moreover, AI can be used to automate quality control by automatically identifying and correcting quality problems in real-time, optimizing processes, and primarily analyzing processes to identify areas for improvement to increase quality and efficiency (Ament & Goch, 2001). Ultimately, one of the fundamental advantages of using AI is analyzing large amounts of data related to quality to ensure a better understanding of trends and potential problems.

The most critical application of AI in quality management is automated quality control. Automated quality control leverages AI to automatically detect and correct manufacturing errors. Machine learning

algorithms are used to analyze production data to identify trends and issues (Dilthey & Heidrich, 1999). This technology can also automatically determine product acceptability criteria and evaluate the quality of each product. This enables faster and more accurate decision-making regarding product acceptability and reduces the risk of releasing low-quality products into the market (Escobar et al., 2021). By embracing automated quality control, organizations can enhance their quality management practices and deliver high-quality products to their customers.

Furthermore, since Industry 4.0 emphasizes the collection of a large amount of data, there is a challenge in analyzing them, especially when it comes to management systems. In this context, if we talk about data analysis and reporting using artificial intelligence, machine learning algorithms analyze the data to identify trends and problems, and based on that, automatically generate reports and recommendations for improvement (Sader et al., 2022). This technology enables fast and precise data analysis and facilitates decision-making regarding improvements in processes and products. The results also help reduce the risk of releasing low-quality products and increase production efficiency and effectiveness (Sader et al., 2022).

In general, the concept of Quality 4.0 emphasizes the automation and digitalization of processes through the use of technologies such as AI and IoT, increased accuracy in assessing and predicting quality, agility and fast response to quality issues, agility in adapting processes, integration of data from various sources, and ultimately increased efficiency in quality management (Nenadál et al., 2022). In this context, efficiency is increased through the automation of processes using artificial intelligence and digital technology that automate quality control processes and eliminate errors (Aziz & Dowling, 2019). Similarly, predicting

problems through machine learning algorithms enables the prediction of issues in processes and products, which allows for the preventive resolution of problems before they reach the final product (Larson & Boland, 2019).

### **2.1. Industry 4.0**

Industry 4.0 is a new trend in manufacturing that relies on advanced technologies such as artificial intelligence (AI), the Internet of Things (IoT), robotics, 3D printing, and more (Buntak et al., 2019). AI and machine learning (ML) technologies are used in Industry 4.0 to automate and improve production processes. They enable manufacturers to use data algorithms and models for automated decision-making, data analysis, fault prediction, and production process optimization. AI and ML also help to reduce production time and costs while increasing efficiency and productivity (Kovačić et al., 2022). Regarding the second most important technology of Industry 4.0, IoT, (Madakam et al., 2015) explain that this technology enables the connection and communication between various devices and sensors in the production environment.

This allows for the automatic collection of data on production processes, device activities, and product quality. IoT also enables devices and production processes to be managed remotely and dynamically adjusted to production needs (Makadam et al., 2015). Furthermore, IoT technology helps improve production efficiency and quality, as well as reduce time and costs in production as discussed in (Farooq et al., 2015).

Generally speaking, Industry 4.0 emphasizes greater automation in the production process, increased use of artificial intelligence and data analytics, increased connectivity among production machines and equipment through the Internet of Things, improved flexibility and adaptability of production, and increased

personalization of products and services (Buntak et al., 2021). All of this provides the possibility of insight into the performance that production processes develop in real-time, which also allows for the identification of opportunities for improvement. One of the particularly significant advantages highlighted, in addition to those mentioned, is increased connectivity and compatibility, which refers to the cooperation of different technologies and systems in the production process as described in (Burns et al., 2019). This includes linking different machines, devices, sensors, and networks to ensure real-time communication and data sharing. This level of increased connectivity enables manufacturers to respond more quickly and efficiently to changes in demand and the market and to adjust production according to customer needs. This also leads to a reduction in losses and an increase in efficiency in production processes.

In addition, it is worth mentioning digitalization, as discussed by Sanchez et al. (2020), refers to the use of information technologies and data networking to create a centralized database for all production processes. This integration of data enables manufacturers to quickly access information on production, products, and operations, and to use it to make decisions on improving production efficiency and quality (Sanchez et al., 2020). Increased digitalization also leads to greater security and transparency in processes, which helps prevent errors and ensures continuous improvement in production.

Increased adaptability and flexibility of production, also an important component of Industry 4.0 emphasized by Fragapane et al. (2022), refers to the ability of manufacturers to quickly and efficiently change their production to respond to changes in market demand. This is achieved through the use of highly automated and connected technologies, which enable fast and easy changes to the production process. This

production flexibility allows manufacturers to respond to market and customer needs faster and more efficiently, ensuring success in a dynamic market environment. It also leads to greater competitiveness and innovation in production. However, despite all the advantages mentioned, there are also several drawbacks (Fragapane et al., 2022). The main drawbacks include high costs of implementation and upgrading of existing equipment, the need for experts to work with advanced technologies, cyber security and the risk of hacking attacks, incompatibility and obsolescence of technologies and devices, and difficulties in adapting workers to new technologies and processes, etc. (Kovačić et al., 2022).

## 2.2. A framework for Quality 4.0

Quality is a key dimension of products and processes. It is considered a competitive advantage for companies and organizations in the global market. Quality models and practices have gone through several evolutionary steps throughout modern history - from inspection, control, and quality assurance, to quality management and design quality. These quality models follow the evolution and revolutions in the industry (Zonnenshain&Kenett, 2020).

Industry 3.0 is accompanied by Quality 3.0, which has been particularly intensively developed in the last decade of the twentieth century and the first two decades of the twenty-first century, through international standards such as ISO series 9000, 14000, 27000, 31000 and others. The Quality Management System (QMS) standard series ISO 9000, along with the ISO 27000 series (Information Security), have followed the technology of the third industrial revolution (Perović, 2019).

The concept of "Industry 4.0" was presented at the Hanover Fair in 2011 to describe the fourth industrial revolution. It is based on

digital transformation to find adequate responses to disruptive changes related to customers, organizations, and organizational boundaries. New business models have been developed for it, emphasizing trust, transparency, and security through digitization. The first introduction of the term "Quality 4.0" was in the American Society for Quality (ASQ) Future of Quality Report in 2015. Based on this approach, we can expect a renaissance of quality tools and methods through themes (Arsovski, 2019):

- Quality as inspection.
- Quality as design.
- Quality as empowerment, i.e. TQM (Total Quality Management) and Six Sigma for a holistic approach to quality, greater responsibility, and empowerment of everyone for continuous improvement.
- Quality as discovery, in adaptive and intelligent environments for solving challenges and problems.

To follow Industry 4.0 requires more knowledge than previously needed. This demands a more advanced approach to quality to understand the technology and its application. What is this increased knowledge and advanced approach, and what needs to be understood? The answers to these questions can be found by resolving the causes of the inefficient automation and digitalization processes in previous applications, from the perspective of quality management principles and approaches.

In addition to the new possibilities of Industry 4.0 such as smart factories, autonomous systems, the Internet of Things, and machine learning, Quality 4.0 aims to leverage new technologies to mobilize quality management practices and organizational excellence. The focus of Quality 4.0 is to reduce costs, improve quality, facilitate compliance, and increase the efficiency of quality operations. (What is Quality 4.0).

In summary, the concept of Quality 4.0 is formulated as follows (Tadić, 2022):

*Main pillars of Industry 4.0 + Quality Control = Quality Control 4.0.*

To achieve effective Quality 4.0, it is crucial to overcome outdated beliefs and negative traditions, including traditional methods, procedures, and structures, as well as blind obedience to authorities. Quality 4.0 emphasizes the role of digital technology in transforming management systems and promoting organizational culture, as well as enhancing competencies, democratic leadership, process synchronization, teamwork, and continuous learning.

Quality 4.0 supports the digitalization of quality management, based on the digitization of quality technology, processes, and people. Its model consists of 11 axes (Arsovski, 2019): (1) data, (2) analytics, (3) connectivity, (4) collaboration, (5) application development, (6) scalability, (7) management system, (8) compliance, (9) culture, (10) leadership and (11) competence.

**Data** is crucial for continuous improvement. Without collecting and analyzing robust data, it is impossible to form future recommendations and plans for improving quality. With the help of connected Industry 4.0 devices, accurate real-time data can be used to empower agile decision-making (What is Quality 4.0). For example (Zonnenshain&Kenett, 2020):

- Collect as many different types of data and perspectives on each situation as possible.
- Use data to develop a deeper understanding of the business context and problems at hand.
- Develop an understanding of variation, both in the data and in the overall business.
- Confront uncertainty and the possibility of making mistakes.

- Recognize the importance of high-quality data and invest in reliable sources and improvements.

Quality 4.0 emphasizes the use of big data **analytics** as one of its main aspects. Data from IoT and other sources are uploaded to cloud storage and analyzed using AI-based algorithms to recommend or make decisions. Quality data mainly relates to rejections and the number, types, and causes of defects. Conclusions are drawn from quality reports based on data analysis that includes recommendations.

**Connectivity** in the proposed Quality 4.0 framework refers to the existence of quality circles within an organization, consisting of representatives from different departments. These representatives can be connected through ERP systems, where data related to quality is inputted by the quality and other departments, and reports are generated using quality tools. Quality circle meetings are held frequently, either physically or remotely, to monitor and control the quality of products and services. Real-time quality reports are presented via ERP systems using quality tools such as histograms, Pareto charts, control charts, and FMEA. The connectivity dimension of the Quality 4.0 framework ensures that all departments in the organization are working towards the same strategic direction decided by the leadership (Zulqarnain, et al., 2022).

**Scalability** in Quality 4.0 refers to the ability of the quality management system to adapt and grow with the needs of the organization. This includes the ability to add new products or services, as well as the ability to expand operations to new markets or regions. Scalability is important because it allows organizations to stay competitive in a rapidly changing business environment.

The Quality Management System (QMS) is the foundation of Quality 4.0. The QMS provides a framework for managing quality that is based on data, analysis, and

continuous improvement. The QMS is integrated with other systems in the organization, such as Enterprise Resource Planning (ERP) and Customer Relationship Management (CRM), to ensure that quality is considered at every stage of the product or service lifecycle.

**Compliance** is another important dimension of Quality 4.0. Compliance refers to the organization's ability to adhere to regulatory requirements, industry standards, and customer specifications. Compliance is critical for organizations that operate in highly regulated industries such as healthcare and aerospace. Culture, leadership, and competence are also important dimensions of Quality 4.0. These dimensions refer to the attitudes, behaviours, and skills of the people within the organization. A culture of quality and a commitment to continuous improvement is essential for the success of Quality 4.0. Effective leadership is also critical for creating a culture of quality and driving continuous improvement. Finally, the competence of the people within the organization is important for ensuring that quality goals are met and that the organization can adapt to changing circumstances.

In summary, Quality 4.0 is a comprehensive framework for managing quality in the digital age. It is based on data, analysis, and continuous improvement, and it encompasses dimensions such as data, analytics, connectivity, collaboration, application development, scalability, compliance, culture, leadership, and competence. By embracing Quality 4.0, organizations can stay competitive in a rapidly changing business environment, meet regulatory requirements and customer expectations, and drive continuous improvement across all aspects of their operations.

Adaptability means that an increased capacity to support data, users, devices, and

analytics can increase a company's scalability. This means that companies can integrate all their data sources and systems in one place, on a larger scale than was previously possible.

The **quality management system** is a conventional part of the Quality 4.0 framework and covers the existence and application of standardization, in the form of SOPs, quality reviews, improvements, management engagement, corrective and preventive actions, etc. This management system within Quality 4.0 relies on technologies that allow management to observe statistics in real-time, control panels, and the organization's KPIs. Communication of organizational policies, SOPs, and KPIs can be facilitated by using ERP-based systems within Quality 4.0. Especially in life sciences, compliance can be a major priority in quality management. Quality 4.0 can automate and digitize compliance processes and further reduce overall quality costs.

The most significant elements of Quality 4.0 are the speed of design, production, and delivery, as well as the quality of software and data processing. Some authors have developed a quality strategy that can meet the demands of Industry 4.0. The strategy is called "Open Quality" and involves freedom in creating the characteristics of a product. The concept of Quality 4.0 must inevitably follow the trends of Industry 4.0 and the technological possibilities that have emerged with it (Tadić, 2022).

The **culture** within the proposed framework of Quality 4.0 refers to the quality culture of the organization. This dimension of the Quality 4.0 framework can be assessed through the existence of quality circles and the use of quality management tools, as well as knowledge and understanding that action should be based on the conclusions drawn from the results of these tools. It involves trust in employees in organizational processes and procedures and trust of the organization in its employees. The culture

includes offering rewards and recognition for performance improvement (Tadić, 2022). Effective leadership in Quality 4.0 requires a deep understanding of key technologies driving digital transformation, including artificial intelligence, machine learning, the Internet of Things, and big data analytics. Leaders must also understand how these technologies can be used to optimize quality processes and improve the quality of products and services.

**Leadership** in Quality 4.0 requires a combination of technical knowledge, change management skills, and a commitment to continuous improvement and innovation. Effective leaders in this field must be able to leverage new technologies and data to foster excellence in quality and cultivate a culture of accountability and ownership among employees. In addition, Quality 4.0 requires a shift in leadership style from a hierarchical approach to a more collaborative and participatory approach. Leaders must be able to facilitate communication and collaboration among different teams and departments, as well as between the organization and its suppliers and customers. This requires the development of strong interpersonal and communication skills, as well as the ability to build and maintain relationships based on trust and mutual respect. Overall, effective leadership in Quality 4.0 is crucial for organizations to stay competitive and adapt to the rapidly changing business environment. It requires a combination of technical expertise, change management skills, and strong interpersonal and communication skills, as well as a commitment to continuous learning and improvement.

These competencies include an understanding of the principles of Industry 4.0 and Quality 4.0, as well as the ability to apply new technologies and tools to improve quality and operational efficiency. They also relate to understanding and applying data management and analytics approaches to

make fact-based decisions. Competent individuals in Quality 4.0 can identify opportunities for innovation and implement new business strategies and models supported by digital transformation. **Competencies** in Quality 4.0 are crucial for the success of organizations struggling with rapidly changing markets and customer needs. (Tadić, 2022).

Based on all the characteristics of Quality 4.0 mentioned above, the following benefits of its implementation can be highlighted: it improves the quality of decision-making, human intelligence, and transparency, adapts to new changes, eliminates defects, and so on.

### 3. Knowledge management in Quality 4.0

Knowledge management (KM) refers to the process or set of processes through which an organization uses individual and collective intelligence within itself to achieve its strategic goals (Calvo-Mora et al., 2015). Ultimately, it aims not only to create and/or acquire knowledge but also to include the practices involved in storing, retaining, transferring, and using available knowledge (Dovleac, 2021).

Regarding the possibility of implementing KM and tools in companies that have implemented total quality management (TQM) practices, different studies emphasize the complementarity of these two disciplines (Paulzen, 2002; Liderman et al., 2004; Molina et al., 2007). In the context of Quality 4.0, which is becoming a trend for companies that want to leverage the advantages brought by technology and Industry 4.0, the role of KM becomes clearer, and the question of data collection and effective management becomes more urgent.

Knowledge management in Industry 4.0 plays a crucial role in enabling organizations to leverage their collective knowledge and expertise to create a competitive advantage. The first aspect of knowledge management in Industry 4.0 is the use of data analytics and artificial intelligence (AI) to collect and analyze large amounts of data generated by sensors and other digital devices in the production process. This data can be used to identify patterns, optimize processes, and inform decision-making. The second aspect of knowledge management in Industry 4.0 is the use of collaborative technologies to facilitate knowledge sharing and collaboration between teams and departments. Cloud-based platforms, social media, and other digital tools can be used to create virtual communities where employees can share knowledge, ask questions, and collaborate on projects in real time. Ultimately, knowledge management in Industry 4.0 involves the use of advanced training and development programs to ensure that employees have the skills and knowledge necessary to use digital technologies in their work. This may include providing training on data analytics, AI, and other technologies, as well as broader concepts of Lean production, continuous improvement, and agile methodologies.

Overall, knowledge management is crucial for success in Quality 4.0. By utilizing advanced technologies for gathering, analyzing, and sharing knowledge, organizations can improve their quality management processes and deliver better products and services. Investing in knowledge management can be key for organizations that want to remain competitive in the dynamic business environment of Industry 4.0.

#### 4. Conclusion

The concept of quality has followed industrial and social development. Four

stages of the industrial revolution are distinguished for the first aspect of development. Current definitions or those from twenty years ago can be used for Quality 4.0, provided that they are properly interpreted, which requires understanding. Such definitions include: quality is an attitude; quality is a process of change that enables the organization to learn about the unspoken desires and needs of the customer; quality is a framework for improvement, a way of life, culture, and thinking, i.e. understanding.

Quality 4.0 aims to democratize Industry 4.0 technology, i.e. to distribute it more fairly among employees, so that it is no longer only available to privileged and rarely qualified individuals but to a larger number of those involved in continuous learning processes. Technology affects people's lives, relationships, and ability to work together. It connects individuals, machines, data, analytics, devices, and processes. The collaboration enabled by these connections is the foundation for improvements and innovations, as well as more efficient Quality 4.0.

Management knowledge plays a crucial role in Industry 4.0 as well as Quality 4.0 due to the complexity of processes, the need for fast decision-making, the development of new business models, and the need for new skills development. Organizational growth and development rely on organizational knowledge that needs to be adapted to new conditions and technologies. Moreover, it should be noted that employees' knowledge changes due to rapid technological changes that require new skills. Organizations are encouraged to create a knowledge base and to disseminate knowledge according to the needs at various organizational levels. This is imperative to enable a basic competitive advantage and to improve business performance. In Quality 4.0, management knowledge is important for managing quality processes and quality assurance in complex

manufacturing environments. Effective quality management in Industry 4.0 requires not only an understanding of quality standards but also data management skills, analytical abilities, decision-making skills, and the ability to successfully manage teams and processes.

Furthermore, the development of new quality standards and frameworks that are specifically designed for Industry 4.0 and Quality 4.0 will continue to evolve. This includes the development of new metrics and

performance indicators that can better capture the performance of digital processes and products.

Finally, the focus on human factors and the development of new skills and competencies for quality professionals will be an important aspect of future development in Quality 4.0. As technology continues to advance, the need for skilled workers who can effectively manage and utilize these technologies will become increasingly important.

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## THE AVAILABILITY OF THE DOCUMENTATION REQUIREMENT TO OBTAIN THE ISO 9001:2015 CERTIFICATE IN PREFABRICATED BUILDING FACTORY- IRAQ: A CASE STUDY

**Abstract:** *The study aims to shed light, define, and diagnose the item (documentation requirement) within one of the components of the general requirements of the international standard (ISO 9001:2015) in the prefabricated building factory in Kirkuk Governorate, Iraq. The purpose of the study was to identify the reality of the availability and application of these requirements necessary to obtain the certificate of international standards, by indicating the levels of achievement of the documentation items, as well as trying to open horizons for the application of other items necessary for the factory to obtain the mentioned certificate. In order to achieve this goal, it relied on the checklists that contributed to obtaining the necessary data to achieve the goal of the study. Based on the conclusions and recommendations of the study in its theoretical and field terms, proposals were made that are consistent with these conclusions, the most important of which was the statistical results showing gaps between the actual reality of the resource management requirements to obtain the international standards certificate (ISO 9001, 2015) and the theoretical academic reality and the prefabricated building factory to address them, where a gap of 70% is considered significant in the degree of application and documentation of certification requirements (ISO 9001, 2015). To improve the performance of the prefabricated building factory in order to obtain the Certificate for International Standards (ISO 9001, 2015). The most important recommendation from the study was the need to set up a computerized database to collect information on the operations and activities of the factory so that it could be used in future analysis and documentation. The need to use both traditional and new TQM tools and train the workforce to use them, as well as the necessity to universally use the documentation clause throughout the factory.*

**Keywords:** *Documentation requirement, ISO 9001:2015 certificate, quality, prefabricated building factories*

### 1. Introduction

The issue of obtaining an international certificate of international standards (ISO

9001: 2015) has attracted the attention of researchers, as it is one of the quality standards adopted by modern administrations (Zimon et al., 2020). The organization's performance level is improved

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by encouraging innovative efforts while taking into account the continuous development and improvement of activities and operations (Yanto & Mahulae, 2021).

Based on this, many business organizations have begun to apply them in a manner that suits their situation and is consistent with their future aspirations aimed at developing and improving their products, helping them to obtain a competitive advantage that gives them uniqueness and distinction and makes them superior to their counterparts from competing organizations in the market (Shafiq et al., 2019). Therefore, we found it appropriate to study the documentation requirement as one of the requirements for obtaining the International Standards Certificate (ISO 9001: 2015) and the role of this requirement in the continuous improvement of the activities and operations of the organization. Based on the foregoing, and to achieve its goals, the study was divided into four sections (Sadikoglu & Olcay, 2014). The first discussed the methodology of the study; the second presented the theoretical framework; the third presented the analytical framework of the study, and the fourth concluded with conclusions and suggestions (Sá et al., 2019).

### **1.1. The study problem**

Obtaining the International Standards Certificate (ISO 9001: 2015) requires a statement of the extent of its commitment to the documentation requirement. As a result, we can present the study's problem by asking two questions:

1. What is the interest of the research factory in applying the documentation required to obtain the international standards certificate (ISO 9001: 2015)?
2. Are the reasons for not qualifying the study sample to obtain the International Standards Certificate (ISO 9001: 2015) due to the lack of

documentation requirements? Or is it for another reason?

### **1.2. The importance of the study**

The importance of the study stems from the importance of the International Standards Certificate (ISO 9001: 2015) and its positive effects on business organizations. The study tried to shed light on the efforts made by the research factory to implement the requirements of the international standard that are consistent with the nature of its activity; it is also an attempt to identify the reality of the availability and application of documentation as one of the requirements for obtaining the international standards certificate by indicating the levels of its achievement, as well as to try to open horizons to implement the other items necessary for the factory to obtain the mentioned certificate.

### **1.3. The objectives of the study**

The objectives of the study can be stated as follows:

1. Knowing the basic concepts of the international standard certificate ISO 9001: 2015
2. Evaluating the level of application and documentation of the documentation requirement from the requirements of the standard specification (ISO 9001: 2015) in order to diagnose the gap compared to the existing quality system in the study sample.
3. Determine the reasons for non-conformity and try to suggest the best ways to overcome them.
4. Develop appropriate solutions to address quality problems in the factory.
5. Providing the company with a set of proposals and recommendations to obtain the prefabricated building

factory for the international standards certificate (ISO 9001, 2015).

### 1.4. The hypothesis of the study

The study is based on the hypothesis that "the prefabricated building factory in Kirkuk governorate did not obtain the International Standard Certificate (ISO 9001: 2015) due in part to the lack of documentation requirements."

### 1.5. The study population and its sample

The study dealt with the presentation and analysis of the prefabricated building factory in Kirkuk governorate, Iraq, which is one of the factories affiliated with the Iraqi ministry of construction and housing in Kirkuk governorate.

This factory was chosen for its excellence in the integration of the manufacturing process, which helped in evaluating the production process in its various stages as well as the problems that this factory suffers from, including damage to the final or semi-finished products.

### 1.6. Methods of data collection

To obtain the data and information necessary to test and prove the hypothesis, the theoretical side has been covered in many sources that were represented by scientific references such as books, magazines, studies, and theses related to the study of factory records, as well as using the checklist called the gap analysis examination, which aims to diagnose the gap between the reality of the quality management system in an organization and the standard requirements in the international specification (ISO 9001:2015). For this purpose, the heptagonal scale was used as a specific weight was assigned to each of the paragraphs of that scale, and accordingly, the analysis was done

and the results were reached.

## 2. The theoretical framework

### 2.1. Concept and importance for (ISO 9001:2015)

The (ISO) quality management system is a standard that expresses an effective quality management system and allows organizations that meet the requirements of this standard to use the certificate (Purwanto et al., 2020). The products offered by these organizations are manufactured according to internationally accepted standards, and they are safe for use by customers (Prada Ospina & Ocampo, 2018). It is defined as "a series of instructions for organizations to establish their quality system by focusing on procedures, control, and documentation, which are supposed to help organizations identify errors and ensure the flow of operational processes to ensure a consistent level of quality (Pacana & Ulewicz, 2020)." (ISO Organization) considers it "a family name for quality management standards and organizations use it to ensure the conformity and quality of their products" (Noryani et al., 2020). It was also defined as "a set of guidelines for organizations to establish quality systems by focusing on procedures, control, and documentation. It also helps organizations to identify errors, streamline operational processes, and ensure the level of quality (Ngambi & Nkemkifu, 2015). The ISO 9000 series includes a harmonized set of general quality assurance measures applicable to any company, whether large, medium, or small, and can be used with any existing system. It helps the company to reduce internal costs, increase quality, effectiveness, and productivity and is a step towards total quality and continuous improvement. The ISO 9000 series is not a set of product specifications and does not cover industry-specific standards, as each document classifies a quality model for use

in different applications. The ISO 9000 standards were published in four parts: ISO 9001, 9002, 9003, and 9004, as (ISO 9001: 2000) represents the international standard, while (ISO 9001, 2008) represents the requirements of a quality management system through which the organization must demonstrate its ability To provide products that address customer requirements and enhance their satisfaction as well as legal controls (ISO 9004: 2008) is concerned with providing guidelines for improving the quality management system, and the recent version (ISO 9000:2008) promotes the process approach to developing quality management systems, as it is built on the belief that the desired results are achieved more efficiently when the activities and resources associated with them are seen as a process. (ISO 9001:2015) and its recent updates, we see it applied to all types of organizations, regardless of their size or work, and can help any organization that wants to achieve and implement quality standards recognized in all of its activities, operations, and dealings with its customers and clients, as organizations can achieve the following through accreditation of (ISO9001:2015)(Mihaela Ionascu, Ion Ionascu, 2017):

1. Contributes to the efficient and effective management of quality systems. (Martin, 2017).
2. Increasing the efficiency and profits of organizations by increasing confidence in their production system (Leong et al., 2012).
3. Achieving customer satisfaction by linking the process closely to its requirements.
4. Increasing and maintaining market share.
5. Increasing the effectiveness of communications among the members of the organization and raising the morale of the employees (Kutnjak et al., 2019).

6. Reducing costs, as well as reducing spoilage, obsolete inventory, and returned work.
7. Increasing the competitiveness of the organization (Hernawan et al., 2019).
8. Better control and greater preservation of the organization's systems(Hailu et al., 2018).
9. Facilitate the compatibility and harmony of the quality system with the rest of the systems (Gallego & Gutiérrez, 2017).

## 2.2. Documentation requirements, concept, and importance

The application of ISO 9001: 2015 is based on several basic principles approved by the (International Organization for Standardization). One of these requirements is authentication, which is part of the general requirements for obtaining the International Standard Certificate (Gal et al., 2020).

The word "documentation" was derived from the word "document," and the use of the term "documentation" prevailed until it became one of the common terms among those concerned in all fields of knowledge, including quality. It is stored, analyzed, and transmitted to the beneficiaries. Documentation is defined as "the provision, selection, classification, storage, dissemination, and exploitation of information"(Fonseca, 2015). The interest in this requirement came as a result of its role in organizing and facilitating activities and operations in any organization, and its relationship to the scientific approach, which has become one of the most important principles of total quality management, as well as being a measure of the organization in obtaining the certificate of international standards (Fahmi et al., 2021), as the system assumes the (ISO) documenting quality processes in all their details, parts, and stages to ensure the application of quality as an

approach, strategy, and work method.

The importance of documentation, and its positive effects on all parties related to the organization, can be stated according to the following (Dąbrowska-Świder Msc, n.d.) (Brooks et al., 2021):

**The importance of documentation for workers** (Bravi et al., 2019) (Armawati et al., 2018) (Anoye, 2015):

- A. Introducing them to the quality system and their responsibilities and authority.
- B. A means of training them on how to implement the documented system.
- C. Providing information that enables them to do their work in an appropriate manner

**The importance of documentation for the organization:**

- A. Ensure the continuity of achieving quality requirements.
- B. Demonstrate the organization's commitment to quality.
- C. reduce the possibility of errors.
- D. Reference for internal quality audit work.

**The importance of documentation for external parties:**

- A. Enhancing the customer's confidence in the organization's ability to meet their requirements and meet the
- B. Confirmation to external parties that the organization has a quality system that has been planned and documented.

### 2.3. Documentation in the ISO 9000 series

The way to improve the performance of organizations is through good management, which comes from following modern administrative work methods, which is called the quality management system, which organizations of all kinds follow. effectively and efficiently and with the

highest possible degree of accuracy without documentation, restriction, and commitment to what has been agreed upon, and considering an approach and method of work. This is the goal of good documentation of the quality management system, which is to provide workers with stability and satisfaction in the ways of completing work, carrying out tasks, using resources, and operating production lines. In this context, the ISO 9000 series of specifications work to determine how any quality system includes all the activities related to quality that can be implemented in any organization to ensure conformance to the performance specifications that have been identified and fully meet the needs of the customer (Almeida et al., 2018) (Ali, 2014) (Alhasani, 2020).

The documentation standards contained in the series of specifications (ISO 9000) represent an important part of any organization intending to implement a quality management system, and it is indeed the typical method of documentation that is most accepted in all organizations. The international specification (ISO 9000:2000) indicates that documentation "achieves the delivery of the goal, the continuity of the action, and its use, and documentation contributes to achieving the following for organizations:

1. Matching products to customer requirements and improving quality.
2. Providing appropriate training to the organization's employees.
3. Work repetition and sequencing.
4. Providing objective proof.
5. Evaluate the effectiveness and continuity of the appropriateness of the organization's quality management system.

### 3. The analytical framework of the study

This topic deals with the presentation of the data shown by the checklists used to determine the availability of the documentation requirements in the prefabricated building factory. In their formulation of questions, the researchers relied on the scale (Ali, 2014), as well as the lists issued by the Central Organization for Standardization and Quality Control, because these lists are more appropriate to the reality of the construction industry environment and show the extent of the gap between the current quality system and ISO requirements. (ISO 9001:2015), will be based on the quantitative expression of the answers in the checklists, which will be analyzed using the following statistical tools:

**A.** Use the weighted mean to find out the application rate of the requirements of ISO 9001:2015, where the number of times the answer is repeated is considered mainly in calculating the result according to the following formula:

Whereas:

X = average or mean

Xi = weights

Fi = frequencies

After comparing it with the paragraphs of the scale, it is possible to determine the level of that requirement and know the number of stages required to reach full conformity and complete documentation with the requirements of ISO 9001:2015.

After comparing it with the paragraphs of the scale, it is possible to determine the level of that requirement and know the number of stages required to reach full conformity and complete documentation with the requirements of ISO 9001:2015.

**B.** The formula for the percentage of conformity was also used, which expresses the percentage of conformity with each of the requirements of ISO 9001:2015, and the number six (6) represents the highest degree on the scale, which represents the state of complete conformity and complete documentation of the requirements of ISO 9001:2015. As previously stated, the analysis will begin with the fourth paragraph because the first three paragraphs (1, 2, and 3) are non-main paragraphs.

To calculate the size of the gap by subtracting the percentage of the number (1) The size of the gap for each checklist = 1- The percentage of conformity to come up with results that prove the hypothesis of the study.

**Table1** : Measurement items and their weights

No.	Paragraph	wight
1	completely implemented and completely documented	6
2	completely Applied and Partially documented	5
3	Completely implemented and undocumented	4
4	Partially applied, completely documented	3
5	Partially Applied and Partially documented	2
6	Partially Applied Undocumented	1
7	Not applicable Not documented	0



**Table 2:** Checklist for Documentation Requirement According to ISO 9001:2015

Documentation requirements	Conformance with ISO 9001:2015						
	1	2	3	4	5	6	7
1. The company has prepared a quality guide to the requirements of this standard, using the guidance in ISO 10013 – ISO.					*		
2. There is a manual for all procedural methods to meet the requirements of this standard.					*		
3. Name the persons responsible for approving and maintaining documentation of quality-related activities.				*			
4. The powers and responsibilities related to the preparation, distribution, review, and control of documents related to quality are defined.				*			
5. Quality-certified documents are identified and coded within the company.							*
6. Issuing, distributing, amending, and canceling documents related to the quality management system.							*
7. All forms and forms related to the quality management system are listed and standardized.						*	
8. The records required to document the results of the quality management system applications are identified.					*		
9. Periods are set for each type of record to be kept.		*					
10. There is an approved context for destroying obsolete records.							*
11. The company owns journals to document the results of the application of various activities related to quality, including corrective measures taken when cases of non-conformance appear.					*		
12. Appropriate conditions for storing records are determined to ensure that they are not damaged and are easy to refer to when needed.				*			
13. Persons responsible for approving and keeping records related to quality are identified.							*
Weighted mean (average)	6	5	4	3	2	1	0
repetitions	0	0	1	3	4	3	2
The result	0	0	4	9	8	3	2
Weighted mean (average)				1.85			
Match extent percentage				% 30			
Gap size				% 70			

Table 2 shows the checklist for the application and documentation of the quality system in the factory and the items of the documentation required according to ISO 9001:2015. This item obtained an average of 1, which indicates that the prefabricated building factory partially applies the provisions of this item and does not document it, with an application rate of 30% of the total items to be applied, which indicates the existence of a gap of (70%) The reasons for the gap are:

1. The prefabricated building factory did not follow the guidelines outlined in the ISO9001:2015 specification, and they lacked a guide for procedural methods following ISO 9001:2015 requirements.
2. There is no clear definition of tasks regarding the documentation system.

## **4. Conclusions and suggestions**

### **4.1. The conclusions**

The researchers reached a set of conclusions, the most important of which are:

1. Business organizations strive to obtain the International Standards Certificate (ISO 9001: 2015) by establishing the fundamental requirements for achieving excellence through quality.
2. To obtain the International Standards Certificate (ISO 9001: 2015), all requirements must be met with the same strength and sobriety, as no requirement can be overlooked or ignored.
3. The checklist is a good tool that enables business organizations to check and measure the availability of the requirements necessary to obtain the international standards certificate (ISO 9001: 2015), including the documentation item, and thus be able to make appropriate decisions to improve the reality of organizations in general, including the research sample, to the acceptable level for obtaining it.
4. The statistical results show that there is a gap between the actual reality of the factory in question and the theoretical academic reality of the documentation requirement specified for obtaining the international standards certificate (ISO 9001: 2015). The amount of gap when examining and comparing was (70%), which can be described as large, and clearly shows the lack of sufficient documentation requirements in the research sample to obtain, apply, and document the requirements of the certificate (ISO 9001: 2015) in the prefabricated building factory in Kirkuk, Iraq.

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### **4.2. The suggestions**

1. Establishing a computerized database in order to collect data related to the organization's operations and activities in order to benefit from it in future analysis and documentation.
2. The necessity of naming the persons responsible for approving and maintaining the documents related to quality and specifying the powers and responsibilities related to the preparation, distribution, and review of the documents of quality.
3. Senior management should follow up with the Documentation Committee by coding approved documents for quality and issuing, distributing, amending, and canceling documents related to the company's quality management system. Inventory and standardization of all forms and forms and identify the records required to document the results of quality management applications.
4. The recommendation of the senior management is to follow up on the documentation committee by setting periods for keeping each type of record and creating an approved context for destroying obsolete records and making records of the results of applications of various quality-related activities, including corrective actions taken when non-conformities arise.
5. The need to generalize the use of the documentation clause and the mechanism of using the tools that can be applied to all parts of the factory and the support and backing of the senior management to apply these tools and train the workers to use them.

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## AN EMPIRICAL INVESTIGATION ON THE PERFORMANCE OF THE COMPONENTS OF QUALITY MANAGEMENT: IN THE CASE OF ETHIOPIAN MANUFACTURING COMPANIES

**Abstract:** *The main issue that requires careful consideration if organizations want to surpass their competition is quality management. The ability to create high-quality goods that meet or exceed customer expectations is critical to the survival and profitability of any government or private manufacturing enterprise. The purpose of this article is to examine the performance of the quality management components in Ethiopian manufacturing firms. Based on the literature reviewed four crucial quality management components were identified (i.e. quality planning, quality control, quality assurance, and quality improvement). As a result, the variables were used to create the conceptual framework and survey questions. Descriptive statistical analysis was used to analyze the data. The results indicate that the performance of quality management components in selected manufacturing companies was found to be low throughout all tents, including quality planning, quality control, quality assurance, and quality improvement.*

**Keywords:** *Quality Management Components; Quality Planning; Quality Control; Quality Assurance; Quality Improvement; Performance; Ethiopian Manufacturing Firms*

### 1. Introduction

Currently, quality management is the standout factor that needs careful consideration if businesses are to outperform their competitors. In any government and private manufacturing firm, the key to its survival and success depends on the capacity to provide high-quality products and meet or exceed customer expectations. It is a common phenomenon that many manufacturing companies encounter issues in delivering satisfactory products to its customer at the minimum manufacturing

cost that will increase the profits and reputation of the company.

Meanwhile, in today's competitive business environment, manufacturing firms are under pressure to match particular client demands while still delivering high-quality items to the market. Moreover, it is reasonable by most of the partners that quality management issues are the stumbling piece for the investors in manufacturing companies. Besides, quality management issues were clear in all divisions. As a result, many companies have reacted to the issues by adopting broad aspects of quality and they

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are beginning to emphasize quality management in all elements and phases of their business rather than just operations. Quality management, despite its prominence, has been the subject of countless empirical studies, for example, see, Agarwal et al., (2013); Bayissa, (2016); Berhe & Gidey, (2016); Bhatia & Awasthi, (2017); Birhanu & Daniel, (2014); Brkić et al., (2011); Buhumaid, (2022); Claver et al., (2003); Gedif, (2019); Gutiérrez et al., (2012); Hoonakker et al., (2010); Jaafreh & Al-Abedallat, (2013); Kitaw & Bete, (2003); Lakhali et al., (2006); Martínez-Costa & Martínez-Lorente, (2008); Milanoi, (2016); Mohammed et al., (2019); Muyanda et al., (2019); Patyal & Koilakuntla, (2017); Phan et al., (2011); Tarí et al., (2007); Zeng et al., (2014); Wanza et al., (2017). Generally, most of the empirical studies focus mainly on discussing quality management practices, and principles, and examining their impact on organizational performance in various sectors. Even if, there are numerous empirical studies conducted on quality management. Still, there is an absence of empirical studies on ascertaining the performance of the quality management components. Consequently, this article critically examines the performance of the quality management components in Ethiopian manufacturing firms. This article is organized in chronological order as follows. Section two presents a related literature review of the concept, theory, definition, models, and findings on components of quality management. Section three describes the methodologies employed in the research. Section four presents the results of the research investigation and demonstrates how different manufacturing firms implement crucial quality management components. Section five interprets the analysis result. Section six shows a conclusion drawn from the research and forwards a method of how the company can

overcome issues related to quality management components.

## **2. Literature Review**

### **2.1. Concepts of Quality and Quality Management**

Regardless of the challenges in defining the concept of quality exactly, however, several scholars have defined the concept of quality from different perspectives (Saghier & Nathan, 2013). Meanwhile, Harvey & Green, (1993) summarize the concept of quality into two different comparative concepts such as quality means different things to different people, and the second is relative to a process or outcomes, subsequently, they reflected quality as an exception, value for money, transformative, and fitness for purpose. Also, based on their importance, the concept of quality can be categorized into five generic classes in terms of, transcendent, product, process or supply, customer, and values approach (Ghobadian et al., 1994). The concept of quality leads to meeting the gap between what customers expect and what they perceive (Shen et al., 2000). Indeed, the concept of quality is quite difficult for customers to understand, consequently, customers describe quality based on their actual perception (Dale, 2003). See, for example, the meaning of quality in Figure 1.

In brief, this means when we discuss anything using the concept of quality, it simply implies that we are referring to the extent or degree to which the stated requirement is met. The concept of quality management has evolved over the last decade, from a nascent set of concepts to a comprehensive framework for controlling all aspects of quality in any organization.



Quality management includes guiding and managing aspects such as staff training, supplier quality management, and product or service design; also, from a system-

structural perspective, quality management may be described as a simple three-stage process mode (Benson et al., 1991). See, for instance, Figure 2.

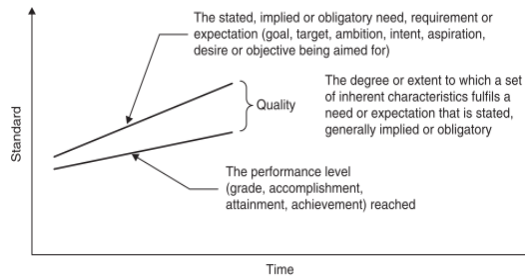


Figure 1. The meaning of quality. Source: (Hoyle, 2007)

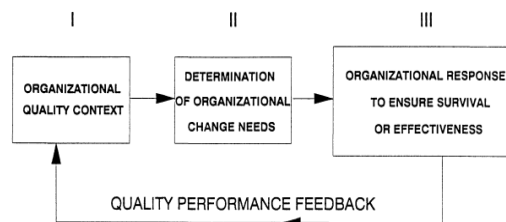


Figure 2. System-structural view of quality management. Source: (Benson et al., 1991)

Quality management is defined as an integrated strategy for achieving and maintaining high-quality output by focusing on the maintenance and continual improvement of processes and defect avoidance at all levels and in all activities of an organization to meet or exceed customer expectations (Flynn et al., 1994). Quality management is described as a management philosophy or strategy comprised of a collection of mutually reinforcing principles, each of which is backed by a set of practices and methodologies (Sousa & Voss, p.92, 2002). Modern statistical quality control, quality improvement, and reliability operate within the concept of quality management (Bisgaard, 2007, 2008). Finally, ISO 9000 describes quality management as a coordinated action that directs and controls an organization's quality (Hoyle, 2007). Quality planning, quality control, quality

improvement, and quality assurance are examples of these activities.

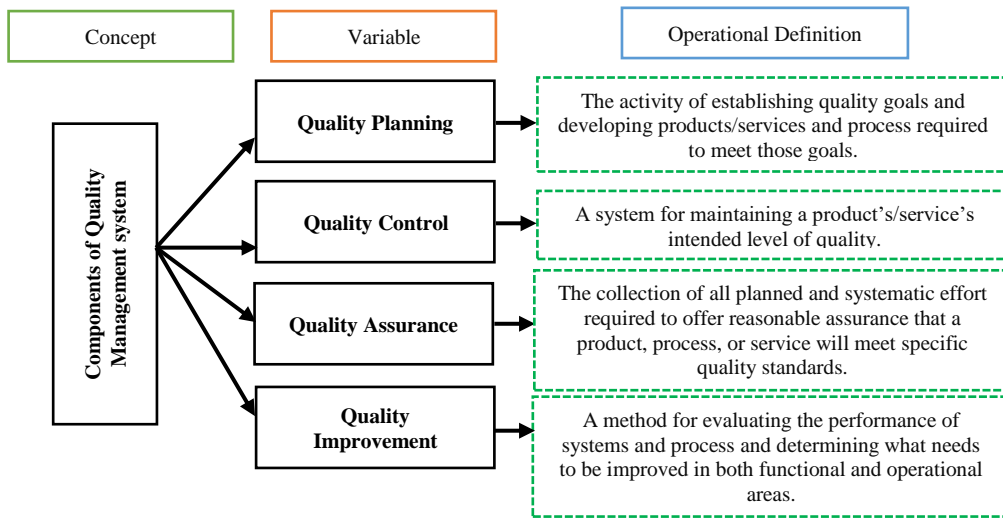
## 2.2. Components of Quality Management

To date, a great deal of studies has been done from many angles to identify the components of successful quality management, with contributions from quality leaders, formal assessment models, and empirical studies as crucial sources (Tari, 2005). It was required to identify each critical quality management component in detail for this research. Numerous scholars stated the pillars of quality management consist of quality planning, quality assurance, quality control, and quality improvement. See, for example, Table 1.

**Table 1.** Component of quality management

Components of Quality Management	Variables	References
Components of Quality Management	Quality planning	Bisgaard, (2007), (2008); Hoyle, 2007;
	Quality control	Mitra, (2016);
	Quality assurance	Tummala & Tang, (1996); Visschedijk et al., (2005);
	Quality improvement	Westgard & Westgard, (2016)

Therefore in this section, the critical quality management components are identified. Accordingly, the variables will be used to create the conceptual framework and survey questionnaires, as well as to look into the possibility of using these components in specific manufacturing companies. Conceptual Framework is shown in figure 3.



**Figure 3.** Conceptual Framework. Source: (Author survey, 2022)

### 2.3 Empirical Studies

In the previous section theories, regarding quality and quality management have been explained in detail. Further, a critical quality management component was identified. With this in mind, the conceptual framework is created using these identified variables. Therefore in this section, empirical studies will be reviewed in each quality management component in detail.

#### 2.3.1. Quality Planning

Several researchers have conducted empirical research over the last decade to explore the impacts of quality planning on different sectors. See, for example, Table 2.

#### 2.3.2. Quality Control

Similarly, numerous scholars have undertaken empirical studies to investigate the effects of quality control in various industries. See, for case, Table 3.

#### 2.3.3. Quality Assurance

This section presents empirical studies on quality assurance from various sources. See, for instance, Table 4.

#### 2.3.4. Quality Improvement

This section presents empirical quality improvement research from a variety of sources. See, for case, Table 5.

**Table 2.** Empirical studies on quality planning

Author	Research Purpose	Methods	Units of Analysis	Findings
(Lam, 1997)	Investigate the quality planning process & its perceived usefulness.	Factor & Cluster analysis	84 quality managers	Different firms could be grouped according to their strategic planning orientation & the level of planning sophistication was found to moderate significantly the strategic performance baseline.
(Senaratne & Thushangi, 2012)	Explore whether the Sri Lankan construction contractor practices quality planning effectively and the extent to which they are ready to implement strategic quality planning.	Descriptive & Inferential Statistics Analysis	3 large-scale constructing firms	ISO 9000 is the most quality management practiced by Sri Lankan construction contractors.

**Table 3.** Empirical studies on quality control

Author	Research Purpose	Methods	Units of Analysis	Findings
(Olayiwola et al., 2019)	Investigate the effect of quality control management and customer retention focusing on the dimensions of employee participation, supplier quality management, higher management commitment, and leadership enhancement in quality.	Pearson Product Moment Correlation & Multiple regression Analysis	150 respondent	+ve significant relationship between high management commitment ( $r = .659$ ), supplier quality management ( $r = .607$ ), employee involvement ( $r = .619$ ), leadership enhancement ( $r = .508$ ) and customer retention.
(Oloo, 2017)	Investigate based on two theories, Deming's theory of total quality management and the reliability theory by Rausand and Hoyland.	Descriptive Statistics & Regression Analysis	5 mobile telecommunication firms	72% of the variation in organizational performance can be accounted for by the variation in the quality control practices discussed, with the remaining 28 % being accounted for by other factors not in the model or by chance variation.
(Alzoubi, 2021)	Investigate the hotel industry in the light of process quality and quality control.	Descriptive statistics, correlation, ANOVA & regression analysis	119 hotel firms	Process quality & quality control has a significant impact on attaining competitiveness in the hotel industry.

**Table 4.** Empirical studies on quality assurance

Author	Research Purpose	Methods	Units of Analysis	Findings
(Belina, 2021)	Investigate the extent of quality assurance implementation from the inspection approach & its contribution to quality enhancement & accountability.	Thematic analysis	2 firms	The inspection strategy design at MOE did not practically implement as it was designed & it has a shortage of linkage to the operational practice.
(Sultana et al., 2020)	Empirically investigate the SQA process followed in software companies in Bangladesh.	Quantitative & Qualitative analysis	9 software companies	More than half of the companies fall short in adhering to SQA practices within their SDLC. The rest either fully or partially comply with it.
(Faller, 2018)	Analyze the impact of quality assurance on management practices & staff performance in the technical college of the Sultanah of Oman.	Descriptive-correlation analysis	233 faculty member	The relationship between all the quality assurance implementation and staff performance, implementation & management practices was significant.
(Sowunmi et al., 2016)	Investigate the software quality assurance practices of practitioners in Nigeria	Descriptive statistics	All software firms in Nigeria	It was observed that quality assurance practices are quite neglected and this can be the cause of low patronage.

**Table 5.** Empirical studies on quality improvement

Author	Research Purpose	Methods	Units of Analysis	Findings
(Maani et al., 1994)	Empirical verification of the operational & strategic value of quality improvement aims to narrow the gap between theory & practice.	Structural Equation Modeling (SEM)	184 plant	Improving quality positively enhances operational performance & productivity.
(Miller et al., 2006)	Investigate quality improvement practices of for-profit & not-for-profit hospitals.	Factor analysis	110 hospitals	Thus, underscoring the utility of quality improvement efforts despite the difference in operating characteristics, strategies & operating constraints is helpful.
(Kokemüller, 2011)	Empirically analyzing the factor influencing the success of data quality improvement.	Structural Equation Modeling (SEM)	179 respondents	Organizational implementation success is positively associated with perceived data quality, whereas no significant contribution of data quality project, to perceived data quality, could be observed.
(Mulay & Khanna, 2020)	Investigate the impact of quality (in terms of customer expectations) related to selected administrative processes in professional higher education institutions.	Partial Least Square-Structural Equation Modeling	725 respondents	The admissions process was found to have the most impact on quality, and exam & placement processes also had a significant impact on quality.

### 3. Methods

With the research objective in mind, the quantitative research method was used in this research. Descriptive statistical analysis was used to examine the performance of the quality management components in Ethiopian manufacturing firms. Meanwhile, in this research, data were collected online from the respondent using close-ended survey questionnaires. Simple random sampling was selected. 385 number of the case company's general manager, head of department/section, QMS coordinators, and quality teams are involved. The case company's employees, who were field workers (like purchasers, and sellers) and those who are newly employed and had inadequate knowledge/information for the quality management implementation were excluded.

#### Reliability Statistics

In reliability statistics, there are so many methods suggested by various literature. Among them, the most preferred method is the internal consistency method which includes (split-half, item-total correlation, and Cronbach's-alpha/coefficient alpha). Among these, the most frequently used method is Cronbach's-alpha/coefficient alpha. Even though Cronbach's-alpha/coefficient alpha is translated in numerous ways in the literature, the most common interpretation is described in Table 6.

**Table 6.** The Classification of Cronbach's Alpha Coefficient.

Cronbach's Alpha Coefficient	Interpretation of Cronbach's Alpha Coefficient
$\geq 0.9$	The internal consistency of the scale is high
$0.7 \leq \alpha < 0.9$	The scale has internal consistency
$0.6 \leq \alpha < 0.7$	The Kaiser-Meyer-Olkin (KMO) test is used in this research to determine the sampling adequacy of data that will be used for exploratory factor analysis. The KMO test
$0.5 \leq \alpha < 0.6$	The internal consistency of the scale is weak
$\alpha \leq 0.5$	The scale has no internal consistency

Source: (Sürücü & Maslakçi, 2020)

Briefly, in this research, Cronbach's-alpha/coefficient alpha was utilized to check the internal consistency of the data. The main aim of conducting reliability statistics analysis (Cronbach's-alpha/coefficient alpha) is to identify the internal consistency of the data. Therefore, Table 7 indicates that the Cronbach's-alpha/coefficient alpha value of each construct falls between  $0.7 \leq \alpha < 0.9$  which shows that the scale has internal consistency.

**Table 7.** Reliability statistics for Cronbach's alpha

No.	Construct	Item	Cronbach's-alpha ( $\alpha$ )	N
1	Quality Planning	QP <sub>1</sub>	0.856	120
		QP <sub>2</sub>		
		QP <sub>3</sub>		
		QP <sub>4</sub>		
		QP <sub>5</sub>		
		QP <sub>6</sub>		
2	Quality Control	QC <sub>1</sub>	0.869	120
		QC <sub>2</sub>		
		QC <sub>3</sub>		
		QC <sub>4</sub>		
		QC <sub>5</sub>		
		QC <sub>6</sub>		
3	Quality Assurance	QA <sub>1</sub>	0.726	120
		QA <sub>2</sub>		
		QA <sub>3</sub>		
		QA <sub>4</sub>		
		QA <sub>5</sub>		
4	Quality Improvement	QI <sub>1</sub>	0.786	120
		QI <sub>2</sub>		
		QI <sub>3</sub>		
		QI <sub>4</sub>		
		QI <sub>5</sub>		
		QI <sub>6</sub>		

Source: (Author survey, 2022)

The internal consistency of the scale is high  
 The scale has internal consistency  
 The Kaiser-Meyer-Olkin (KMO) test is used in this research to determine the sampling adequacy of data that will be used for exploratory factor analysis. The KMO test also allows us to ensure that the data we have are suitable for running an exploratory

analysis and it also determines whether or not we have specified what we intend to measure. Furthermore, a KMO score between 0.8 and 1 shows that the sample is appropriate if the KMO value is less than 0.6 the sampling is insufficient for analysis. Therefore, the table below shows that the KMO test value is 0.892 which is between 0.8 and 1 indicating that the sampling is appropriate for further exploratory factor analysis.

Furthermore, the usefulness of exploratory component analysis was verified by Bartlett's test of Sphericity, which is employed as a measure of the strength of the

link between variables. The score of Bartlett's Test of Sphericity (Chi-Square) is 1,848.058, suggesting that the data were suitable to proceed with the exploratory component analysis.

**Table 8.** KMO and Bartlett's test.

KMO & Bartlett's Test		
Kaiser-Meyer-Olkin measure of sampling adequacy		0.892
Bartlett's Test of sphericity	Approximate Chi-square	1848.058
	df.	0.231
	Sig.	0.000

Source: (Author survey, 2022)

**Table 9.** Total variances explained.

Components	Total Variance Explained					
	Initial Eigen Values			Rotations sums of squared loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.236	46.527	46.527	9.965	45.297	45.297
2	3.047	13.851	60.377	2.585	11.749	57.047
3	2.449	11.133	71.510	2.296	10.438	67.485
4	1.804	8.200	79.710	2.152	9.784	77.269

Source: (Author survey, 2022)

Note: Extraction Method: Principal Component Analysis

The primary objective of doing exploratory factor analysis is to identify the important factors or dimensions of competing priorities. To assess the number of components to keep for quality management, the researcher applied the notion of Kaiser's rule (Eigenvalue >1), but with a more interpretable factor loading. Similarly, the leftmost section of the preceding table represents the variation explained by the first solution; only four components in the initial solution have Eigenvalue >1, and the entire cumulative percentage weights 77.269 percent of the variability in the original variables. This suggests that four hidden influences are linked to quality management. However, the remaining components are unexplained variances since their Eigenvalue is less than one. Likewise, the rightmost half of the preceding table represents the variation explained by the extraction factor

after rotation.

The rotation factor model makes minor modifications to all four components. Following the completion of the aforementioned stage, which is the KMO and Bartlett's Test of Sphericity, the researcher conducted exploratory factor analysis utilizing the principal component extraction method with quartimax rotation and Kaiser Normalization. Kaiser normalization is used to provide solution stability across samples; in this analysis, all elements have equal weight while rotating. Similarly, quartimax is used for orthogonal rotation because it finds overall factors as well as optimizes squared loading such that each item loads most strongly onto a single factor. Similarly, orthogonal rotation analysis presupposes that all factors are independent or unrelated to one another.

**Table 10.** Exploratory factor analysis of components quality management.

Construct	Rotated component matrix			
	1	2	3	4
QP <sub>1</sub>	0.929			
QP <sub>2</sub>	0.912			
QP <sub>3</sub>	0.757			
QP <sub>4</sub>	0.840			
QP <sub>5</sub>	0.795			
QP <sub>6</sub>	0.856			
QC <sub>1</sub>		0.516		
QC <sub>2</sub>		0.762		
QC <sub>3</sub>		0.750		
QC <sub>4</sub>		0.900		
QC <sub>5</sub>		0.779		
QC <sub>6</sub>		0.850		
QA <sub>1</sub>			0.964	
QA <sub>2</sub>			0.473	
QA <sub>3</sub>			0.667	
QA <sub>4</sub>			0.979	
QA <sub>5</sub>			0.642	
QI <sub>1</sub>				0.903
QI <sub>2</sub>				0.736
QI <sub>3</sub>				0.689
QI <sub>4</sub>				0.855
QI <sub>5</sub>				0.883
QI <sub>6</sub>				0.502

Source: (Author survey, 2022)

Note: Extraction Method: principal component analysis  
 Rotation Method: Quartimax with Kaiser Normalization  
 Rotation coverage in 7 iterations

## 4. Results and Discussion

This section presents the descriptive statistics analysis of the research investigation and demonstrates how different manufacturing firms implement crucial quality management components. Based on the descriptive statistics obtained, under quality planning, there are six sub-criteria. Among these companies, employees are given adequate time to plan for and test improvement (-0.942) and each department and workgroup within this company/division/team maintains specific goals to improve quality (-0.849) that is exceptionally skewed negatively (-0.942). Under quality control, there are six sub-

criteria. All of them are skewed negatively. However, the quality and supervision organization is sited enough to ensure satisfactory quality control in the companies (-1.938), the company/division/department/teams have adequate knowledge to challenge quality control results in the organizations (-1.673), and quality control is performed efficiently at the companies (-1.519) are significantly skewed negatively. Similarly, under quality assurance, there are five sub-criteria.

**Table 11.** Descriptive statistics.

Manufacturing industries			
Construct	Std. deviation	Skewness	Kurtosis
QP <sub>1</sub>	1.2050	-0.942	-0.050
QP <sub>2</sub>	0.8982	-0.849	0.182
QP <sub>3</sub>	1.0241	-0.275	-1.038
QP <sub>4</sub>	0.5021	0.000	-2.034
QP <sub>5</sub>	0.8754	-0.514	-0.283
QP <sub>6</sub>	0.2148	-0.756	-0.124
QC <sub>1</sub>	0.9258	-1.938	2.643
QC <sub>2</sub>	0.7515	-0.348	-1.151
QC <sub>3</sub>	0.4602	-0.884	-1.240
QC <sub>4</sub>	0.9204	-1.673	-1.953
QC <sub>5</sub>	0.4920	-0.413	-1.860
QC <sub>6</sub>	0.4017	-1.519	0.312
QA <sub>1</sub>	0.8754	-1.321	1.450
QA <sub>2</sub>	0.4602	-0.884	-1.240
QA <sub>3</sub>	0.4602	-0.884	-1.240
QA <sub>4</sub>	0.8096	-1.159	-0.454
QA <sub>5</sub>	0.4602	-0.884	-1.240
QI <sub>1</sub>	0.8341	-1.251	1.615
QI <sub>2</sub>	0.9204	-1.673	1.953
QI <sub>3</sub>	0.8341	-0.191	-1.540
QI <sub>4</sub>	0.4920	-0.413	-1.860
QI <sub>5</sub>	0.8754	-1.321	1.450
QI <sub>6</sub>	0.4920	-0.413	-1.860

Source: (Author survey, 2022)

The companies/divisions/departments/teams view quality assurance as continuing the search for ways to improve (-1.321), and the company has an independent quality assurance department within the company (-1.159) that is strongly skewed negatively. Finally, under quality improvement, there are six sub-criteria. All of them are skewed negatively. Nonetheless, the company/division/department/teams provide highly visible leadership in maintaining an environment that supports quality improvement (-1.251), and the

company/division/department/teams allocate adequate organizational resources (e.g finance, people, time, and equipment) to improve quality (-1.673), and quality improvement only involves managers (-1.321) are significantly skewed negatively.

## 5. Conclusions

The present research contributes to the dearth of research on quality management components in emerging manufacturing companies, particularly in Ethiopia, whereas past research has solely, focused on the total quality management practices, however, this article has focused on exploring the crucial quality management components that are significant for the success of any manufacturing companies. And investigate the challenges of implementing crucial quality management components. Besides, for effective usage of quality management, participation, individual association, group soul, devotion, communication, and a qualified workforce are required. And normal preparation, best administration, worker engagement, arrangement, adequate asset assignment (individuals, machines, crude materials), and rectifying documentation are all vital. The outcome of the descriptive analysis support that the practicality of quality management components in selected manufacturing companies was found to be low throughout all tents, including quality planning, quality control, quality assurance, and quality improvement, according to an analysis of the quality management components self-assessment report evaluation.

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## THE INFLUENCE OF DIGITAL MARKETING ON CONSUMER BUYING INTEREST ON SHOPEE MARKETPLACE IN SOCIETY 5.0 (PEKANBARU CITY STUDENT CASE STUDY)

**Abstract:** This study aims to determine the effect of digital marketing on consumer buying interest in the Shopee marketplace in Society 5.0. This study uses a sample of 100 respondents, the respondents are Pekanbaru city students who have visited the Shopee marketplace. Sources of data used are primary data and secondary data, and the data collection method in this study used a questionnaire. The test used to test the research instrument is in the form of validity and reliability tests. The data analysis technique used descriptive statistics, classical assumption test, and simple regression analysis. The results of this study indicate that the independent variable of Digital Marketing can affect the dependent variable of Consumer Buying Interest. Based on the results of partial hypothesis testing, the independent variable Digital Marketing has a significant and positive effect on Consumer Buying Interest.

**Keywords:** Digital marketing, buying interest, Shopee, consumers, Society 5.0

### 1. Introduction

The internet is an information medium that provides convenience and facilities in obtaining the information needed. With advances in the field of information and communication technology, the world no longer recognizes the terms boundaries, distance, space or time (Margaretha, 2017; Wijaya et al., 2021; Handayani et al., 2022). In research conducted by Google and Temasek with the theme economy SEA 2018, the number of internet users in Indonesia was named the largest in Southeast Asia. In the Southeast Asian region there are 350 million internet users and 150 million from Indonesia (Hidayat et al., 2021; Putera et al., 2022; Norrahmiati et al., 2022). The more

advanced technological developments are also followed by the development of media, both online and electronic media. Now media online is not only used to find information, but online media has also become a business land or now often referred to as an online e-commerce business (Wijaya & Oktavianti, 2019; Wanidison & Shaddiq, 2021; Irpan et al., 2021).

E-commerce is an alternative for people who want to shop or find services such as online milk transport without having to meet and negotiate (Mewoh, Tampi, & Mukuan, 2019; Wagiono et al., 2022; Joko et al., 2022). Through survey data conducted by the Indonesian Internet Service Providers Association in 2020, Shopee is a popular Shopee marketplace with a percentage of

27.4% beating lazada, tokopedia, and marketplaces (Rizal et al., 2020; Surti et al., 2022). Shopee has a variety of features, namely; website, search engine marketing, email marketing, and social media marketing (Iyansyah et al., 2021; Shaddiq et al., 2021; Rizani et al., 2022).

Based on the results of survey, it shows that shopee users are millennials who average age 20-24 years. Which is generally at this age are millennials who have undergone education or as students. Generally, students do online shopping not based on needs alone, but for the sake of pleasure and lifestyle so as to cause someone to be extravagant or better known as consumptive behavior or consumerism behavior.

### **1.1 Problem formulation**

Apakah Digital Marketing has a significant effect on Consumer Buying Interest in Shopee Marketplace (Pekanbaru City Student Case Study)

### **1.2 Research objectives**

To see if there is a significant influence of Digital Marketing on Consumer Buying Interest in Shopee Marketplace (Pekanbaru City Student Case Study)

Benefits of research:

#### **a. Practical Benefits**

This research is expected to provide the right insights and strategies in the field of marketing that are able to attract the attention of consumers more than ever, and can be a material for strategic research for companies.

#### **b. Academic Benefits**

This research can be an example or guideline in making other scientific papers, and is also expected to add insight to readers.

## **2. Review the library**

### **Consumer Concerns**

Consumer behavior is the study of individuals, groups, and organizations selecting, buying, using, and utilizing goods, services, ideas, and experiences satisfying needs and their desires. According to Kertamukti (2015) a Brand Ambassador is an individual who is well-known (public figure) in a public for awards other than the products he supports. According to Setiadi(2019) to understand consumers and develop the right marketing strategy, we must understand what they think (cognition) and they feel (affection), what they do (behavior), and where (events around) that affect and are influenced by what the consumer thinks, feels, and does (Arizal et al., 2021; Fadilurrahman et al., 2021; Habibah et al., 2021).

#### **1. Factors affecting Consumer Behavior**

According to (Suharno&Sutarso, 2010) Stated that there are four main influencing factors in making a purchase, namely as follows: (1) Cultural Factors (2) Social Factors (3) Personal Factors (4) Psychological Factors.

### **Consumer Buying Interest**

According to Kotler and Keller (in Satria, 2017) consumer interest is the behavior of a person who has a desire to choose atau even buy a product, based on experience in choosing, using and consuming a product (Saputra et al., 2020; Norrahmi et al., 2021). Buying interest arises from experience and thinking so as to create motivation and become a strong desire to meet needs by actualizing those in one's mind. According to Putri (2018) consumers' buying interest is a process that exists between alternative evaluation and purchase decisions. After consumers evaluate existing alternatives, consumers have an interest in buying a product or service offered.

1. Consumer Buying Interest Indicator  
According to Tjptono (2007, in Masyithoh & Novitaningtyas, n.d.) : (1) Transactional Interests (2) Referenced Interests (3) Preferential Interests (4) Exploratory Interests.

### Digital Marketing

According to Puthussery (2020) digital marketing is the promotion of goods and services by utilizing digital technology, cellular, visual advertising, and other media. Digital marketing is based on online and offline internet systems that can build, promote, and distribute brand quality to all digital end users. According to Chaktin (2019) digital marketing or digital marketing is all efforts made in terms of marketing by utilizing internet-connected

devices with various strategies and digital media with The goal can be to communicate with consumers with online channels.

1. Indikator Digital Marketing  
According to Ryan (2009) namely: (1) Website (2) Search Engine Marketing (3) Email marketing (Social Media Marketing).

### 3. Research framework

The research framework is shown in figure 1, by hypothesis:

$H_1$ : There is a significant influence of *digital marketing* on consumers' buying interest in the shopee marketplace (Case study of Pekanbaru city students).

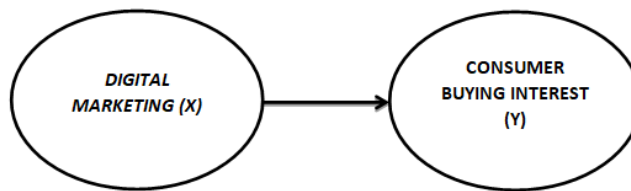


Figure 1. The research framework

### 4. Research methods

Method quantitative researcher. The type of population in the study ini is Non-Probability with the population being students of Riau Islamic University. The sampling technique uses Purposive Sampling Technique, with the following criteria: (1) Students who have visited the Shopee Marketplace (website/application), (2) Active students from 3 Pekanbaru campuses (3) Students who have received information from e-mail and Shopee Application. Jumlah Sampling determination uses a formula from Lemeshow (1997) and obtained result 96 which will be rounded into 100 respondents.

The sampling technique uses a questionnaire in the form of a google form (Gform).

### 5. Results and discussion

#### A. Validity Test

Based on the table 1, it can be seen that all R-count values > 0.195 which means all data valid.

#### B. Reability Test

From the results of the table 2, the Cronbach Alpha value is > 0.6, which means all data reliable.

**Table 1.** Validity Test

VARIABLE	ITEMS	PERSONS CORRELATION R CALCULATE	R TABLE	INFORMATION
DIGITAL MARKETING (X)	X01	0,891	0,195	VALID
	X02	0,932	0,195	VALID
	X03	0,942	0,195	VALID
	X04	0,956	0,195	VALID
	X05	0,963	0,195	VALID
	X06	0,950	0,195	VALID
	X07	0,958	0,195	VALID
	X08	0,947	0,195	VALID
	Y01	0,972	0,195	VALID
	Y02	0,953	0,195	VALID
	Y03	0,961	0,195	VALID
	Y04	0,967	0,195	VALID
	Y05	0,978	0,195	VALID
	Y06	0,974	0,195	VALID
	Y07	0,972	0,195	VALID
	Y08	0,979	0,195	VALID
BUYING INTEREST (Y)				

**Table 2.** Reability Test

Variable	Cronbach's Alpha	N Of Items	Information
Ambassdor Brand (X1)	0,982	8	Reliable
Trust (X2)	0,991	8	Reliable

**C. Classical Assumptions**

**1. Normality**

It can be seen from the table 3, indicating a significant value of  $0.165 > 0.05$ , which means that the data is distributed normally and is feasible to test.

are distributed normally and there are no symptoms of multicollinearity

**2. Multicollinearity**

From the table 4, it can be seen that the variable X1 has a tolerance value of  $1 > 0.10$ . Then it can be concluded that the data

**3. Heteroscedasticity**

From the figure 2, it can be seen that the dots spread out and there is no forming any pattern, which means that there are no symptoms of heteroscedasticity.

**Table 3.** One-Sample Kolmogorov-Smirnov Test

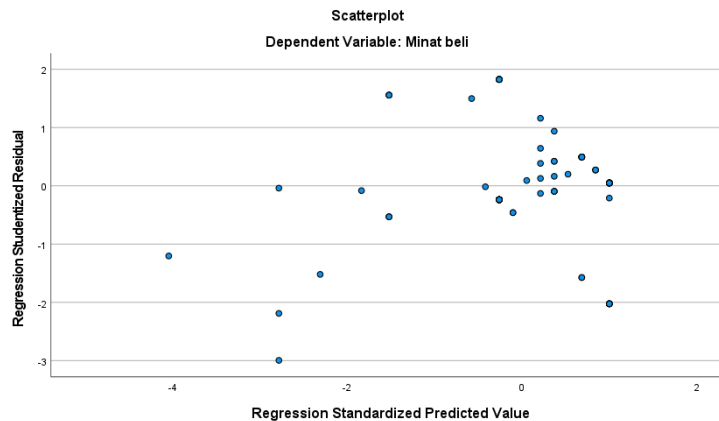
		Unstandardized Residual
N		100
Normal Parameters <sup>a</sup>	Mean	.0000000
	Std. Deviation	3.87716482
Most Extreme Differences	Absolute	.226
	Positive	.141
	Negative	-.226
Kolmogorov-Smirnov Z		2.263
Asymp. Sig. (2-tailed)		.165



**Table 4.** Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	5,371	2,113		2,542	,013		
	X	,861	,062	,816	13,952	<,001	1,000	1,000

a. Dependent Variable: Y



**Figure 2.** Scatterplot

### D. Simple Linear Regression Test

$$Y = a + b1X1$$

$$Y = 5,371 + 0,861X1$$

- Constant: 5.371

It can be interpreted that the Digital marketing variable (X) has not changed and

its value is fixed, then the Buying Interest variable (Y) value is 5,371

- Coeffesien X:0.861

If the value of the Digital Marketing variable increases by 1% then the Buying Interest variable (Y) will also increase by 0.861

**Coefficients<sup>a</sup>**

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5,371	2,113		2,542	,013
	Digital Marketing	,861	,062	,816	13,952	<,001

a. Dependent Variable: Minat beli

**Figure 3.** Coefficients

### E. KoeTestPhysioficial Determination

Based on the figure below, it can be seen that the coefficient result of determination ( $R^2$ ) is 0.751 derived from the squaring value of  $0.867 \times 0.867 = 0.751$ . The magnitude of

the coefficient of determination (*R Square*) is 0.751 or equal to 75.1%. This figure means that the *Digital Marketing* (X) variable partially affects the Consumer Buying Interest (Y) variable of 75.1%.

While the rest (100% - 75.1% = 25.9%) is influenced by other variables outside this regression equation or variables that are not studied. So it can be concluded that the free

variable, namely Digital Marketing, is able to influence the bound variable, namely Consumer Buying Interest.

**Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,867 <sup>a</sup>	,751	,748	2,960

a. Predictors: (Constant), Digital Marketing

**Figure 4.** Model Summary

**F. Hypothesis Test**

1. Partial Test (T Test)

T-test for Digital Marketing variable (X)  
 Based on the results of testing the hypothesis of product variation variables (X) showed a calculated t value of 13,952 > 1,984. Significant values of 0.01 < 0.05. So it can be concluded that product variations partially have a positive and significant effect on the influence of Digital marketing on consumers' buying interest in the shopee marketplace (case study of Pekanbaru city students).

**6. Discussion**

**1. The Influence of Digital Marketing on Consumers' Buying Interest on Shopee Marketplace (Pekanbaru City Mhasiswa Case Study)**

From the results of the tests that have been carried out, it is shown that Variabel Digital Marketing (X) has a positive and significant effect on Consumer Buying Interest (Y). So it can be concluded that the better digital marketing based on websites, search engine marketing, email marketing, and social media marketing, the more it will increase consumers' buying interest in the Shopee marketplace. This research is in line and strengthened by research conducted by (Masyithoh&Novitaningtyas, 2021; Kurniawan et al., 2021) which states that digital marketing variables have a positive and significant effect on buying interest.

**7. Conclusion**

1. The results showed that the Digital Marketing variable (X) had a positive and significant effect on the dependent variable, namely the consumer Buying Interest variable (Y.) So it can be concluded that the better Digital marketing is able to influence and encourage consumers' Buying Interest in the shopee marketplace (case study of Pekanbaru city students).

**7.1 Suggestion**

1. Further improve new Digital marketing strategies, and be able to provide innovations along with the development of Digital marketing. Improving the website to make it more practical and easier for consumers, as well as doing more vigorous promotions on social media, and making improvements to the shopee application which makes it easier for consumers to shop online.
2. It is hoped that this research can open wider insights both theoretically and practically. And it is hoped that this research can be carried out in depth such as adding variable ppcadvertising, affiliate marketing, online relationships, consumer relationship management and many more. By taking more and more diverse samples, such as all groups such as employees, students and housewives and others so that the results obtained are better and spread.

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## MODEL OF DEVELOPMENT AND IMPLEMENTATION OF IMS

**Abstract:** *This paper analyzes how a systemic approach to management can be used to facilitate the development and implementation of an integrated management system (IMS) within an organization. It is argued that every solution for integrating management systems requires two elements: a conceptual model and a supporting methodology. While research on IMS modeling is quite extensive, the development of methodologies for achieving fully integrated systems is still not at a satisfactory level. In the IMS acronym, particular emphasis is placed on the I (path to integration). The label M (Management) refers to the desired level of quality, while S (System) represents the methods and activities necessary to achieve the desired goal. It should be noted that all three concepts are directly related. From the above, it can be concluded that the development of IMS represents a broad field of diverse approaches. The paper presents an original model for the development and implementation of IMS systems, thus providing an approach and a set of criteria for selecting the most appropriate IMS model.*

**Keywords:** *IMS, integration, system, PDCA, synergy, model, management*

### 1. Introduction

In extensive literature in this field, there are numerous models of IMS. The research analysis aims to highlight the common integration models of several IMS, aspects related to IMS implementation, the benefits of IMS implementation, and the nature of integration strategies [11]. The research results provide valuable information that can be used to encourage the application of integrated management systems. Integrating documentation, followed by aligning internal objectives, processes, and finally resources, is one possible approach. Some companies integrate parts of MS documentation (e.g., policies), while others aim for full integration of objectives, processes, and resources. Therefore, partial and complete

integration are possible. Quality, environment, and safety are the most common, as the basic standards are easily accessible. Corporate social responsibility is also essential. In what order should selected management systems be introduced? This depends on existing systems and focus. Quality, followed by the environment and safety, is the most common order. Other possible sequences are considered by Karapetrović and Villborn (1998b), BPMJ. However, the practicality of this ultimate level of integration will probably be debated for a long time. [35]

### 2. Prerequisites for IMS

Moreover, companies should present their quality product and service-related issues.

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From these needs, the concept of integrated management systems (IMS) has been developed. In theory and practice, the question is posed as to why some companies integrate their management systems, while others with similar contexts do not even accept specific management systems. Understanding decision-making regarding IMS and the motivations that influence IMS implementation is crucial for two reasons: First, it will help theorists predict behavior during IMS implementation, and second, IMS will identify the mechanism that encourages implementation.

Effective communication of strategies and policies is critical to the sustainable success of an organization. Communication should be purposeful, timely, and continuous. A process-oriented approach based on the PDCA concept should be considered vital support, regardless of the methodology applied.

What are the necessary levels of integration? For example, Jonker and Klaver (1998) mention five: political, conceptual, systemic, normative, and pragmatic. It should be possible to use a common structure of policy, goals, control routines, monitoring, and improvement for general management. This is the way to achieve business goals through planning as a process that relates to the entire business system. In order to achieve defined goals, changes must be made in the business system, primarily in culture. Culture is made up of tradition, habits, and accepted behavior that are partly inherited and partly can be influenced by it. Culture is not a static concept, it develops slowly and is reflected in the policy of the business system, which is the basis for planning [39]. There is no unanimous definition of organizational culture. According to Gallea and Ghobadian (2004), some scholars describe culture as "shared values", another group as "way of working", and a third group considers it a combination of both.

However, there is a general consensus that culture is a dynamic concept that can be learned (Schein, 1990). Cultural changes can only be a matter of adapting to company values, not a true change in behavior. The authors suggest that while culture can be managed and specific values changed, the rationale for change affects the success of change efforts. It becomes critical that all participants understand the principles to be adopted and participate in their implementation: "the success assessment of change programs depends on the perception of what changes are supposed to achieve" (Ogbonna & Harris, 1998, p. 285).

A quality culture requires a combination of organizational culture, individual culture, and quality principles (Detert et al., 2000; Hildebrandt et al., 1991; Kanji & Iui, 1997). A strong quality culture includes customer orientation, continuous improvement, using data and analysis to support decision-making, and involving people in quality issues (Bahzad & Irani, 2008; Briscoe et al., 2005; Ishikava, 1984).

Vision is a guiding force that is the result of three components: openness, spontaneity, and a sense of reality. Openness is directed outwards, while spontaneity is directed inwards, accepting various positions from which the functioning of the system is observed. The synthesis of openness and spontaneity must be based on reality if we want the vision to succeed. Management values can stem from the vision and can be a powerful tool for consistent implementation of management in practice. [39].

### 3. IMS definition

The Integrated Management System (IMS) is defined as a set of interrelated processes that share a common set of human resources, information, materials, infrastructure, and financial resources to achieve composite objectives related to satisfying various stakeholders [1,2,3,4]. The Integrated



Management System (IMS) represents a management system that integrates all components of the business into a coherent system to enable the achievement of its purpose and mission through an integrated approach [5,6,7]. Quality, environment, and occupational health and safety often form the core of the IMS. Compatibility provides the opportunity to integrate the three systems into the organization. However, it should be noted that the three systems have their own specificities. ISO 9000 is customer-focused, ISO 14000 aims to support environmental protection and pollution prevention while promoting social and economic harmony, and OHSAS 18001 emphasizes proactive professional risk control and allows the organization to improve its safety and health of employees [9]. Resources include human and financial resources. The use of resources requires consideration of the similarities and compatibilities of the three systems in implementation. [5,6,7]. Different companies have different management practices for defining their mission, vision, strategy, including budget preparation, performance control, and motivation. It can be seen that there has been no real attempt to integrate the economy into the ISO system. We propose the following definition for a fully integrated management system: one that involves managing all relevant stakeholder needs, including all suppliers, customers, and other stakeholders in the supply network. Top management must be actively involved in conveying organizational goals and plans and in motivating and rewarding employees. Support and commitment from top management are essential for process integration and for maintaining and improving organizational processes. Resistance to integration is expected due to a lack of a strategic plan at the enterprise level, undefined responsibilities, and weak training (Sommerville & Savier, 1997). Therefore, people learn and develop a quality culture, which exists through the values that the

organization defends, the way of working, and collective learning (Gallear & Ghobadian, 2004). The main proposal for overcoming internal difficulties is a necessary cultural change, training, and education of all employees at all hierarchical levels to improve their understanding of the process and thus their motivation. If organizations are aware of the difficulties in integration, they will face the integration process more prepared, and the likelihood of successfully completing the process will increase, and staff training could help in this challenge. This can make organizations more efficient and competitive. (Sommerville & Savier, 1997) (Antunes, Cunha, & Barata, 2014; Antunes & Cunha, 2013).

#### 4. Level of integration

The scope of integration is often limited, which indicates that it is important to define what is meant by an IMS. If it is viewed as a fully integrated IMS, the mission, vision, policy, goals, organization, and roles should be well understood and accepted by the organization. The management system (MS) includes four main elements: policy, management objectives, management responsibilities, and process definition, to ensure performance improvement [12,13,14,15]. The system should be interpreted as a whole composed of a set of subsystems that group processes, which also include activities. The organizational system is based on the organizational structure in which management functions are applied. The correlation of all subsystems (organizational, informational, decision-making, and methodological) is the basis for the organizational structure that encompasses current internal management practices. In order to be considered as integrated parts of the company's management system, it is necessary to establish mutual connectivity between these subsystems so that there are no boundaries

between the company's processes [11].

The level of integration describes to what extent different systems have become one, ranging from a low level with some coordination to complete merging. In Bernardo et al. (2009), a model with four levels (0-4) is presented, showing eight different studies and their degrees of integration. Karapetrovic (2002) presents three possible levels of integration. The first level concerns the integration of documentation, i.e., a common manual with specific procedures required by different areas in the IMS. The second level concerns the alignment of basic processes, goals, and resources, i.e., directing the use of basic processes "by integrating planning, design, implementation, and other activities vertically through management systems." The third level relates to the creation of an "all-in-one system," i.e., a universal system that manages all previous systems in the organization. The implementation of different management systems is possible because there are common principles (process approach, PDCA, risk management, etc.), specifications and methods for integration, common elements of standards, and methods for aligning the interests of stakeholders. Partial implementation of standards/systems can be achieved by [34]:

- Inclusion, by creating documentation for the basic standard/system (QMS according to ISO 9001), and then expanding it according to the requirements of other standards/systems, and
- Addition, by having each standard/system have its own documentation that is interconnected.

The core that connects all management systems into one system is a process. In order to implement an integrated management system, the business system must meet the requirements of all integration standards. The question arises as to how to

do this, or which implementation approach to apply. Implementation of integrated management systems is a process like any other, which is used to convert inputs into outputs. The inputs to this process are the requirements of standards such as ISO 9001:2008, ISO 14001:2015, OHSAS 45001:2018, etc., and the outputs are documented quality management systems, environmental protection and health and safety management systems, and other systems. Like any other process, this process can be modeled in various ways. Depending on how the process of establishing an IMS is modeled and implemented, the results obtained at the output also depend.

There are three basic approaches to implementing integrated management systems:

- Sequential approach to implementing integrated management systems
- Parallel approach to implementing integrated management systems
- Combined approach to implementing integrated management systems

Since the object of IMS implementation is a complex production-business system that needs to meet the requirements of ISO 9001:2015, ISO 14001:2015, and ISO 45001:2018 standards, there is a dilemma as to which of the above implementation approaches is optimal.

The sequential approach to implementing integrated management systems proceeds in such a way that one management system is established first, followed by the second and then the third system. Since ISO 9001 standard is the first to emerge in 1987 and serves as the basis for other management systems, it is logical to establish QMS first, although this is not necessarily a rule in all three approaches (EMS or OHSAS can be established first, depending on the needs of the organization).

ISO has not developed a standard that would guide all organizations in implementing the system, but it has published an ISO manual (2008) that provides some guidance on integration, but nothing concrete enough to be illustrated by all organizations worldwide. A very important aspect of IMS is the common structure of updated ISO standards, which ensures management in all organization processes. An organization that already has an integrated management system has an advantage over an organization that does not have an integrated system. [30]

The advantages of IMS consist of risk reduction and profit increase, reduced documentation, identification of new customers, strengthening of market position, facilitation of staff training, continuous improvement, and implementation of a vision for future development [40].

It has been analyzed that just as there are advantages, there are also barriers and risks for implementing IMS, which have been identified in the literature: [1] [6] [8] [17] [40] [32].

Our proposal is that organizations should identify their stakeholders and their needs. These needs must be met efficiently by prioritizing and using existing standards and guidelines to build an IMS. The system's structure is determined by the mission assigned by the organization's management [24].

## 5. Basic aspects of modeling

Enterprise modeling is a dynamic process that never ends. It is a process of continuous improvement that adapts to real needs. For these reasons, it is necessary to have a good understanding of the goals and current state of the enterprise.

Modeling can be done from multiple aspects. Here, the functional aspect, information aspect, resource aspect, and organizational

aspect are particularly interesting. Each of them is discussed in more detail in [39] [43].

By modeling, we more efficiently define appropriate business processes and analyze their structure. The object of modeling in this paper is the enterprise, with the aim of facilitating its integration, which involves connecting into a whole that is more than a simple collection of parts.

The British Standards Institution (BSI) has prepared a publicly available specification (PAS 99:2006), which is a methodological guide for integrating two or more management systems, whether they already exist as independent or an organization has certified one and wants to align its business with the requirements of other management systems. The specification insists on two elements:

- a systemic approach to defining all processes and documents of the management system,
- treating risks.

PAS specifies common requirements for management systems and aims to provide a framework for implementing two or more standardized management systems in an integrated manner. [34]

The PAS 99:2006 specification issued by the BSI provides a recommendation on how to integrate the requirements of different management systems.

PAS 99 takes into account six common requirements for management system standards and follows the PDCA (Plan, Do, Check, Act) approach present in all major management system standards. By combining the PDCA cycle and common requirements, the structure of the management system is defined.

The PDCA model provides the framework for an IMS based on existing and accepted philosophies of QMS, EMS, and OHSAS. The model interprets the common elements of IMS, which organizations should consider when implementing such a system. The

model also indicates that the integration of documentation and verification forms is only part of IMS, and that other elements and factors will influence the achievement of organizational goals.

## 6. PDCA cycle

Similarities between the PDCA cycle and updated standard requirements can facilitate the integration process by developing an effective integration strategy [19].

Starting from the PDCA structure, the integrated management system is a complex construction that identifies common standard models and aims to leverage the advantages of several separate systems by making them work together as a unified whole.

Based on the PDCA cycle, Zeng et al. (2007) [19] proposed an interesting strategy based on three levels of integration: (1) strategic synergy is a priority, (2) organizational structure synergy, and (3) documentation synergy. The PDCA cycle is also advocated by Rebello (2014) [21], Nunhes et al. (2016) [17], Majernik et al. (2017) [22], Bernardo et al. (2018) [18], and Souza and Alves (2018) [23], who have proposed models similar to those of Zeng et al. (2007) [19], with minor differences in implementation, which from our point of view, have a chance of success in implementing IMS. The PDCA model has more and more supporters worldwide, and more and more organizations are implementing IMS according to the PDCA model.

As a result of the analysis of proposals for implementing IMS, it can be concluded that the use of the PDCA cycle can lead to the lowest implementation costs.

## 7. Synergy

The word synergy comes from the Greek word *syn-ergos*, which means cooperation or joint work. It refers to a type of reaction

where two factors combine to give a greater common effect than the sum of their individual effects. Simply put, synergy refers to the phenomenon  $2 + 2 = 5$ . A greater common effect as a goal was also the idea for this model.

"More than the sum of its parts" is the vision presented by Cunha and Figueiredo (2005) for the development of IMS. Their work was an inspiration and starting point for expanding the scope of knowledge in this thesis. IMS deals with the principles, policies, processes, and procedures needed to achieve quality goals (Zhu & Scheuermann, 1999). ISO 9001 is one of the most popular programs for IMS implementation (Sampaio, Saraiva, & Rodrigues, 2011; Zhu & Scheuermann, 1999), leading organizations to create a documented system for managing their quality efforts (ISO, 2008a). The biggest challenge that organizations face in their efforts to implement IMS is for quality to become a daily practice, internalizing quality principles in the development of a quality culture (Briscoe, Favcett, & Todd, 2005; Ishikava, 1984; Kanji & Iui, 1997; Kanji, 1998).

The synergistic IMS model (in three levels), authors [33], was developed in China based on research studies of the implementation of quality, environmental, health, and safety management systems.

At level 2, there are three pillars: resources, organization, and culture.

The synergy of organizational culture is also significant for the integration of the management system. The synergy between different responsibilities in the integrated management system and continuous performance improvement is most likely to be established as a result of high ambitions related to the integration process. Therefore, the management system must be internally implemented through the organization and externally through relationships with participants. The synergy of positive

interactions between top management and subordinate management systems increases innovative ability, problem-solving speed, and learning ability. [33]

## 8. Model of development and implementation of tqm system

The development and implementation of an IMS system involves a long and continuous process that must involve all the resources available to the business system. In short, various implementation strategies can be used for IMS integration. However, the development approach should be tailored to the organization. We believe that an approach focused on the PDCA concept and synergy is a very efficient approach.

The development and implementation of the IMS system are a continuous process that involves all business resources. This process can be divided into 6 phases [39] [43]:

- Determining the IMS strategy
- Preparation of IMS activities
- Development of an IMS system plan and program
- Development of an IMS system
- Implementation of an IMS system
- Improvement of the IMS system

Each of these phases contains several processes that continue or run in parallel with each other. This interdependence

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implies interaction from the perspective of synergy, which establishes a connection between all phases.

## 9. Conclusion

The main innovation of this research is the quality assurance approach based on synergy and the PDCA cycle. It has been shown that some human errors in quality assurance can be eliminated by proper use of synergy. In today's dynamic environment, it is not a question of whether management systems should be integrated, but which is the best for a particular organization. Since all organizations differ in their goals and established business culture, it is difficult to develop a single integration model that would meet the requirements of all organizations. For the success of management integration, it is crucial that the company analyzes the state of the company and ensures that all involved individuals understand the process before the actual start of the process. This is the only way for the implementation of an integrated management system to become an important factor in achieving sustainability. Finally, the need to align IMS with a comprehensive business strategy should always be a priority in order to provide significant support to organizational success.

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## OVERVIEW OF RISK MANAGEMENT TOOLS AND METHODS

**Abstract:** Due to the lack of a risk management system, many organizations in the world have suffered significant financial losses. Therefore, it is necessary for every organization to establish a risk management system as a structural element of the management system as a whole. The problem of risk management exists as a global problem that requires global solutions. One of the possible solutions is to meet the requirements of international risk management standards ISO 31000: 2009 and use risk assessment techniques in accordance with ISO / IEC 31010. The risk management system is compatible with the quality management system ISO 9001: 2008 and is based on the same principles. If the risk is not recognized and the organisation does not cope or is unprepared for the crises, the organization can suffer great losses. The review of tools and risk management tools creates preconditions for better preparation of the organization for crises, for better coping and faster exit from the crisis.

**Keywords:** Crisis, Risk Management Measures, ISO 31000: 2009, ISO/IEC 31010:2019

### 1. Introduction

Risk represents uncertainty in the outcome of expected events in the future, i.e. it is a situation in which we are not sure what will happen, and reflects the probability of possible outcomes around an expected value where „the expected value is the average result of unpredictable situations that recur“. In order to avoid crises in which non-recognition and untimely response to risks could lead us, it is necessary to assess all internal and external factors that may lead to the realization of the risk. The ISO 31000: 2018 standard, as a separate standard, has an advisory effect on the management, emphasizing the importance of timely and preventive mechanisms for risk detection. The ISO / IEC 31010 - Risk Assessment Techniques (International Standardization Organization / International Electrotechnical Commission) standard serves to support the

ISO 31000 standard through a quality management system. The most used are: HAZOP method, HACCP analysis, Brainstorming method, Risk mapping, Bowtie analysis, FMEA method of the risk assessment system, Pereto diagram and Ishikawa diagram. By applying the techniques prescribed in the internationally harmonized and recognized standard ISO / IEC 31010: 2019, it is possible to assess the significance of individual risks to the process or project and to create preconditions for an adequate response before risks bring the organization into crisis, which can result in major problems or even be disastrous for the organization.

### 2. Crisis

According to Osmanagić Bedenik (2010), the philosophical dictionary (1982) states that crisis (Greek: krisis) means "break, a

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transient difficult state in every natural, social and thought process" and that in ancient Greece the word „crisis“ meant „decision“. A crisis can be seen as an event or set of events that disrupts the current state of regular activities or as a potential threat in the future that needs to be detected in a timely manner with defined strategy to overcome or avoid it. The crisis is in most cases an undesirable situation for the organization, but it can also contain certain positive characteristics if the management responds in a timely manner and with an effective strategy, that turns the crisis in their favour. The negative characteristics of the crisis are certainly more numerous than the positive characteristics, so it is not surprising that most people perceive the concept of crisis in a negative context.

### 3. Risk and Introduction of Risk Management Measures

Srića (2011) states that "Risk represents uncertainty in the outcome of expected events in the future, i.e. it is a situation in which we are not sure what will happen, and reflects the probability of possible outcomes around an expected value" where "expected value is the average result of unpredictable situations which are repeated. Buntak and Kovačić (2020) state four types of risks in their risk matrix: dangerous risks (low probability, high impact); critical risks (high probability, high impact); minimal risks (low probability, low impact); routine risks (high probability, low impact). Observing the risks from the aspect of managers in a business organization, two types play the most important role, namely: "Business risks (occurring within cash flow), and Financial risks (related to the way the organization is financed, especially borrowing which can cause insolvency and bankruptcy.)"

The PDCA cycle (P-plan, D-do, C-check, A-act) serves as a support technique for the risk management because any action aimed at

risk cancellation is not final and requires continuous monitoring of the implemented risk management strategy with the aim of timely adaptation. The introduction of a risk management system in the organization reduces costs in the long term through preventive measures. In addition to the economic benefits for the organization, risk management creates a safer workplace by reducing business risks to a lower level. Organizations may introduce a specialized risk management department or authorize individuals or groups within individual departments to support the entire organization in risk analysis in its processes.

The following indicators appear as indicators of the necessity of introducing risk management measures:

- activity indicators: such as asset turnover ratio, current assets turnover ratio, receivables turnover ratio, inventory turnover ratio and supplier turnover ratio
- liquidity indicators: such as current liquidity ratio, accelerated liquidity ratio, current liquidity ratio and financial stability ratio
- indebtedness indicators: such as indebtedness ratio, own financing ratio, financing ratio and interest cost coverage
- cost-effectiveness indicators: such as cost-effectiveness of total business and cost-effectiveness of business (sales)
- profitability indicators: such as return on assets (ROA) - return on total assets, return on equity (ROE) - return on invested capital, gross profit margin and net profit margin
- investment indicators: such as return on investment (ROI) - return on investment, earnings per share (EPS) - earnings per share, dividends per share (DPS) - dividend per share, dividends payout ratio (DPR) - dividend payment

ratio, price per share (PPS) - total return on shares and dividend yield.

These indicators are used to analyse the business of the organization and may indicate certain imbalances in business that need to be managed in a timely and effective manner.

#### 4. Application of Standards in Risk Management

Risks are events that may or may not occur, but it is necessary to consider the broader context of events and to reduce the impact of risks on the outcome with the quality planning or to avoid them completely by continuous monitoring and adaptation of the strategy. In order to detect risks, it is necessary to assess all internal and external factors that can lead to the realization of the risk. Risk management needs to be handled responsibly and thoughtfully due to the possible damage that may result from the insufficient quality of management's approach in acting on them. Systematic risk management must be seen in the form of continuous monitoring and timely action with the aim of complete elimination or reduction of harmfulness within various departments of the organization.

The quality management department may take a decision on the implementation of the ISO 31000: 2019 standard for risk management in departments and on the implementation of the ISO 22301: 2019 standard intended for the management of continuity and consistency. The ISO 9001: 2015 standard is one of the key standards in the quality management system, and according to Džolan (2017) it "includes risk identification, risk analysis, risk categorization, control and risk reassessment." Vuković (2015) states that "the current draft ISO 9001: 2015, although it sets requirements for risk assessment, does not require the existence of a formal risk management system". The standard ISO

22301: 2019 defines guidelines for business continuity management in organizations. As a rule, it is associated with the security of information systems in which there are significant risks of personal data theft and misuse.

ISO 31000 defines the principles and guidelines of risk management and is not intended for certification, but serves to raise awareness of organizations about the possibility of implementing additional security aspects in business to prevent unwanted and unnecessary losses that may arise from inadequate approach to risk management. The ISO 31000: 2018 standard, as a separate standard, has an advisory effect on management, emphasizing the importance of timely and preventive mechanisms for risk detection. Management principles and risk assessment techniques defined in the ISO 31000 family are key prerequisites for the evolution of business towards a quality management system through the implementation of standards intended for environmental management (ISO 14001: 2015 - environmental management systems) and standards for safe drinking water supply (46001: 2019 - water safety management system for human use) by using the information on risks in processes that may harm biodiversity and human, plant and animal health through negligent handling of harmful substances. Increasing the safety of products intended for human consumption can be achieved by implementing the HACCP method, which creates control points in which the harmfulness and deviations of substances in products are examined, thus preventively responding to the possible realization of risks in consumption by end users.

ISO / IEC 31010 - risk assessment techniques (International Standardization Organization / International Electrotechnical Commission) standard serves as a support to ISO 31000 standards through a quality management system. The first version of the

ISO 31010 standard appeared in 2009, and in the meantime, it has been adapted and reissued in the form of ISO 31010: 2019. The techniques of the ISO / IEC 31010 standard consist of a wide range of qualitative and quantitative analyses which can provide a closer insight into the realization of the effects of risk in individual processes. For maximum utility of the techniques, it is necessary to educate people in managerial positions in departments in order to have a balanced effect on risks throughout the organization. The greatest effectiveness comes from a combination of the techniques themselves to get a broader picture and provide a greater chance of identifying, analysing, evaluating, and determining treatments with the objective of eliminating threats to the vitality of the organization. ISO / IEC 31010 techniques

offer both qualitative and quantitative methods of risk assessment, but each technique is unique and has a different form of application in the risk assessment process, and therefore it is recommended to combine techniques to achieve the most accurate assessment used by risk management to decide on further steps related to risk management. The usual practice of linking is based on risk assessment through techniques that provide the possibility of their identification, which is followed by support in the form of numerical evaluation, statistical analysis and creating a visual representation in accordance with the identified intensity of certain assessed risks. The current version consists of 31 techniques that provide qualitative and quantitative support in the identification, analysis, evaluation and treatment of risk:

**Table 1.** List of ISO / IEC 31010 risk assessment techniques

Oluja mozgova	Analiza uzroka i posljedica
Strukturirani /djelomično strukturirani intervju	Analiza uzroka i efekata
Delphi tehnika	Analiza slojevite zaštite (LOPA)
Liste provjere	Stablo odlučivanja
Analiza primarnih opasnosti (PHA)	Analiza ljudske pouzdanosti (HRA)
Analiza opasnosti i operativnosti (HAZOP)	Leptir mašna analiza ("Bowtie")
Analiza opasnosti i kritičnih točaka (HACCP)	Održavanje usredotočeno na pouzadnost
Procjena rizika u okolišu	Analiza informativnog kruga
"Što ako?" tehnika (SWIFT)	"Markov" analiza
Analiza scenarija	"Monte Carlo" simulacija
Analiza poslovnog utjecaja	Bayesova statistika i mreže
Analiza korijena rizika	FN krivulja
Analiza posljedica pogrešaka (FMEA)	Indeksiranje rizika
Stablo problema	Tablica vjerojatnosti i posljedica
Stablo događaja	Analiza troškova i koristi (CBA)
	Analiza višekriterijskog odlučivanja (MCDA)

Source: Kundih, D.: Risk management in the circumstances of the crisis situation, Final thesis, Koprivnica 2020, p 31.

**Table 2.** Analysis of risk assessment techniques ISO / IEC 31010: 2019

TEHNIKE PROCJENE RIZIKA	PROCES PROCJENE RIZIKA				
	IDENTIFIKACIJA RIZIKA	ANALIZA RIZIKA			VREDNOVANJE RIZIKA
		POSljedICE	VJEROJATNOST	RAZINA RIZIKA	
Oluja mozgova	■	■	■	■	■
Strukturirani/ djel. strukturirani intervju	■	■	■	■	■
Delphi tehnika	■	■	■	■	■
Liste provjere	■	■	■	■	■
Analiza primarnih opasnosti	■	■	■	■	■
Analiza opasnosti i operativnosti	■	■	■	■	■
Analiza opasnosti i kritičnih točaka	■	■	■	■	■
Procjena rizika u okolišu	■	■	■	■	■
“Što ako analiza”	■	■	■	■	■
Analiza scenarija	■	■	■	■	■
Analiza poslovnog utjecaja	■	■	■	■	■
Analiza korijena rizika	■	■	■	■	■
Analiza posljedica pogrešaka	■	■	■	■	■
Stablo problema	■	■	■	■	■
Stablo događaja	■	■	■	■	■
Analiza uzroka i posljedica	■	■	■	■	■
Analiza uzroka i efekata	■	■	■	■	■
Analiza slojevite zaštite	■	■	■	■	■
Stablo odlučivanja	■	■	■	■	■
Analiza ljudske pouzdanosti	■	■	■	■	■
Analiza leptir mašne	■	■	■	■	■
Održavanje usredotočeno na pouzd.	■	■	■	■	■
Analiza informativnog kruga	■	■	■	■	■
“Markov” analiza	■	■	■	■	■
“Monte Carlo” simulacija	■	■	■	■	■
Bayesova statistika i mreže	■	■	■	■	■
FN Krivulja	■	■	■	■	■
Indeksiranje rizika	■	■	■	■	■
Tablica vjerojatnosti i posljedica	■	■	■	■	■
Analiza troškova i koristi	■	■	■	■	■
Analiza višekriterijskog odlučivanja	■	■	■	■	■

■ **strogo preporučeno**      ■ **može se upotrijebiti**      ■ **nije primjenjivo**

Source: Kundih, D.: Risk management in the circumstances of the crisis situation, Final thesis, Koprivnica 2020, p 32.

The HAZOP (Hazard and operability studies) method is currently the first choice for identifying weaknesses in the design process and is used worldwide within the manufacturing industry. Outside the manufacturing industry, it is used in a modified form.” (Crawler and Tyler, 2015). According to Čičak (2017), one of the biggest disadvantages of this method is that „it is not possible to analyse more complex situations and complex systems, such as situations created by the simultaneous

occurrence of multiple independent events“.

HACCP (Hazard analysis and critical control points) analysis is based on the definition of critical control points within the risk assessment process and is most often used as a technique in the food industry. Critical points are a key factor in evaluating a particular service or product because of the knowledge of potential deviations from acceptable values, which provides guidelines for further action to align the end service or product with that defined in the organization

plan thus ensuring consistency and quality maintenance.

The brainstorming method is primarily a qualitative method of imaginative analysis of potential problems and solutions in a particular process. In the field of risk analysis, brainstorming can identify certain threats that may arise in the process. To manage them successfully, it is necessary to use other techniques that include a quantitative component of risk management due to accuracy and defined numerical values that describe in more detail their significance on conducting a particular project with much greater precision and the ability to rank risks according to the priorities they represent in a particular process.

**Risk mapping** - The process of risk mapping defines the identification of risks, quantification of their impact and probability, and the addition of a label that is later applied to visual tools such as a matrix display and scoring scale. Risk scoring is performed by multiplying the assumed probability of realization of the source of danger and its impact on the process itself, and for a given risk a label is set which is later incorporated into the matrix display and scoring scale. The scoring scale groups risks according to intensity through probability and impact analysis. The matrix presentation defines risks according to significance and probability. The specified matrix can determine whether it is a dangerous, critical, minimal or routine risk.

**Bowtie analysis** is a visual representation of the input values, potential hazards and outcomes that result in the realization of hazards. With this analysis, it is possible to see the broader context of a particular hazard and thus point to the need to create guidelines with the aim of effective preventive action aimed at eliminating the hazard. The wider possibility of applying bowtie analysis manifests through combining with techniques that complement

the hazards defined by the analysis by adding quantitative features that can more closely define the criteria by which management is directed towards preventive action on hazards. Šotić (2016) states that the "objective of risk analysis is to describe the risk, i.e. to present an informative picture of risk. ", and also explains that "to present such a picture in the dissertation is used a "bow-tie" diagram, which illustrates the building blocks of risk, i.e. risk analysis."

FMEA method of risk assessment system (Failure Mode and Effect Analysis) is a method that prevents risks and minimizes their impact through a planned approach. In practice, the name FMECA method (Failure Mode and Criticality analysis) is also used. According to Dobrović (2008) "FMEA is a method that maximizes customer satisfaction by completely eliminating or partially reducing the causes of potential problems. In order to achieve this, the FMEA needs to be implemented as soon as possible, regardless of the fact that not all data or information is fully known at a given time. " ISO / IEC 31010: 2019 recognizes four basic types of application of FMEA analysis: 1. FMEA system; 2. FMEA design; 3. FMEA processes and 4. FMEA services. Buntak et al. (2014) state that "regardless of the risks involved, the FMEA method can reliably assess the possibility of their realization through the calculation of RPR factors, whose acceptable values are predetermined" where the RPR factor is defined as the level of potential risk.

The Pareto diagram is a method that determines that 80% of all nonconformities account for 20% of the problem. The evaluation process consists of the detected frequency of non-compliance in the sample expressed as a percentage in the order from highest to lowest and by expressing the cumulative values which according to the ABC structure are classified into classes A (up to 80% of cumulative), B (80% up to 95% of cumulative) and C ( 95% -100% of

cumulative). This diagram can identify key risks on which management can base further guidance.

The Ishikawa cause-and-effect diagram is used to analyze the factors that lead to a particular problem through evaluating items from the problem cause groups. Based on the information obtained, the probable causes that lead to the problem can be identified. The diagram is named after the creator Kaor Ishikawa, for whom Pipušić and Grubinić (2014) state that he "advocated the thesis that quality improvement is a continuous process that can always be further improved." It is also called a fish bone diagram because of its characteristic appearance. According to Čelar et al. (2014) Ishikawa "in his considerations found that there are 6 major groups of causes in the occurrence of errors and called them 6M: machine, method, material, man (man power, mind power), measurements and the environment (Milieu / Mother Nature)."

## 5. Conclusion

Risk cannot be avoided because there is no entrepreneurial activity without risk. Risks

should be taken, but in a planned way. Risk should be accepted as a reality and everything should be done to get to the risk management phase. The risk management system should be a structural element of the management system of the organization as a whole. Risk management is a necessary component of any business organization. With an adequate approach, it reduces potential losses in the long term, which can have disastrous proportions for their further business and even survival. Using ISO / IEC 31010: 2019 risk assessment techniques, such as FMEA method, HACCP method, HAZOP method, Bowtie analysis, brainstorming and many others, it is possible to approach certain threats and danger to the organization and to lay the foundations for the prospective success of crisis avoidance and crisis situations and to better overcome and prepare organization's management in crisis situations. A review of risk management tools and methods discussed in this paper leads to a conclusion that it is very important to make management aware of the need to integrate risk management into the business process in order to identify in time all the risks that could lead to a crisis.

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## THE IMPACT OF QUALITY COSTS ON THE LEVEL OF IMS MATURITY

**Abstract:** *The paper presents an overview of the impact of quality costs on the development and implementation of an integrated management System (ISO 9001:2015, ISO 14001:2015, and ISO 45001:2018). Based on the assessment of the current state, the values of scrap and complaints in production business Systems of complex structure were obtained. It is shown how continuous improvements can reduce costs and increase the efficiency of IMS if the causes of their existence are eliminated through improvements. The framework of all three Systems functions on the basis of the PDCA cycle of continuous improvement, which is the key to all three standards. This is another reason that has enabled us to combine three Systems into one Integrated Management System and to increase the maturity level of IMS through improvements.*

**Keywords:** *Business effectiveness, cost efficiency, integrated management System s, international standards, compliance control, process management, management System s, IMS, PDCA*

### 1. Introduction

Integration of management Systems is increasingly being seen as an imperative for optimizing and increasing organizational management efficiency. In today's dynamic environment, the question is not whether management Systems should be integrated, but rather which one is best for a specific organization. Since all organizations are different in terms of their goals and established business culture, it is difficult to develop a single integration model that would meet the requirements of all organizations.

For the success of management integration, it is crucial that the company analyzes the situation and ensures that all involved individuals understand the process before the start of the integration process. This is the

only way in which the implementation of an integrated management System will become an important factor in achieving sustainability and cost reduction.

However, first there needs to be a parallel drawn between the concept of management Systems and the concept of management. It is a misconception that these two concepts are identical. They have the same structure, but different perspectives. The management System only encompasses technical resources, while management also manages human resources, with the goal of achieving performance.

If we focus only on performance, we cannot do business well. The same situation is true for the management process. Isaac Adizes says, "I do not agree with authors whose focus is solely on managing results. It should be managing for results, with appropriate

processes." Primary attention is focused on the goal, but not on the means to achieve that goal. Almost all organizations prioritize financial results as their primary plan. By introducing a quality System into their organizations, many managers think they will solve all problems, including financial ones. Unfortunately, this is not the case, especially in the first years after introducing a quality System, particularly if the quality System is falsely introduced rather than real.

## **2. Correlation between costs and level of IMS**

Performance means achieving specific, measurable results in terms of meeting goals. An efficient management System that supports leadership enables managers to quickly analyze and evaluate achievements or performance in an appropriate form - tailored to their role and responsibility - in accordance with aspects of productivity/profitability, quality, environmental and occupational health and safety. Furthermore, measuring performance in these categories allows a well-founded management assessment of leadership in a pragmatic relationship with specific leadership requirements and established standard requirements.

From an economic perspective, performance focuses on measurements of cost/benefit (productivity, level of performance, yield...) that are suitable for the business model. Goals and measurement parameters need to point towards strategic positioning (cost management, niche positioning, etc.) and orientation. Productivity and quality are closely related according to contemporary understandings of performance. Key performance indicators are considered part of quality indicators. Costs can be shown, but benefits cannot be clearly assigned; therefore, the focus is on cost reduction, not maximizing return on investment.

Observations about the high cost due to a lack of training or personal risks for managers due to non-compliance with legal requirements usually become extremely important only in the case of actual damage. Complaints, waste, environmental damage, and scrap increase the potential for damage, which means that the benefit that arises from consistently applied Integrated Management System is often only visible through potential damage. Figure 1 shows the correlation between the amount of damage (scrap, complaints, rework...) and the maturity level of the Integrated Management System.

## **3. Assessment of the current state**

### **3.1. Methodology for evaluating the current state**

The necessary conditions for a realistic assessment using this methodology are:

- elimination of the subjectivity of the assessor,
- analysis of all processes, activities, and accompanying documentation, and
- direct collaboration and objective relationship between the management and the assessor.

Three business Systems were used for the analysis:

System A is a business System with more than 100 employees. This System has decades of experience in cigarette production, with significant production and personnel resources.

The second characteristic System examined is business System B in the food industry with 80 employees. The System has equipment for the production of juices and oils.

The third characteristic analyzed System is System C in the field of paper packaging

production.

A very small number of companies track quality costs. Quality costs do not solve the problem themselves, but are just a tool that helps management understand the importance of problems in the process. Therefore, it is necessary to solve the problem of collecting data on quality costs and establishing a relationship between total quality costs, external, internal, and prevention costs.

For each subSystem of the observed

companies, a certain number of questions were formulated. Each question was given attributes in the range from "poor" to "excellent", with a real basis for obtaining an appropriate rating of both the entire System and its subSystems, using numerical values from 0 to 10. The rating for each question is recorded in a table as shown in Figure 1. Each question is assigned a certain number of points in advance according to its importance.

**Table 1.** Table for assessing the current state

Grade	Assigning the maximum number of points for a question	Satisfaction assessment	Number of points		
<b>BAD</b>	<b>WEAK</b>	<b>UNCONVINCING</b>	<b>BORDERLINE</b>	<b>CAPABLE</b>	<b>EXCELLENT</b>
0	2	4	6	8	10
0%	20%	40%	60%	80%	100%

After answering questions within a subSystem, the summary table is filled in as in Table 2, with the final evaluation of that

request. Results obtained by testing are presented in Table 3.

**Table 2.** Table for evaluating requests

Assigned maximum number of points	Earned number of points	Satisfaction percentage	Request evaluation

**Table 3.** Table for evaluating requests

<b>External costs</b>			
Name	SYSTEM A	SYSTEM B	SYSTEM C
Complaint costs	6.66	7.68	7.98
Transportation and travel costs	2.70	1.69	3.75
Other external defect costs	3.80	1.69	1.25
<b>Total</b>	<b>13.16%</b>	<b>11.06%</b>	<b>12.98%</b>
<b>Internal costs</b>			
Name	SYSTEM A	SYSTEM B	SYSTEM C

Scrap costs	36.18	0	31.92
Rework costs	5.71	29,00	11.92
Other internal defect costs	8.57	9.39	5.29
<b>Total</b>	<b>50.46%</b>	<b>38,39%</b>	<b>49.13%</b>
<b>Preventive costs</b>			
Name	SYSTEM A	SYSTEM B	SYSTEM C
Quality planning	1,6 %	1.9%	1.6%
Personnel training	1.9%	3.4%	5.29%
Process analysis and improvement methods	?	?	?
Quality monitoring	?	?	?
Equipment development and other costs	?	?	?
<b>Total</b>	<b>3.6 %</b>	<b>5.3 %</b>	<b>6.89 %</b>
<b>Assessment costs</b>			
Name	SYSTEM A	SYSTEM B	SYSTEM C
Laboratory testing	8,57	11,95	7,98
Energy costs	?	?	?
Control costs	13,33	7,68	9,32
Depreciation	?	?	?
Service costs	2,6	3,72	2,1
Measurement equipment costs	?	?	?
Material costs	?	?	?
Other costs	?	?	?
<b>Total</b>	<b>24,5 %</b>	<b>23,35 %</b>	<b>18,4 %</b>

BUSSINES SYSTEM A	91,72 %
BUSSINES SYSTEM B	78,1 %
BUSSINES SYSTEM C	87,4 %

From Table 3 it can be seen that for some costs there is no data, so the values for these costs were estimated. Also, it can be seen from the table that the sum of these costs is not 100%, which means that the costs for which there is no data make up the difference up to 100%. If prevention and assessment costs increase, total quality costs decrease. If the scope of preventive activities increases, total error costs decrease. In order to prevent future nonconformities, it may be necessary to modify the project, development process, production, packaging, transportation, or storage, to revise product specifications or revise the quality SYSTEM.

From Table 4, it is noticeable that a high percentage of quality costs for all business SYSTEM s are due to scrap, rework, and repairs, which means that attention must be

paid to reducing internal and external errors. For such a high percentage of costs, the optimal strategy is investing in preventive activities which significantly reduces the costs of internal and external deficiencies. It is necessary to define which activities must be carried out to achieve the desired improvement, which would correspond to effective and efficient business operations. Obviously, these activities cannot be achieved without strategic quality planning from which improvement projects arise. Activities within the projects must be implemented step by step, because gradual and careful implementation of each step converges to a positive and efficient solution to the problem.

Table 4 provides values for scrap, rework, and complaint costs in percentage and in euros, while Fig. 2 shows a diagrammatic

representation of these costs for all three states. Analysis and reports on quality costs have a purpose only if corrective actions are taken based on them.

Corrective actions can be directed towards:

- eliminating quality deficiencies that are realized by professional services within normal authorization,
- eliminating deficiencies based on quality improvement programs. Corrective measures are used when

deficiencies are of such a nature that their causes are unknown or are only assumed. In this case, a team of experts from various fields should be formed to conduct analyses and identify causes, and then define measures to solve the problem,

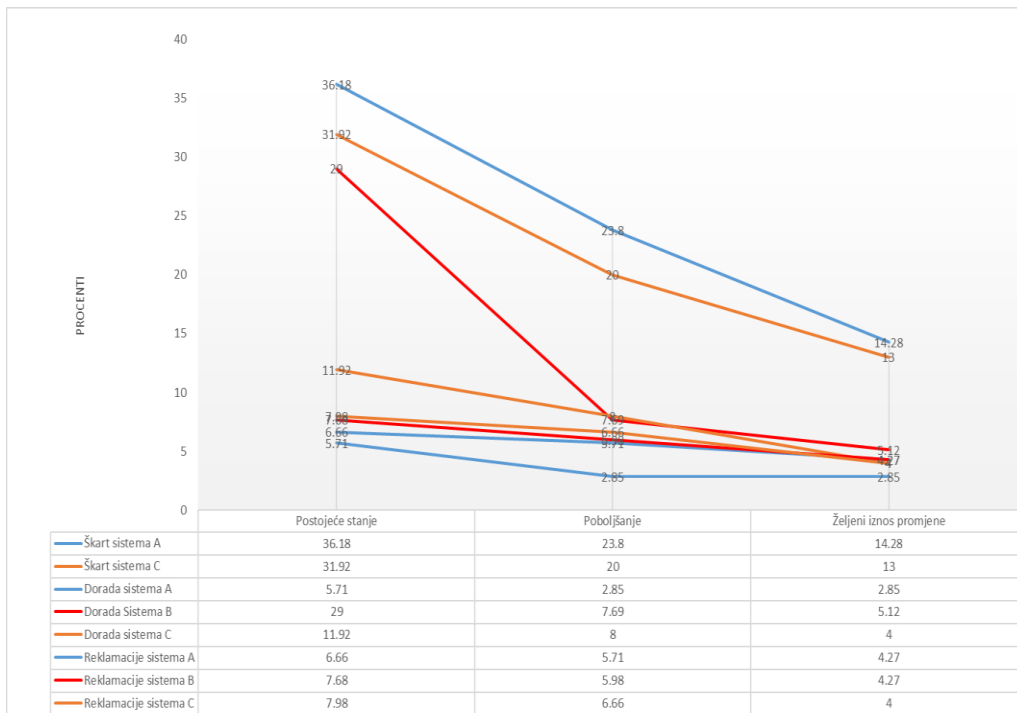
- regardless of the corrective action taken, the initiative must come from the management of the company.

**Table 4.** Values of scrap, rework, and complaint costs

	EXISTING STATE	IMPROVEMENT DESIRED	AMOUNT OF CHANGE
Scrap			
System A	36,18% 110760	23,8% 72868	14,28% 43721
Savings		12,38% 37891	21,28% 67039
System B	0	0	0
Savings	0	0	0
System C	31,92% 3050	20 % 1906	13 % 1271
Savings		11,92% 1143	18,92% 1779
Correction			
System A	5,71% 17478	2,85% 8744	2,85 % 1023078
Savings		2,86% 8744	2,85 % 8744
System B	29% 12929	7,69% 3422	5,12% 2281
Savings		21,3% 9507	23,88% 10648
System C	11,92% 289	8% 762	4% 381
Savings		3,92% 381	7,92% 762
Complaints			
System A	6,66% 20403	5,71% 17488	4,27% 8744
Savings		0,95% 2915	3,81% 11659
System B	7,68% 3422	5,98% 2664	4,27% 1901
Savings		1,7% 757	3,41% 1521
System C	7,98% 762	6,66% 635	4,0% 127
Savings		1,32% 127	3,98% 381

Based on the values from Table 4, a diagram in Figure 2 was constructed, where the values for scrap, complaints, and rework costs are graphically represented for all three business SYSTEMS. The results for the case

of improvement and the desired amount of change are also graphically presented. As costs decrease, the maturity level of the IMS increases.



**Figure 1.** Diagram representation of scrap, rework, and complaints costs

## 4. Conclusion

In order to reduce quality costs, it is necessary to apply an effective improvement strategy. This involves focusing on preventive costs and appraisal costs. It has been proven on a concrete example that this approach reduces scrap and rework costs. Integrated management SYSTEM can

represent a very small, but sufficiently large basis for building business excellence, because it enables the organization to gradually shift its focus from customers only to all stakeholders. Integration of management SYSTEMs is crucial if companies want to achieve greater optimization and efficiency in their management.

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## EVALUATING SCOR METRICS OF SUPPLY CHAIN PERFORMANCE BASED ON INVENTORY MANAGEMENT

**Abstract:** *Because Supply Chain Performance coordinates Inventory Management under the SCOR Metrics paradigm; this research was performed to evaluate the SCOR Metrics of Supply Chain Performance based on Inventory Management at Shiraz Petrochemical Company of Iran. Performance indicators, as Alternatives; and Inventory Management factors, as criteria; were extracted from the research literature. The research method was descriptive-analytical, employing a hybrid FAHP-SCOR approach. Consequently, after weighing the criteria, the five alternatives have been prioritized. The results of this study lead to two deductions: firstly, the type of production is the most important factor in Inventory Management. Secondly, companies with a complex supply chain need to carry out processes to strike the right balance between the size of their inventory. The findings of this study can be applied to all petrochemical industries as a strategic plan.*

**Keywords:** *Supply Chain Performance, Inventory Management, SCOR, FAHP*

### 1. Introduction

In today's global situation, despite the challenges in supply chain management (SCM), including competition, changing markets, globalization, and balancing supply and demand (Ben-Daya et al., 2022), it is necessary to provide a variety of products according to customer demand. The customer's demand for high-quality service has faced company challenges. Consequently, in today's competitive market, economic, manufacturing, and service enterprises, in addition to managing internal resources, have found themselves in need of managing and monitoring resources and elements outside the organization. This approach is to gain a competitive advantage that companies intend to gain a larger share of the target market (Sigh et al., 2018; Solke et al., 2022; Subramanian and Suresh, 2022).

Accordingly, activities such as dynamic supply and demand planning, material procurement, production planning, logistics, inventory management, distribution, delivery, and just-in-time customer service, which were previously performed at the company level, are now transferred to the value chain level. The basic point in a supply chain is the management and coordination of all these activities; It is such that customers can receive quality products and lean services in the shortest time and at the lowest cost (Tan and Sidhu, 2022).

Many studies have been done on different dimensions of the supply chain inventory (Daryanto and Wee, 2020). Multiple models have been introduced to appraise the supply chain performance. In 1996, the Supply Chain Association introduced the Supply Chain Operations Reference (SCOR) model, which is presented as a standard reference

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for SCM. It helps companies increase their supply chain's effectiveness and provides a process-oriented approach to SCM (Huan et al., 2004). As companies move toward SCM, evaluating Supply Chain Performance seems more necessary. Notably, traditional evaluation methods are less related to SCM because the scope they examine is much more limited than examining a wide range of evaluation activities (Ricardianto et al., 2022; Rodríguez Mañay et al., 2022).

From the establishment of Shiraz Petrochemical Company in 1959 until now, the National Iranian Petrochemical Company (NPC), as one of the country's main industries in creating added value from oil and gas resources, has been a pioneering and value-creating industry. This industry plays a crucial role in Iran's financial and economic prosperity, sustainability in development, localization of technology acceptance, growth and development of downstream industries, and creation of full employment. The main advantage of this industry in Iran is the variety of feedstock resources, access to the high seas, and specialized human resources (National Iranian Petrochemical Company, n.d.).

Shiraz Petrochemical Company, the first production unit of NPC, produces nitrogen fertilizers. The company started with the operation of four production units for ammonia, urea, nitric acid, and ammonium nitrate, as well as a unit for providing ancillary services (water, electricity, steam, and compressed air). At present, the effort and importance of the company's management and employees to improve the quality of the work environment have led to obtaining certificates in quality assurance management, environmental management, and professional occupational health and safety management (Shiraz Petrochemical Company, n.d.).

Therefore; in the current unfavorable economic conditions of the country, with the proper knowledge of the market and with the

help of proper SCM, from the purchase of raw materials to sales and after-sales services, and paying attention to the Inventory Management approach of smoothing the supply chain processes (Ben-Daya et al., 2022), it is possible to help the continuity of production and sales in the market. In this field, much research has been done so far, but comprehensive research that deals with the performance of SCM, identifying and ranking essential indicators, and applying a comprehensive approach to performance evaluation in Shiraz Chemical Company has not been done, which adds to the importance and necessity of this research.

Accordingly, in the present research, we intend to evaluate the indicators of Supply Chain Performance based on Inventory Management at Shiraz Petrochemical Company. This research aims to combine FAHP and SCOR in evaluating SCM indicators based on Inventory Management at Shiraz Petrochemical Company of Iran.

## 2. Literature review

### 2.1. Supply chain management

Today, SCM is considered one of the infrastructure bases for implementing electronic business worldwide. In today's global competition, various products should be made available according to the customer's demand (Richey et al., 2022). A short definition of the supply chain is that supply chain management includes all physical and informational activities related to the flow and transformation of products, from raw material extraction to final product delivery (Mentzer et al., 2001). The main processes of sustainable supply chain operation are as follows: information management, logistics management, and communication management.

### 2.2. Information management

Today, the role and position of information are clear to everyone. The correct circulation and transmission of information makes coordinating activities and processes more effective and efficient and simplifies their management (Anand and Goyal, 2009). Correct information management leads to greater coordination in the supply chain. So that more and more appropriate information coordination between partners and different work departments greatly affects speed, accuracy, quality, and other effective aspects. (Yang and Fan, 2016).

### 2.3. Logistics management

In analyzing production and service systems, the logistics issue includes the physical part of the supply chain. This stage includes all physical activities that start from the stage of preparation of raw materials and continue until the delivery of final products. The most important of these activities include production planning, transportation, storage, etcetera, which account for a relatively large part of the effective activities in the supply chain (Soni and Gupta, 2020). This means that the concept of logistics is not only the flow of materials and products but also includes all activities of the supply chain; To the extent that practical information is one of the logistics support tools to improve the activities of that organization (Stock and Lambert, 2001; Buurman, 2002; Durach and Kembro, 2021).

### 2.4. Relationship management:

It is a factor that leads us to the conclusion of literature and discussion. The most important part of SCM in terms of its structure and form is relationship management in the supply chain. Relationship management strongly affects all levels and functional dimensions of the

supply chain (Hingley, 2011). The information systems and technology needed for SCM operations are often easily accessible, and they may be completed and deployed in a rather short amount of time. However, many of the initial failures in the supply chain are due to the lack of optimal planning in the definition and deployment of the chain (Sutthachaidee et al., 2022). In addition, the most important factor for SCM's success is having reliable mutual communication between chain partners. In short, in developing an integrated supply chain, trust and confidence between partners are critical factors for success (Cox, 2004; Meng, 2012).

### 2.5. Inventory Management in the supply chain

Inventory Management in the supply chain is very important in various production and service areas. Among the material flows, which are: financial, informational, and material; Materials are of great importance (Cachon and Fisher, 2000; Singh and Verma, most of Iran's manufacturing and industrial units, the traditional point of view is still used for supply, production, and distribution planning so that each of these plans their activities independently. For this reason, it primarily increases the total costs of the supply chains (Manzouri et al., 2010; Valmohammadi, 2014; Bazaz et al., 2022). In today's daily life, with the increase in the issue of purchasing, the importance of decisions related to purchasing has increased. In most industries, raw materials and utilized parts are the major part of product costs. So more than 50% of the total cost of the products includes purchased materials and services. Therefore, decisions related to adopting strategies in the purchasing chain determine profitability (Weele ,2018). Inventory Management by the seller is a new way of integrating the supply chain, where the supplier is

responsible for controlling and replenishing the retailer's inventory (Sui et al., 2010; Lotfi et al., 2022). The three main criteria of Inventory Management, with their concepts and attributes, based on Eissa and Rashed (2020) and Farmaciawaty et al. (2020), are determined as follows:

- Product with relevant factors (standard product, duplicate product, low demand changes for the product, clarity of the forecasted demand and inventory levels)
- Company with relevant factors (the stability of the company's annual income, high purchase transaction costs, good communication and information systems, sharing forecasted inventory information with the company's suppliers)
- Supplier with relevant factors (high level of trust and long-term relationship with the supplier, benefits of Vendor-Managed Inventory (VMI) implementation for the company and the supplier, key suppliers that have a high percentage of purchase orders, the company's information system association with suppliers)

This article considers an inventory model in a two-level supply chain under the VMI system, including a manufacturer and retailer. This model is formulated to optimize pricing decisions, replenishment amount, and frequency simultaneously to maximize supply chain profits. The retailer's market demand is price-dependent, and the manufacturer sends the manufactured stock to the retailer in several smaller batches to meet the demand. In real production conditions, generally, in addition to non-defective items, defective items are also produced. In this model, the production process is incomplete, and the shortage is not allowed.

## 2.6. SCOR model

The model of SCOR is a reference model and provides a standard and comprehensive model and framework for specifying efficient and effective activities along the supply chain; the main advantage of performance evaluation by this model compared to previous models is the process-oriented perspective of this model (Hasibuan et al., 2018). The SCOR model creates a balance between horizontal (inter-process) and vertical (hierarchy between processes) perspectives, and its use allows organizations to play an important and effective role in improving the overall performance of the chain by using common terminology and standard processes (Poluha, 2007; Kusriani et al., 2019). As a result of this process-oriented view, a hierarchical and structured body of evaluations and criteria is created, which gives a general view of the supply chain to all supply chain managers. Since the SCOR model is one of the suitable examples of process-oriented performance evaluation systems and is a comprehensive and standard model in this field, this research, based on the model and the indicators presented in the first level of the model and research techniques in operations, a model has been presented to evaluate the performance of SCM (Bolstorff and Rosenbaum, 2007). In the following, the five factors of Supply Chain Performance are explained:

**Supply Chain Reliability:** The performance of the supply chain considers the delivery of the necessary products, at the best possible place and time, with optimal conditions, in the necessary quantity, and according to the right documentation to the desired customer (Rombe and Hadi, 2022).

**Supply Chain Responsiveness:** It is the average actual time spent to satisfy the demand (SCOR11:2012).

**Agility of the supply chain:** the agility and flexibility of the supply chain in responding

to market changes to maintain or increase competitive advantages (SCOR11:2012).

**Total supply chain costs:** total supply chain costs spent on delivering products and services to customers (SCOR11:2012).

**The efficiency of asset management:** the use of an organization in asset management to support the satisfaction of demand; this feature includes the management of fixed and variable assets (SCOR11:2012).

## 2.7. The theoretical framework of research

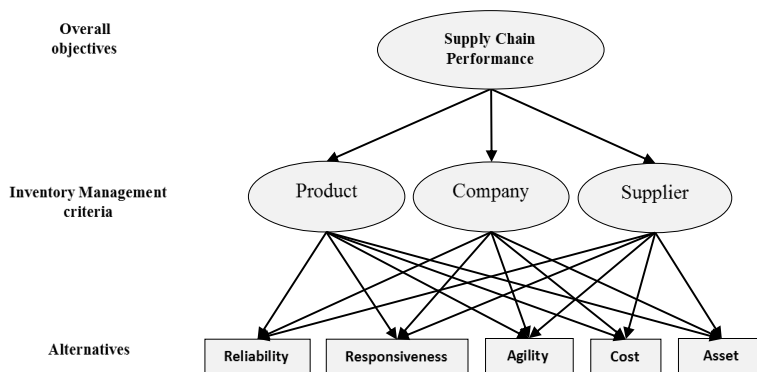
SCM indicators were presented in the 1990s by the Supply Chain Council, based on which SCM was examined in five indicators: Reliability, Responsiveness, Agility, Cost, and Asset (Putra et al., 2022; Rodríguez Mañay et al., 2022). The model, which was

designed based on the business process, examines all supply chain activities according to the five mentioned indicators (Thunberg and Persson, 2014; Maestrini et al., 2015; Balfaiah et al., 2016).

Moreover, as stated in paragraph 2.2 of the research literature; the factors of Inventory Management (Eissa and Rashed, 2020; Farmaciawaty et al., 2020) have been determined by the following three factors:

- Product with a number of sub-criteria
- Company with a number of sub-criteria
- Supplier with a number of sub-criteria

The present research will examine SCM criteria based on the five main criteria of the SCOR model, presented in Figure 1.



**Figure 1.** Proposed FAHP Model for SCOR Metrics of SCP based on Inventory Management

## 3. Research method

A descriptive-analytical research method was used to evaluate SCM indicators based on Inventory Management with the combined approach of SCOR and FAHP. Based on the SCOR model, the indicators are divided into five alternatives: Reliability, Responsiveness, Agility, Cost, and Asset. Three criteria of product, supplier, and company were considered for Inventory

Management, and the results were analyzed based on the pairwise comparison questionnaire provided to 15 experts. After data collection, the research's reliability was checked, consistent, and suitable for analysis. In the following, during quantitative operations, Inventory Management factors as criteria; and Supply Chain Performance factors as alternatives; are ranked. A schematic diagram of the steps mentioned above is shown in Figure 2.

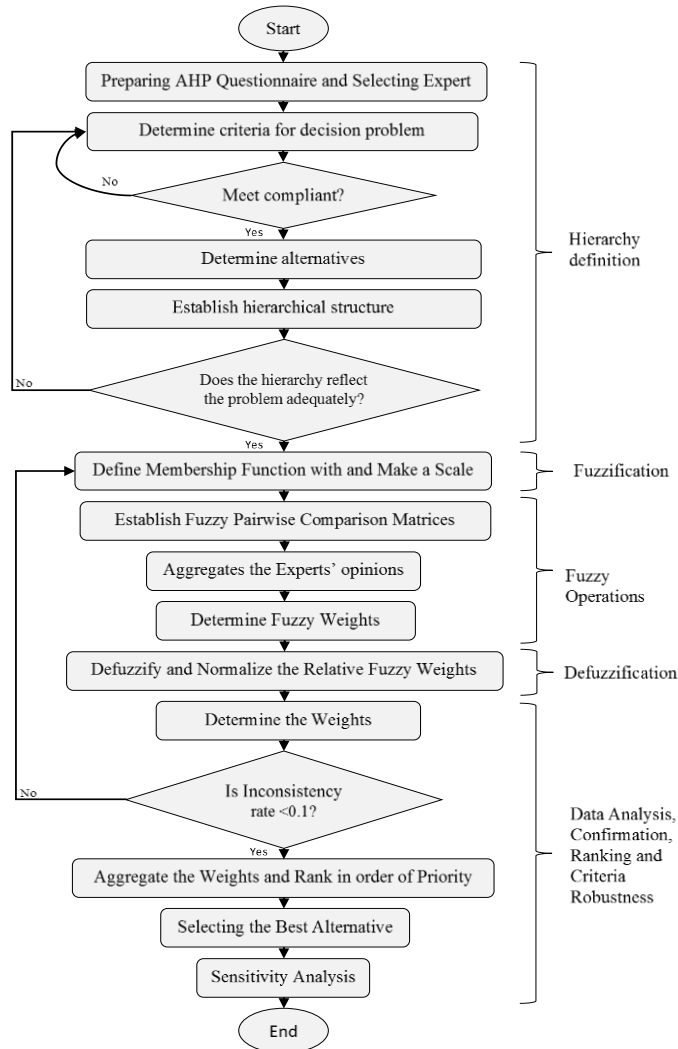


Figure 2. Fuzzy AHP flowchart

### 3.1. Analytical Hierarchy Process

Analytic Hierarchy Process (AHP) is a measurement method used to prioritize homogeneous elements through pairwise comparisons and heterogeneous elements through clustering (Saaty, 1994), which helps the decision maker to make decisions

with subjective and conflicting criteria. AHP is mainly used in the following cases; when the problem analysis shows that it should be broken into its constituent elements and When there is a hierarchy of constituent elements about the goal (Saaty, 1988).

### 3.2. Fuzzy AHP (FAHP)

The hierarchical analysis process method deals with hierarchically prioritizing options. However, many researchers have created ambiguities in the correctness of this method and have stated that this method cannot correctly show the decision maker's opinion and considering it is not certain that pairwise comparisons are made subjectively. For this reason, decision-makers can use fuzzy numbers instead of definite numbers in pairwise comparisons. Fuzzy numbers are used in the fuzzy hierarchical analysis process to perform pairwise comparisons (Sun et al., 2010; Chan et al., 2019).

#### Step 1 - Construct the hierarchy structure model

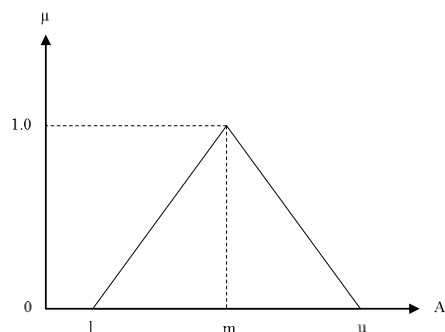
At this stage, decision-makers with relevant knowledge and experience are selected to assist in the work process, like preparing a standard questionnaire and determining criteria and alternatives to construct a hierarchical process.

#### Step 2 - Fuzzification

In the current study, Triangular Fuzzy Numbers (TFNs) were used to decrease ambiguity and uncertainty for pairwise comparison. In triangular fuzzy, numbers are represented with three points in the interval

$(0,1) \tilde{A} = (l, m, u)$ , represented in Figure 3. Where  $a$  and  $c$  represent the smallest and largest number of the set and  $b$  is the mid-value. Equation (1) shows the membership function of TFNs.

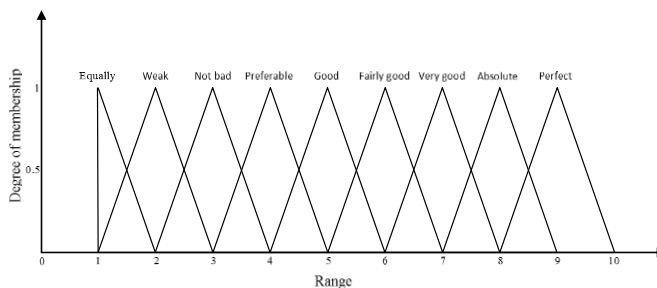
$$\mu(\tilde{A}) = \begin{cases} \frac{x-l}{m-l} & l \leq x \leq m \\ \frac{u-x}{u-m} & m \leq x \leq u \\ 0 & \text{Otherwise} \end{cases} \quad (1)$$



**Figure 3.** The membership function of TFNs

#### Step 3 - Fuzzy Operations

In this article, 9-point TFNs ( $\tilde{1}, \tilde{2}, \tilde{3}, \dots, \tilde{9}$ ) are used for constructing a pairwise comparison matrix. The 9 TFNs are defined with the related triangular fuzzy sets, as shown in Figure 4 and Table 1 (Saaty, 2000).



**Figure 4.** The membership functions of TFNs (linguistic values) ( $\tilde{1}, \tilde{2}, \tilde{3}, \dots, \tilde{9}$ )

**Table 1.** Definition and membership function of Linguistic Terms

Intensity of importance	Fuzzy number	Definition	Explanation	Scale of Fuzzy number	Inverse Fuzzy equivalent
1	$\bar{1}$	Equally important	Two attributes contribute equally	(1, 1, 1)	(1, 1, 1)
2	$\bar{2}$	Weak advantage	Equally to moderately more important	(1, 2, 3)	(0.333, 0.5, 1)
3	$\bar{3}$	Not bad	Experience and judgment slightly favor one activity over another	(2, 3, 4)	(0.25, 0.333, 0.5)
4	$\bar{4}$	Preferable	Moderately to strongly important	(3, 4, 5)	(0.2, 0.25, 0.333)
5	$\bar{5}$	Good	Experience and judgment strongly favor one activity over another	(4, 5, 6)	(0.166, 0.2, 0.25)
6	$\bar{6}$	Fairly good	Strongly to very strongly more important	(5, 6, 7)	(0.142, 0.16, 0.2)
7	$\bar{7}$	Very good	An activity is favored very strongly over another; its dominance demonstrated in practice	(6, 7, 8)	(0.125, 0.142, 0.166)
8	$\bar{8}$	Absolute	Very strongly to extremely more important	(7, 8, 9)	(0.111, 0.125, 0.142)
9	$\bar{9}$	Perfect	The strongest potential order of affirmation exists for indicating that one activity is preferable to another.	(8, 9, 10)	(0.1, 0.111, 0.125)
<b>Reciprocals</b>			Reciprocals for inverse comparison		

Next, the Fuzzy reciprocal judgment matrix, using TFNs, is established as Equation (2):

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{a}_{12} & \dots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \dots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \dots & 1 \end{bmatrix} \quad (2)$$

After aggregating experts' opinions, geometric mean was used to determine the fuzzy weights of matrices. Equations (3) and (4) are suggested by Buckley (1985) to use fuzzy geometric mean and fuzzy weight, respectively.

$$\tilde{r}_i = \left( \prod_{j=1}^n \tilde{a}_{ij} \right)^{\frac{1}{n}} \quad (3)$$

$$w_i = \tilde{r}_i / (\tilde{r}_1 + \dots + \tilde{r}_n)^{-1} \quad (4)$$

**Step - 3 Defuzzification**

At this stage, the obtained weight has been converted into a crisp real number. Several methods are available, e.g., mean of maximum, center of area, cut method, and Sugeno defuzzification method (Zhao and Govind, 1991; Guney and Sarikaya, 2009). In this present study, Sugeno defuzzification

method is used to obtain output crisp real numbers. In order to obtain a crisp value, each input is multiplied by a constant and added up to the result to make equations called 'rules of strength' or 'degree of applicability' and finally mathematically combine these equations, which is the weighted average of all rule outputs (Sugeno and Tanaka, 1991; Mendis et al., 2020). The defuzzified value of the fuzzy number is computed using Equation (5).

$$W_{\text{crisp}} = \frac{\sum_{i=1}^n w_i z_i}{\sum_{i=1}^n w_i} \quad (5)$$

**Step - 4 Data Analysis, confirmation, ranking, and criteria Robustness**

Normalization of crisp real numbers is conducted using Equation (6).

$$n_{ij} = \frac{a_{ij}}{\sum_{i=1}^n a_{ij}} \quad (6)$$

The consistency of the decision problem is examined in two aspects; 1) The variables and criteria that are compared should be related and of the same type, and 2) The



consistency ratio of pairwise comparison judgments is investigated. The inconsistency index (II) and inconsistency rate (IR) are calculated using Equations (7) and (8), respectively. Where  $\lambda_{max}$  is the largest eigenvalue of the comparison matrix, n is the dimension of the matrix, and the

inconsistency index of the random matrix (IIR) is selected from Table 2 (Saaty,1994; Saaty, 2000; Kwong and Bai, 2010).

$$II = \frac{\lambda_{max}-n}{n-1} \tag{7}$$

$$IR = \frac{II}{IIR} \tag{8}$$

**Table 2.** Inconsistency index of the random matrix

N	1	2	3	4	5	6	7	8	9	10
<b>IIR</b>	0	0	0.52	0.39	1.11	1.25	1.35	1.40	1.45	1.49

If the IIR value is less than 0.1, the comparisons are acceptable, and variables can be ranked; otherwise, decision-makers must revise the original values in a pairwise comparison matrix. At last, to investigate the robustness of the criteria, sensitive analysis is applied by switching the weight of the criteria.

### 3.3. Data Analysis

This research aimed to evaluate Supply Chain Performance based on Inventory Management. Data analysis has been done in two stages: the first stage, Pairwise

comparisons of the triple factors of Inventory Management, and the second stage, Pairwise comparisons of five SCOR indices based on Inventory Management criteria.

**Step 1** - Pairwise comparisons of the three criteria of Inventory Management (product, company, supplier).

After preparing the pairwise comparison questionnaire and obtaining SCOR through 15 experts in the industry, Aggregation of questionnaires (using the geometric mean method) and fuzzy transformation were done (Table 3).

**Table 3.** Aggregation of experts' opinions of criteria (geometric mean)

Inventory Management	Product (C1)			Company (C2)			Supplier (C3)		
<b>Supplier (C3)</b>	1.00	1.00	1.00	1.70	2.80	3.85	0.71	1.07	1.65
<b>Supplier (C3)</b>	0.25	0.33	0.52	1.00	1.00	1.00	0.43	0.63	0.83
<b>Supplier (C3)</b>	0.66	1.05	1.68	1.52	2.15	3.14	1.00	1.00	1.00

As evident in Table 3, all the fuzzy numbers of the aggregated questionnaire of the experts in the pairwise comparison of Inventory Management factors have been calculated through the geometric mean. The fuzzy weights of Inventory Management factors are shown in Table 4.

As evident in Table 3, all the fuzzy numbers of the aggregated questionnaire of the experts in the pairwise comparison of Inventory Management factors have been calculated through the geometric mean. The fuzzy weights of Inventory Management factors are shown in Table 4.

**Table 4.** Final weights of Inventory Management factors

Criteria	Final weight	Normal weight	Rank
Product	0.4587	0.427	1
Company	0.1905	0.177	3
Supplier	0.4248	0.396	2

Based on Table 4, in pairwise comparisons of Inventory Management criteria, the product criterion with the highest weight, is in the first place, and supplier and company criteria are ranked second and third, respectively.

**Step 2** - Pairwise comparisons of SCM indicators. The SCOR ranking (Reliability, Responsiveness, Agility, Cost, and Asset) is based on the criteria of Inventory Management (product, company, supplier) presented in Table 5.

**Table 5.** SCOR factors (alternatives) ranking based on Inventory Management criteria

Criteria	Reliability (A1)	Responsiveness (A2)	Agility (A3)	Cost (A4)	Asset (A5)
Reliability (A1)					
Responsiveness (A2)					
Agility (A3)					
Cost (A4)					
Asset (A5)					

Based on this model, pairwise comparisons of 5 alternatives (Supply Chain Performance indicators) are performed in three stages based on three Inventory Management criteria (product, company, supplier) separately. Carrying out this process for each of the criteria is in four steps:

1. Pairwise comparisons alternatives based on criteria
2. Geometric mean of Alternatives based on criteria

3. Fuzzy weights of Alternatives based on criteria
4. Final weights of Alternatives based on criteria

**Ranking alternatives based on product:** Criteria Aggregated experts' opinions of pairwise comparison of alternatives based on product criteria (geometric mean) are shown in Table 6.

**Table 6.** Pairwise comparison alternatives based on product criteria

Product Criteria	A1		A2		A3		A4		A5						
A1	1.00	1.00	1.00	0.34	0.50	0.80	0.26	0.35	0.56	2.49	3.59	4.64	1.52	2.27	3.25
A2	1.25	2.00	2.96	1.00	1.00	1.00	0.33	0.50	1.00	3.18	4.36	5.45	2.64	3.68	4.70
A3	1.78	2.86	3.90	1.00	2.00	3.00	1.00	1.00	1.00	5.16	6.21	7.24	4.08	5.10	6.12
A4	0.22	0.28	0.40	0.18	0.23	0.31	0.14	0.16	0.19	1.00	1.00	1.00	0.33	0.50	1.00
A5	0.31	0.44	0.66	0.21	0.27	0.38	0.16	0.20	0.25	1.00	2.00	3.00	1.00	1.00	1.00

As evident in Table 6, all the fuzzy numbers of the aggregated questionnaire of the experts in the pairwise comparison of the Supply Chain Performance alternatives based on the criteria of the products (inventory) have been calculated through the geometric mean, and the numbers of the main diameter are all one. The numbers below the main diameter are the inverse numbers above the main diameter. After

determining the IR (less than 0.1), the questionnaires are consistent according to Table 6 and are suitable for analysis. In the following, the fuzzy weights of the Supply Chain Performance alternatives based on the product criteria are given in Tables 7 and 8.

The final weights of SCM **alternatives** based on product criteria are shown in Table 9.

**Table 7.** The geometric mean of Alternatives based on product criteria

Product Criteria	l	m	u
A1	0.8000	1.0732	1.4664
A2	1.2833	1.7418	2.3761
A3	2.0649	2.8293	3.4903
A4	0.2831	0.3486	0.4761
A5	0.4036	0.5425	0.7128
Sum of averages	4.8348	6.5353	8.5218
The inverse of the total	0.1173	0.1530	0.2068

**Table 8.** Fuzzy weights of Alternatives based on product criteria

Product Criteria	l	m	u
A1	0.09387	0.16422	0.30331
A2	0.15059	0.26651	0.49146
A3	0.24231	0.43293	0.72191
A4	0.03322	0.05333	0.09847
A5	0.04736	0.083	0.14744

**Table 9.** Final weights of Alternatives based on product criteria

Product Criteria	Final weight	Normal weight	Rank
A1	0.181	0.168	3
A2	0.294	0.271	2
A3	0.458	0.423	1
A4	0.060	0.055	5
A5	0.090	0.083	4

According to Table 9, the final ranking of Supply Chain Performance **alternatives** based on the criterion of the product will be as follows: 1-Agility, 2-Responsiveness, 3-Reliability, 4-Asset, 5-Cost.

**Ranking alternatives based on Company:**

Pairwise comparisons of Supply Chain Performance **alternatives** based on the company criteria. Due to the repetition of the work steps of evaluating the alternatives based on different criteria, only the first and

last tables have been given.

Based on the numbers obtained in Table 10, it is clear that all the fuzzy numbers of the aggregated questionnaire of the experts in the pairwise comparison of the Supply Chain Performance **alternatives** were calculated based on the company criteria (inventory) through the geometric mean, and the numbers below the main diameter are inversed numbers above the main diameter.

In the following, after calculating of

“Geometric mean” and “Fuzzy weights” of Alternatives based on Company criteria, the Final weights of Alternatives based on Company criteria are calculated in Table 11. In the following, after calculating the

“geometric mean” and “fuzzy weight” of the alternative options based on the company criteria, the final weights of the alternatives based on the company criteria are calculated in Table 11.

**Table 10.** Pairwise comparison alternatives based on company criteria

Company criteria	A1		A2		A3		A4		A5						
A1	1.00	1.00	1.00	1.10	1.68	2.30	0.58	1.00	1.55	2.49	3.59	4.64	1.89	2.61	3.59
A2	0.44	0.59	0.91	1.00	1.00	1.00	0.30	0.43	0.76	1.43	2.57	3.65	1.52	2.55	3.57
A3	0.64	1.00	1.72	1.32	2.35	3.37	1.00	1.00	1.00	2.79	3.87	4.92	1.72	2.86	3.94
A4	0.22	0.28	0.40	0.27	0.39	0.70	0.20	0.26	0.36	1.00	1.00	1.00	0.33	0.50	1.00
A5	0.28	0.38	0.53	0.28	0.39	0.66	0.25	0.35	0.58	1.00	2.00	3.00	1.00	1.00	1.00

**Table 11.** Final weights of Alternatives based on Company criteria

Company criteria	Final weight	Normal weight	rank
A1	0.325	0.293	2
A2	0.213	0.192	3
A3	0.362	0.326	1
A4	0.085	0.077	5
A5	0.124	0.112	4

According to the results from the company criteria, agility is more important, and reliability is ranked second.

**Ranking alternatives based on supplier:** Pairwise comparisons of Supply Chain

Performance **alternatives** based on supplier criteria. Due to the repetition of the work steps of evaluating the alternatives based on different criteria, only the first and last tables have been given.

**Table 12.** Pairwise comparison alternatives based on supplier criteria

Supplier criteria	A1		A2		A3		A4		A5						
A1	1.00	1.00	1.00	1.32	2.35	3.37	3.32	4.34	5.35	3.57	4.57	5.58	3.44	4.48	5.50
A2	0.25	0.33	0.50	1.00	1.00	1.00	2.00	3.00	4.00	3.00	4.00	5.00	2.86	3.90	4.92
A3	0.33	0.50	1.00	1.00	2.00	3.00	1.00	1.00	1.00	1.15	2.17	3.18	0.80	1.52	2.41
A4	0.20	0.25	0.33	0.33	0.50	1.00	0.25	0.33	0.50	1.00	1.00	1.00	0.33	0.50	1.00
A5	0.25	0.33	0.50	0.25	0.33	0.50	0.33	0.50	1.00	1.00	2.00	3.00	1.00	1.00	1.00

Based on the numbers obtained in table 12, it is clear that all the fuzzy numbers of the aggregated questionnaire of the experts in the pairwise comparison of the Supply Chain Performance **alternatives** were calculated based on the criteria of the supplier (inventory) through the geometric mean, and the numbers below the main diameter are inversed numbers above the main diameter. After determining the IR (less than 0.1), the questionnaires are consistent according to

Table 12 and are suitable for analysis. In the following, after calculating the “geometric mean” and “fuzzy weight” of the alternative options based on the company criteria, the final weights of the alternatives based on the Supplier criteria are calculated in Table 13.

According to Table 13, the final ranking of the Supply Chain Performance **alternatives** based on the criteria of the supplier will be as follows: 1- Reliability 2- Responsiveness 3- Agility 4- Asset 5- Cost.

**Table 13.** Final weights of Alternatives based on Supplier criteria

Supplier criteria	Final weight	Normal weight	rank
A1	0.439	0.404	1
A2	0.265	0.244	2
A3	0.202	0.186	3
A4	0.076	0.070	5
A5	0.104	0.096	4

**Determining the normal weights of the alternatives:** The final weight of each alternative should be normalized once weights are determined based on criteria, and these weights will be taken into account when determining the final rank of each criterion.

The ranking of SCM alternatives based on Inventory Management is given in Table 14. After calculating the weights of SCM based

on inventory alternatives, in the last step, the final matrix of the obtained weights should be calculated, and the final results should be considered as the final rank of each alternative in the SCOR model.

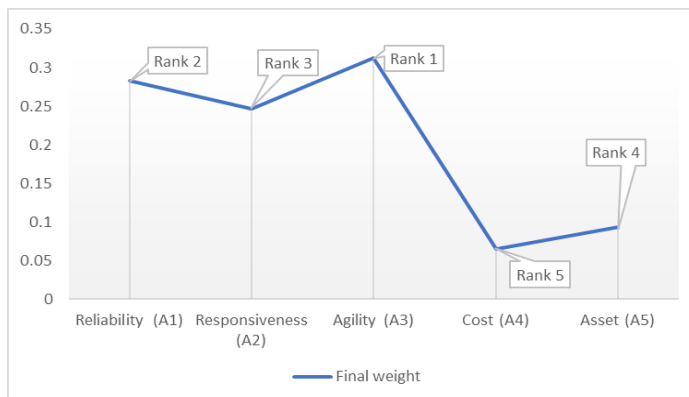
According to Table 15, the final ranking of alternatives based on Inventory Management will be as follows; Agility, Reliability, Responsiveness, Asset, and Cost, as illustrated in Figure 5.

**Table 14.** Final ranking of Alternatives based on criteria

	A1	A2	A3	A4	A5
C1	3	2	1	5	4
C2	2	3	1	5	4
C3	1	2	3	5	4

**Table 15.** Final ranking matrix of Alternatives

$\begin{pmatrix} 0.427 & 0.177 & 0.396 \end{pmatrix}$	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="text-align: left;">0.16758</td> <td style="text-align: left;">0.27138</td> <td style="text-align: left;">0.42268</td> <td style="text-align: left;">0.05505</td> <td style="text-align: left;">0.08332</td> </tr> <tr> <td style="text-align: left;">0.29314</td> <td style="text-align: left;">0.19217</td> <td style="text-align: left;">0.32621</td> <td style="text-align: left;">0.0768</td> <td style="text-align: left;">0.11167</td> </tr> <tr> <td style="text-align: left;">0.40367</td> <td style="text-align: left;">0.24405</td> <td style="text-align: left;">0.18628</td> <td style="text-align: left;">0.07019</td> <td style="text-align: left;">0.09581</td> </tr> <tr> <td style="text-align: left;">A1</td> <td style="text-align: left;">A2</td> <td style="text-align: left;">A3</td> <td style="text-align: left;">A4</td> <td style="text-align: left;">A5</td> </tr> <tr> <td style="text-align: left;">Final weight</td> <td style="text-align: left;">0.283</td> <td style="text-align: left;">0.247</td> <td style="text-align: left;">0.312</td> <td style="text-align: left;">0.065</td> <td style="text-align: left;">0.093</td> </tr> <tr> <td style="text-align: left;">Final rank</td> <td style="text-align: left;">2</td> <td style="text-align: left;">3</td> <td style="text-align: left;">1</td> <td style="text-align: left;">5</td> <td style="text-align: left;">4</td> </tr> </table>	0.16758	0.27138	0.42268	0.05505	0.08332	0.29314	0.19217	0.32621	0.0768	0.11167	0.40367	0.24405	0.18628	0.07019	0.09581	A1	A2	A3	A4	A5	Final weight	0.283	0.247	0.312	0.065	0.093	Final rank	2	3	1	5	4
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**Figure 5.** Final ranking of alternatives based on their weights

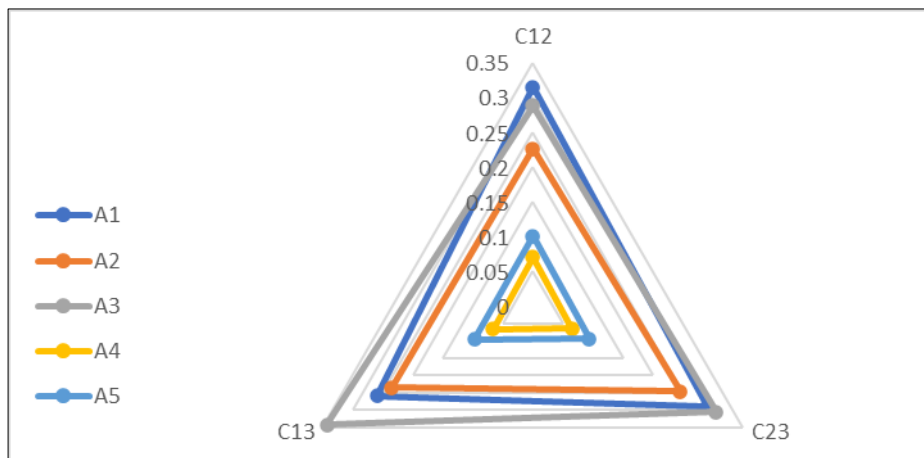
#### 4. Sensitivity analysis

Sensitivity analysis is used to determine independent parameters' effect on dependent parameters. The outcome is determined by varying the independent variables over a predetermined range (Sachan and Datta, 2005; Anand et al., 2019). Sensitivity analysis demonstrates the degree to which a result depends on a particular variable. The results are sensitive if the ranking order is altered by elevating or lowering the weight of the criteria; otherwise, it is robust (Senthil et al., 2014).

By varying the weights of two criteria, which resulted in three scenarios, various scenarios were represented to investigate the impact of weights on selecting five alternatives. The weights of criteria 1 and 2 are switched in each experiment as indicated by the C12 symbol, which denotes the weight switch. Table 16 and Figure 6 present the sensitivity analysis results, showing that A3 scored highest twice and A1 ranked first once in the three experiments. The outcome demonstrates the robustness and low sensitivity of the criteria. As a result, the decision-making process rarely responds to the weight of the criteria.

**Table 16.** Results of sensitivity analysis

Scenario No.	Experiment No.	A1	A2	A3	A4	A5
1	C12	0.31468576	0.22673465	0.28787291	0.07033269	0.10037149
2	C23	0.29061455	0.24568992	0.30466201	0.06536453	0.09367118
3	C13	0.25908969	0.23517543	0.34263508	0.06634278	0.09675733



**Figure 6.** Sensitivity analysis in a radar chart.

#### 5. Discussion and Conclusion

Based on the presented model, the evaluation of **SCOR Metrics of Supply Chain Performance** indicators based on Inventory Management with the hybrid approach of FAHP and SCOR was discussed in Iran

Petrochemical Company. Based on the SCOR model, the indicators are divided into five **alternatives**: Reliability, Responsiveness, Agility, Cost, and Asset, and three criteria of product, supplier, and company are considered for Inventory Management. The designed questionnaire

given to 15 experts at Iran Petrochemical Company served as the basis for analyzing the results. The improved FAHP technique was initially employed as the best technique for problem-solving. The IR, based on which all 15 research questionnaires and the obtained cumulative matrices were deemed consistent and appropriate for analysis, was also checked to determine the reliability of the research. The **alternatives** and the final rank on each scale were studied further to produce the results shown below:

**Ranking of Inventory Management criteria:** Product-related factors received the top ranking in this comparison, followed by supplier-related factors in second place and company-related factors in third place. There has not been any comparable study in this area to compare. However, given that the product's contributing factors include: standard products (minimum customization of the products), repetitive products (small changes made by the customer), low demand changes for the products, clarity of forecasted demand, and inventory levels, it is concluded that when choosing petrochemical company products, it is important to keep the following in mind:

- Selecting the type of products produced according to the market
- Raising the standard level of the products according to foreign samples
- Proper and accurate forecasting of the target market and products demand

Based on the results obtained in this research, it seems that SCM that is based on inventory, the importance of product criteria depicts that the supply chain approach based on customer orientation and customer satisfaction is very significant and creates value for customers in manufacturing companies, creating value for customers can be the most critical function for the supply chain.

**The results of the final ranking of the SCOR Metrics of Supply Chain Performance:** In general, Supply Chain Performance indicators were presented by the Supply Chain Council in the 1990s, based on which SCM was evaluated based on five **alternatives** of Reliability, Responsiveness, Agility, Cost and Asset. Based on this, this model, designed based on the business process, examines all supply chain activities based on the five mentioned indicators (Sellitto et al., 2015). The following are the final rankings for SCM based on inventory management: Agility, Reliability, Responsiveness, Asset, and Cost. The most important indicator in this regard was organizational agility and reliability, and it shows that the petrochemical company should use all available tools for agility and reliability strategies.

Guritno et al. (2015), in similar research to the evaluation of supply chain factors and classification of Inventory Management at the level of fresh vegetable suppliers based on the SCOR reference model, showed that the most efficient indicator was cost. In a similar research, the results of Hasibuan et al. (2018) research in "Performance analysis of SCM" indicate the prioritization of five performance criteria of the supply chain as follows: Responsiveness, Agility, Reliability, Asset, and Cost. The above research results are precisely the same as the present research. Praharsi et al. (2021), in a research field of "Supply Chain Performance," showed that the lowest performance metric value is the cost of goods. But in Kusriani et al. (2019). "Supply Chain Performance Measurement" research, agility ranked last. The reasons for the different results can be things like: type of industry, type of organization, type of country, type of product, et cetera. Ambe's (2014) research findings showed that the reliability and quality of the final products are the most significant indicators of South Africa's light vehicle market.

Although the purpose of SCM is to ensure that the products are delivered at the right place and time through inventory optimization, it can be seen that the importance of the five factors (Reliability, Responsiveness, Agility, Cost, and Asset) is different according to the type of company. Therefore, a single result cannot be prescribed.

According to the current research results, since organizational agility and reliability are ranked first and second, prioritization results indicated that human, organizational, technical, and technological factors and strategic factors in terms of organizational agility and reliability should be prioritized for improvement and upgrade. In fact, by training and creating capable and multi-skilled employees, quick response, continuous feedback; agility, and reliability are gained to make it possible to make a decision about the appropriate amount of inventory for each of these levels and help in determining the minimum inventory needed to face uncertainty and products and supply chain problems.

- As a result; Considering the ranking and importance of agility, reliability, and responsiveness, it is recommended to observe the

following points in petrochemical company:

- It is suggested that an aggregated information system be formed from suppliers, and all purchases, inputs, and outputs of the company are made based on determining the order point of stock in products and products. The advantage of this becomes essential since all the raw materials of the factory have expiration dates, and sometimes the lack of proper forecasts causes damage to materials and products;
- Developing standard products and creating forecasted demand;
- Improving the level of high trust and long-term relationship with the supplier, the connection of the company's information system with the suppliers;
- Determining critical points and solving challenges and agility obstacles in the organization;
- Defining reliability engineering in the organization and providing the appropriate policy;
- Drawing a detailed process to respond to all requests (customers, market, and suppliers).

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## IMPACT OF GLOBAL CRISIS ON SUPPLY CHAIN MANAGEMENT QUALITY: CASE STUDIES

**Abstract:** *Once the pandemic was brought under control in February 2022, the ongoing conflict between Russia and Ukraine started, which has additionally affected the operations of a number of companies and a number of countries as well. Supply chain interruption poses a risk for companies with long-term impacts, particularly in a highly globalized era in which companies tend to have long and complex chains. The poor preparedness of companies, with no alternative solutions, has brought changes in business processes and supply chains worldwide. The ways the global crisis caused by COVID and the war in Ukraine impacted the supply chains and the business process modifications in domestic companies, will be demonstrated by two case studies: Defining the criteria for supplier selection on the national market and Comparative analysis of exporting the same product by a manufacturer in the automotive industry before and during the global crisis*

**Keywords:** *Supply change management, suppliers, production companies*

### 1. Introduction

The global pandemic caused by COVID-19, declared at the beginning of 2020, initiated significant changes in both society and business. In a very short period, market conditions and business models, as well as many other factors, with digitalization being the one that stood out the most and the one that has become increasingly important in modern business, drastically changed. Business organizations had to adjust rapidly to the newly emerging circumstances, so that they could adapt to the radical changes that were taking place. Once the pandemic was brought under control in February 2022, the ongoing conflicts between Russia and Ukraine began, which has additionally affected the operations of a number of companies and a number of countries. The

increased uncertainty on a global level forced both large and smaller companies to find alternative solutions in terms of trading partners and become even more aware of the significance regarding the source of raw material, component and other production and service material stocks. It is evident that today's companies, through successful cooperations with suppliers and other actors in supply chains, can achieve certain benefits that often result in significant savings, which on the other hand is one of the goals every company strives to achieve. Supply chain interruption poses the risk that can have a long-term effect, particularly in a highly globalized era in which most companies have long and complex chains. The poor preparedness of companies, with no alternative solutions, has brought changes in business processes and supply chains

worldwide. Closing borders led to the disruption in the structure of multinational companies, due to the fact that there were a number of problems during not only the production process, but also the supply chain and logistics. All these factors led to the collapse of the global economy and the establishment of predominantly national companies. Therefore, the supply chain in which the goods, processes and structures can easily be replaced needs to be foreseen as a response to changing condition (Zekhnini, K., et al., 2020). These changing conditions and disruptions bear significant negative consequences on sales return, profit, share yield, brand image, recruitment in companies, customer safety and the total supply chain impact (Chovdhuri et al., 2019; Elliott et al., 2019; Paul, S. K., & Chowdhury, P., 2021).

This paper aims at reviewing the impacts of the global crisis caused by COVID 19 and the war in Ukraine on supply chains and business process modifications in domestic companies providing two case studies as examples: Defining the criteria for supplier selection on the national market and Comparative analysis of exporting the same product by a manufacturer in automotive industry before and during the global crisis.

The first study deals with the analysis of the delayed raw material delivery caused by the closure of borders due to the COVID 19 pandemic, which resulted in the failure to comply with the production deadlines and therefore with the deadlines for the delivery of a final product to its customer. All the above forced companies to seek raw material suppliers on the domestic market.

The second study deals with the analysis of the observed period from 2020 to 2022, in which the total business interruption occurred, followed by the reduced scope of business in the analyzed manufacturing company. For research purposes, the comparison of the reference unit export in 2022 and the export carried out in 2018 has

been demonstrated.

## 2. Supply chains

Supply chain management (SCM) has broadly been defined as the “systematic, strategic coordination of the traditional business functions and tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole” (Payán-Sánchez, B. et al.; 2021, Mentzer et al., 2001, str. 18).

Supply chain is an integrated system that starts from raw material or semi-finished goods, continues with the production, packaging, storing goods and their distribution, and finishes with the delivery of the final product to the end customer (Toygur, A., & Yildirim, U., 2023). The relations within the chain are not limited only to manufacturers and suppliers. There are a number of various parties across the supply chain such as service and logistics providers, retailers, insurance companies, customs brokers and customers (Cooper et al., 1997; Min & Zhou, 2002; Chopra & Meindl, 2007; Toygar, A., & Yildirim, U., 2023.).

Supply chains are the processes you use to deliver your product to customers. The chain encompasses everything, from obtaining the raw material necessary for your product manufacturing to its delivery to the customer (R.Ray, 2009.). A supply chain is the network of all the individuals, organizations, resources, activities and technology involved in the creation and sale of a product. A supply chain encompasses everything from the delivery of source materials from the supplier to the manufacturer to its eventual delivery to the end user.

The supply chain activities imply the transformation of natural resources, raw



material and components into a final product and its delivery to the end user. Supply chain management is the essence of business since it is one of the important added values of trading companies, in which a product is transferred from its place of origin (Manufacturer) or other source (Supplier) to its place of consumption (Buyer).

### 2.1. Production Company Supply Chains

Supply chain is characterized by the flow of material and information within and between the business subjects including suppliers, manufacturers and buyers. The ultimate goal of supply chain management is to satisfy customer requirements in a more efficient manner. For a production company, the goal is to create the right product, for the right customer, in the right amount and at the right time (Wang, G., et al., 2005). This requires carefully devised supply chains.

A manufacturer obtains raw material and components for final goods production from its suppliers. The material may be delivered directly to the factory or they may be handed to an external warehouse where they are consolidated and only then delivered to the factory. The material is processed in the factory, converted into a final product, and then packaged and eventually delivered to warehouses and distribution centers from which the goods are delivered to end users.

The supply chain concept refers to the flow of material (Picture 1):

- 1) from the source (supplier) to the warehouse, from the warehouse to the company (manufacturer); within the company, to the place it is needed; from the company-manufacturer (factory) to the distributor-trader; to the end user (customer)
- 2) from the source (supplier) to the company (manufacturer); within the company to the place where it is needed; from the company-

manufacturer (factory) to the end user (customer)

- 3) from the source to the company (manufacturer); within the company to the place where it is needed; from the company-manufacturer (factory) to the end user (customer)

A typical production supply chain includes the following processes:

- The inbound supply chain that includes: sources, incoming quality control, inbound transportation from the supplier to the production unit, import documentation / customs processes in case the material is imported, receipt of goods and their storage, the management of production raw material stocks;
- The production and internal processes that include: production planning, timetable and production, quality control process, inventory management during the work process, plant maintenance;
- The outbound supply chain/distribution that includes: outbound transportation, final goods quality control, final goods storage in the company factory, external storages and distribution centers, packaging, problems with goods, final product inventory management;
- Customer service that includes: defining the level of services for customers, order management, return management, packaging, defining the distribution channels, product development;
- Other supply management functions that include: backup logistics, supply chain exception management, outsourcing logistics (which is usually conducted at the company headquarters);

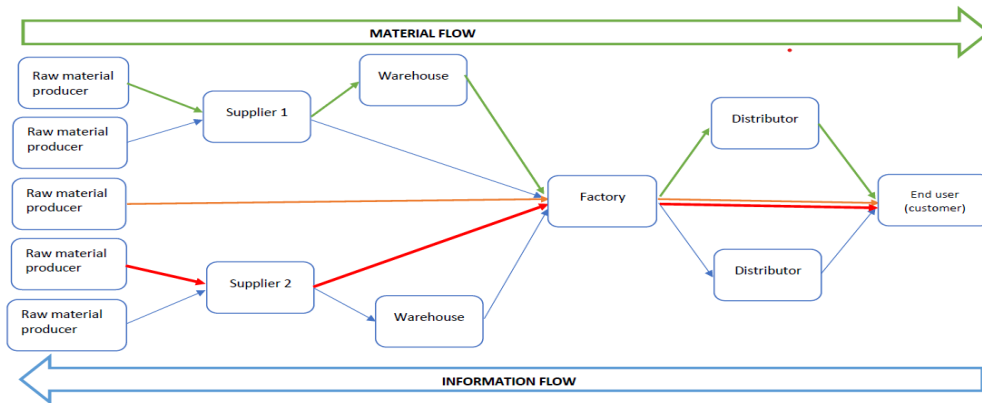


Figure 1. Possible material flow in supply chains

## 2.2. Supply Chain Participants – Suppliers

A supply chain additionally encompasses production and supply. Therefore, it has a significantly wider focus since it includes a number of businesses (including suppliers, manufacturers and traders) that work together in order to satisfy the user requirements for a product or a service.

According to (Hugos, M. H., 2018), there are four types of participants in every supply chain. They perform the activities that make the supply chain work and give the reason for its existence. These participants are: 1) producers; 2) distributors or wholesalers; 3) retailers; and 4) customers or consumers.

If we observe supply chains through their simplest form, we may say that it consists of a company, its suppliers and customers. By combining these actors (supplier, company, customer) we obtain a simple supply chain.

Companies today have become aware that successful cooperation with suppliers can lead to certain benefits that often result in significant savings, which is one of the goals that every company strives to achieve.

According to the definition (Akamp and Muller, 2013) supply relationship management (SRM) is the practice of planning, implementing, developing and

monitoring the relationship of a company with both current and potential suppliers. The key supplier management activities are the selection and evaluation of suppliers, their monitoring, development and integration.

According to (R. Ray, 2009.), supplier relationship management is the key factor that includes all the processes that refer to supply management such as supply planning and execution, source analytics, the selection of suppliers, monitoring their performance, the cooperation with suppliers and all other processes that enable analyzing, controlling and optimizing a source.

Suppliers are an integral part of every business, production in particular. The selection of suppliers is the process of finding the right supplier for business, which includes the steps taken for a supplier discovery, selection and cooperation with them. If we talk about a product quality or its success, the supplier selection is an essential part, since the process of selecting the right supplier is the crucial one.

There are many different types of criteria used for supplier selection. They include price, quality, service, delivery, reputation etc. Certain companies will use all these criteria, whereas some may focus only on one or two of them.

### 3. Case study

#### 3.1. Defining the Criteria for Supplier Selection on the National Market

This part of the paper will demonstrate a case study that analyzes a company which, like most companies in Serbia, was not ready for the challenges in supply chain caused by the global pandemic. The analysis deals with the delay in the raw material delivery caused by the closure of borders due to the COVID 19 pandemic and the consequent inability to import the raw material, which led to a non-compliance with the production deadlines, and therefore with the deadlines to the final product delivery to its customers. All the above forced the company to seek a raw material supplier on the domestic market.

The case study analyzes the company that produces rubber technical goods, including the production of semi-pneumatic wheels, rubber rollers, metal rims, plastic mass and silicon products, compression pressure, injection and die-cutting technologies. The accent is on the semi-pneumatic wheels for agricultural machinery. The company had imported the raw material from Slovenia and Austria until 2020, when the COVID 19 pandemic began, causing the closure of borders, which led to the production decline and the drop in the final product export to the foreign market in the following months, since the company exports more than 90% of the wheels to the foreign market (Germany, Russia, Austria, etc.).

The company values and selects its suppliers based on their ability to meet the requirements from the agreement/specification, including the requirements that refer to the quality management system, as well as any other specific quality requirement.

The Procurement Officer along with his or her team defines the criteria and the method of the evaluation and selection of suppliers

that include the suppliers of raw material, material and components, as well as service providers – external providers, in order to create the “List of Verified Suppliers”, with the goal to ensure adequate reliability with respect to harmonizing the procurement of material and goods or the contracted service with the agreement/specification requirements, including the requirements that refer to quality management system.

The basic criteria for supplier rating are: quality control, certificate of analysis, supplier reliability, complaints and meeting the standard requirements. Each of these criteria is broken down into sub-criteria, i.e. levels, and each level is evaluated by the correspondent number of points. The company defines various evaluation criteria for:

- the suppliers of raw material and services that directly affect the product quality;
- the suppliers of hazardous material and other services (consulting, legal work, safety and health at work, laboratory tests, etc.);
- the suppliers of consumables.
- At the end of the financial year, the Procurement – Sales Officer reviews individual deliveries according to suppliers and type of goods/services.

Every supplier is awarded the appropriate number of points, according to all 5 evaluation criteria. The average annual rating for each supplier is obtained by adding up the number of points according to the defined criteria. The Procurement – Sales Officer defines the supplier status based on the determined criteria that can be (Picture 2):

- A – approved supplier (> 70 points)
- B – temporarily approved supplier (from 50 to 70 points)
- C – unreliable supplier (below 50 points)

Evaluation is conducted by:			Evaluation criteria:			Date of evaluation:			Approval changes:			
Serial number	Supplier code:	Supplier	Quality	Delivery time	Price	Evaluation	Category	Range	Category	Range	Approved	Date
1						0	A	Approved				
2						0	B	Temporarily approved				
3						0	C	Unreliable				
4						0						
5						0						
6						0						
7						0						
8						0						
9						0						
10						0						
11						0						
12						0						
13						0						
14						0						
15						0						
16						0						
17						0						
18						0						
19						0						

Figure 2. Supplier-Provider Rating Scheme

The team formed to find a solution to the circumstances that affected the company had to make a decision on which raw rubber supplier on the domestic market may provide the raw material of approximately the same quality as the one the company had imported until the moment when the level of raw rubber stocks fell below the permitted level. The team concluded that the method they had been using to evaluate the suppliers was not sufficient and, as a solution to the problem, they defined the *checklist* (Table 1) with the criteria and sub-criteria for the

selection of the domestic market suppliers. Then they also added the new procedure *Defining procurement conditions and requirements* to the Quality Regulations.

Depending on the type of a product, service, raw material that is ordered as a new or a standard product, as well as on whether they are verified or unverified suppliers, in order to make the best decision, the Procurement Officer checks the supplier through the checklist presented below (table 1).

Table 1. Supplier checklist

Criteria	Description of criteria	Check
1. Basic data about supplier company	Basic information about the supplier company through the chosen portal( <a href="http://www.infopoint.rs/usluga-checkpoint">http://www.infopoint.rs/usluga-checkpoint</a> which monitors operations of buyers and suppliers in the country, provides insight into their credit rating and business rating and information on blockages accounts, court cases, etc.)	
2. Certificates	1. Certificate ISO 9001:2015 2. Other certificates (ISO 14001:2015, OHSAS 18001:2015, etc.)	
3. Material quality	1. Possession of a certificate on the origin and quality of the material	
	2. Compliance with a query	
	3. Delivery of samples for control and testing quality	

4. Fulfillment of obligations defined through contract	In order to ensure the fulfillment of the contract obligations, from our suppliers or customers we may require several instruments:	
	1. Authorized Promissory note*	
	2. Bank guarantee*	
	3. Other	
5. Price	Price quality ratio	
	Lowest price/quality on request	
	Market price/quality on request	
	High price/quality offered on request	
6. Fulfillment of company's requirements	1. Type and quantity	
	2. Applicable specifications, drawings, process requirements and other important technical characteristics	
	3. Statement on the purpose of the goods and other necessary data	
	4. Flexibility and delivery deadlines	
	5. Method of packaging and labeling	
	6. Method and place of delivery	
	7. Method of payment	
	8. Offer validity period	
7. Communication	1. Good service	
	2. Poor service	
8. References of the supplier	1. Business cooperation, clients	
Note:		

In order to maintain the quality level of its products, the company had the choose among three domestic raw rubber suppliers by means of the defined checklist and the conditions determined by the new procedure, as an additional method and with the aim of satisfying the raw material quality requirements, as well as the product quality, so as to satisfy the needs of very demanding customers.

### 3.2. Comparative Analysis of Exporting the Same Product by a Manufacturer in Automotive Industry Before and During the Global Crisis

The case study relates to a micro-enterprise in the automotive industry field, or more precisely to a manufacturer of special purpose trailers and semi-trailers. The company is a micro-enterprise with up to 10 employees and an annual turnover lower than 2 million euros. It manufactures two types of special units intended for on-road

and off-road driving. The company carries out the production operations outside the EU zone not taking the advantage of the possibilities, i.e. benefits of an exporting company (VAT refund), nor the opportunities of working in a duty-free zone (the opportunity of temporary import and refinement).

The observed period relates to the period from 2020 to 2022. Within that period, there was even a total interruption of the company operations in a certain number of months, followed by the reduced scope of business operations. For research purposes, the comparison of the reference unit export in 2022 and the export carried out in 2018 has been demonstrated. The comparison significance lies in the following:

- It is the same product type/variation/version;
- In both cases the destination EU country was the same, with the same central place of unloading;

- In both cases the buyer, i.e. end user was the same.
- In both cases the services of the same transport company were used for the transportation to the country/destination.

The importance of the study lies in the fact that the homologation requirements (ECE regulations) do not allow the replacement of one component with another unless it has priorly been defined in homologation documentation (the so-called alternative components). Or in other words, only the goods that have been pre-defined or approved can be purchased or acquired. Otherwise, additional tests, which require both time and costs, need to be carried out.

The company defined the following four categories: chassis, superstructure (extension), light and signalization and functional equipment. The following elements were defined as the critical purchase elements: brake axle, traction control device, wheels, led light signalization.

However, the observed comparison has certain limitations:

- In the supply chain, only the road transportation was observed as the only form of transportation the company carries out within EU;
- The critical elements like the brake axle was on stock and for the comparison purposes the first offer by the supplier was included;
- For the comparison financial aspect purposes, the cut-off was made after the critical elements had been received and customs-cleared (control device, wheels) and it did not include the subsequent leveling of element or service prices by a manufacturer or a supplier.

The company could not avoid the supply chain disruptions as the consequence of the global crises caused by COVID 19 and the military conflict in Ukraine. The observed

product unit that was taken as a reference due to the relativity of the comparison with the period prior to 2020 contains 32% of the components that were obtained from abroad either by direct import or by import through other suppliers. For the purpose of exporting to the EU countries, all components were obtained from 8 EU countries. The comparison of the two above-mentioned export cases emphasizes the following facts:

- At the moment when the cut-off was made, the total increase in the product element purchase prices was 36% as compared to the prices before the global crises, i.e. before February 2020;
- The global crisis caused the crucial element delivery time upon purchase to be extended by 4 weeks on average. In the case of the control device, the manufacturer was not able to define the delivery date;
- The unavailability of the elements at the manufacturer caused the creation of alternative supply channels, focusing on sales agents or more precisely dealers. However, the total transport of product elements and key elements from EU did not increase by more than 10%, counting the price per km or square meter;
- When the purchase was made on the domestic market, the deferred payment terms were either canceled or reduced due to the new circumstances;
- Given the good workshop positioning in terms of transport conditions and the allocation of human and material resource, the workshop level of equipment in the domain of tools and micro-climatic conditions, as well as the proximity of the service providers, there were no significant increases in labor and

service costs, nor the disruption in the production and service realization;

- The increase in the fuel prices caused by the leveling of prices at a global level led to the increase in operating costs;
- There was an increase in the bulk transport price (including the transport insurance) by 212%.

#### 4. Conclusion

The global crisis caused by COVID 19 and the war in Ukraine has transformed the whole world. All over the world, companies faced huge business losses. The change in market conditions caused by the global crisis forced many companies to transform their operations. Production companies encounter a number of challenges due to supply chain disruption on a global level, therefore many companies had to modify their operations on the domestic market and seek suppliers in their own countries. This paper and the conducted case studies aim at answering the question of how domestic manufacturing companies have responded to the current global crisis and the disruptions in supply chains they came across.

The significance of the first case study lies in the discovery that companies similar to the analyzed one need to have alternative solutions regarding the raw material procurement, and they should not be limited only to their global suppliers, but should instead foster the cooperation with the local market suppliers as well, thus avoiding the challenges arising from unpredictable circumstances, the import suspension caused by the global pandemic being one of them.

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The second study leads us to the conclusion that following business strategy changes need to be carried out: to replace “delivered at place” (DAP) by “ex-works” strategy so that the production could meet the given deadlines, to reorganize the assembly process in accordance with new conditions, i.e. new procurement period, to reduce the number of elements within functional equipment with the aim to harmonize new retail price with the market demands, to improve the superstructure modularity in order to increase the sales offer, to carry out the additional selection of alternative components, principally in the critical element domain, with the goal to absorb the potential negative trends and changes in supply chains.

The analyzed studies make us conclude that the companies succeeded in adjusting their supply chains to the modified operation conditions caused by the global crisis. There were no significant differences among companies in terms of the supply chain disruptions, and the experience forced them to redesign their supply chains, which even resulted in the modifications regarding the supplier selection processes, procurement and production processes, and company strategies.

Based on the experience of the analyzed companies, the research findings may be practically used and implemented by managers, procurement and logistics officers to identify and develop efficient supply chain management measures during unpredictable circumstances. Further studies may aim at identifying efficient solutions for supply chain risk management.

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## MODELLING FRAMEWORK FOR CRITICAL SUCCESS FACTORS OF GREEN SUPPLY CHAIN MANAGEMENT-AN INTEGRATED APPROACH OF PARETO, ISM AND SEM

**Abstract:** *The study aimed in identifying Green supply chain critical success factors, develop and validate the framework through integrated approach of ISM, MICMAC and SEM so as to promote green practices throughout the supply chain activities in Indian manufacturing sectors. Interpretive structural modelling(ISM) is applied to develop hierarchical contextual relationship among identified critical success factors via Pareto analysis. The methodology then follows classification of success factors into four clusters by Matrice d' Impacts Croisés-Multiplication Appliquée à un Classement (MICMAC) and statistical validation of the ISM model through Structural Equation Modelling(SEM) by AMOS. In this study, 16 critical success factors of Green supply chain practices for manufacturing industries were identified, followed by development of an ISM model using 16 critical success factors, later the model was statistically verified that identified nine CSF's responsible for generating SEM model by satisfying all the model fit indices. The linkage variables identified are Green manufacturing, Green Procurement, Green marketing and Distribution, Green purchasing, Supplier cooperation, Customer cooperation, Environmental strategies and management, Environmental Participation and Green training that are forming the driving force for practising green supply chain. Research limitations/implications: The results of the study are restricted to manufacturing industries, which might vary when applied for other sectors. The developed model on green supply chain management practices would help policy makers, decision makers, researchers and industry professionals to anticipate potential success factors to implement green supply chain practices. Accordingly, the focus on critical success factors would be prioritized for obtaining better performance of supply chain and greening the chain.*

**Keywords:** *Green Supply chain, factors, Pareto analysis, SSIM, Transitivity matrix, Digraph, ISM Framework, MICMAC analysis.*

### 1. Introduction

Modern manufacturing industries are striving hard to develop a supply chain process which can minimize the negative impact on environment. Industrial impact on the environment is not only confined to greenhouse gas emissions but also leads to

water shortages, difficulties in usage of the land, hazardous waste, water contamination, deforestation, pollution levels, and energy use are all essential issues that are important to bring it in the light. (Maertens et al 2012, Memia 2018, De Carvalho et al 2020, Vijayvargy et al 2017). The noteworthy truth is that the leading 2500 global corporations contribute to more than 20% of global

greenhouse gas emissions, and their supplier networks constitute a significant share of emission levels arising from business operations. As a result of globalization, distribution systems for goods and services have become extremely complicated, (Reuter et al., 2010). Therefore, in order to manage the supply chain and minimize its negative impact on environment the theory of Green Supply Chain Management(GSCM) was created which also address these ecological consequences.

Through the exhaustive literature survey, 28 GSCM factors are identified including both external and internal factors influencing Green practices in manufacturing supply chain. Identification and quantification of these factors is more challenging and important also for the sustainable development of the organization. Therefore, our Research is an effort to find the most relevant factors of GSCM and it is called as Critical Success Factors.

Pareto chart was constructed to identify the critical success factors. Therefore, by using the 80-20 rule, we narrowed down the 28 GSCM factors to 16 critical success factors. The success factors are analysed using Interpretive structural modelling(ISM) and then a proposed model is built considering MICMAC that specifies the association

among them. ISM methodology typically develops a compact model based on the results from Delphi technique. The Delphi panel consisted the experts from Industry as well as Academia. The Expert opinion from Industry as well as academia together is considered to build an ISM model that indicates the position and importance of success factors along with the alternatives that converts the fuzzy information into responsive model based on discussions during Delphi technique. Further Structural Equation modelling (SEM) was applied for the theoretical ISM model to statistically validate the results. The current study aimed in developing a hybrid model that combines ISM and SEM. The distinctive feature of the study is that offers a combined approach for ISM-SEM for analysing the factors influencing Green Supply chain practices in Indian manufacturing industries. In the present study, structural relationship SEM approach has been used to validate the ISM based model.

## 2. Literature Review

The Literature has been reviewed from the perspectives of Green supply chain factors, ISM and SEM applications as presented in Tables 1-3.

**Table 1.** Review on Green Supply Chain Manufacturing

<b>Author and Year</b>	<b>Objectives</b>	<b>Methodology</b>	<b>outcomes</b>
Lin et al.,(2011)	To identify the elements that influence the performance of automobile industries through Fuzzy DEMATEL approach.	Fuzzy DEMATEL approach.	Findings show that use of eco material is the significant factor.
Bhool et al.,(2013)	To identify enablers and barriers of GSCM in different sectors of manufacturing industries.	Questionnaire based survey and mean, SD of GSCM drivers through SPSS.	Government rules & legislation' have more important and crucial for adoption of GSCM for 4-wheeler industries
Zhu et al.,(2007)	To determine GSCM practices and implementation strategies to obtain the associated link and measure the efficiency of the obtained relationship.	Statistical analysis by ANOVA Test.	Electrical and electronic industry practise Green supply chain more effectively than other industries in China.

Surajit et al.,(2014)	To build a GSCM framework for the rubber industry.	ISM and MICMAC approach	A tenfold framework was developed that might assist rubber manufacturing industries.
Panpatil et al.,(2022)	To obtain the association between GSCM practices and measure its impact on performance of Industry.	Fuzzy MICMAC.	Developed an integrated model that reveals direct and incidental effect on GSCM practices. The results also showed that driver GSCP's have deliberate importance and dependant GSCP's are more performance oriented.
Venkatesa Narayanan et al.,(2021)	To know the relationship between elements of learning organization and green supply chain practices in manufacturing sector.	Multiple Linear Regression, ISM and MICMAC approach.	Findings of the study identified Green distribution and reverse logistics as driving factors.
Diabat et al.,(2011)	To develop and validate a GSCM model for a manufacturing company.	ISM, MICMAC approach.	The developed model results in increasing the overall cost of the product.
Waqas et al.,(2020)	To determine the association between RL barriers in manufacturing industries, Pakistan.	ISM and MICMAC approach	The model developed identified the obstacles and will help policymakers to frame strategies focusing on major obstacles identified through ISM, MICMAC.
Paul et al.,(2022)	To examine critical Success factors for sustainability in Bangladesh wood industries.	Principal Component Analysis(PCA), ISM and MICMAC Approach.	The findings reveal that research and development, supplier relations, and using eco-friendly technology are the most significant CSFs of the Bangladeshi wood industry.

**Table 2.** Literature study on SEM applications

Author and Year	Objectives	Methodology	outcomes	Sector applied
Thirupathi et al(2016)	To develop hybrid model using ISM and SEM techniques.	ISM and SEM	Findings of the study show that strong relationship exists between sustainable manufacturing enablers.	Automotive component manufacturing organisation
Masoumik et al(2015)	To develop a conceptual model on GSCM initiatives.	ANP , SEM	A conceptual framework on Green supply chain imitativeness is developed.	Business Sector
Khaksar et al(2016)	To determine the relationship between GSCM Factors.	Correlation and SEM	There is a positive and significant relationship between GSCM factors and organizational performance.	Cement Industry
Agarwal et al(2021)	To find out the different barriers of GSCM practices	SEM	A contextual relationship among the identified barriers is developed and model is statistically validated using SEM approach.	Rubber Industry.
Umar et al(2021)	To determine the influence of industry performance in terms of technology, environment through GSCM practices acting as mediating element.	SEM	The outcomes indicate that green supply chain practices mediate the economic and environment performance.	Manufacturing firms.

Juma et al(2022)	To identify the barriers that hinder from implementing GSCM practices.	SEM	SEM identified and statistically validated the factors of GSCM practices that influence green organizational performance.	Jordan manufacturing firms
Amjad et al(2022)	To investigate the influential effect of GSCM practices in leather industry considering competitiveness and investment recovery as mediating factors.	PLS SEM	Findings of the study reveal that GSCM practices effect organizational performance.	Leather Industries.
Nureen et al(2022)	The study attempts to develop a conceptual model between GSCM practices as mediating factors and institutional pressure as moderating factor on organizational performance.	PLS SEM	Findings of the analysis show that technical practices and performance are moderated by institutional pressure.	Manufacturing industries.

**Table 3.** Review on ISM applications

Author and Year	Objectives	Methodology	outcomes	Sector applied
Mandal et al(1994)	To develop an ISM model that shows the interrelationship between different criteria level in vendor selection.	Dickson’s study identified vendor selection criteria. Out of 23 identified criteria’s 11 have been finalised as most important.	Developed vendor selection process framework based on qualitative and quantitative approach.	Vendor selection for Purchasing department in Indian Engineering Industries.
Raut et al(2017)	To investigate CSF for cloud computing adoption in Indian SME’s.	Interpretive structural modelling and Multi criteria decision making model MICMAC analysis.	Previous technological experience is identified as most influential critical success factor for harnessing the benefits of Cloud computing.	Indian micro, small and medium enterprises.
Beikkhakhian et al(2015)	To evaluate agile supplier selection criteria and rank the suppliers.	Interpretive structural modelling, Fuzzy AHP, Fuzzy TOPSIS.	Supply chain agility model is developed by ISM procedure that identified delivery speed as highest driving variable.	Manufacturing industries.
Ali et al(2020)	To build a model by identifying barriers to lean supply chain.	ISM to identify the contextual relationship and MICMAC analysis to determine Supply chain barriers.	Developed model that shows the contextual relationship between the barriers.	Apparel manufacturing Industries.
Talib et al(2011)	To develop a hierarchy of TQM barriers that identifies the relationship between the identified barriers.	ISM approach to know the mutual dependency of one barrier over the other. MICMAC to cluster the barriers and know their dependency.	Developed ISM based TQM barriers model and determined driver, dependent cluster of TQM barriers	Service sectors.
Khan et al(2015)	To model the interrelationships among retail brand experience variables.	ISM to develop the framework and MICMAC approach to cluster the variables.	Findings of the study revealed that retail brand experience is influenced by variables with high driving power and weak driving power.	Retail sectors.

Attri et al(2017)	To develop a 5S hierarchy based model and identify the dependency of one barrier over the other.	ISM to identify the relationship among identified barriers and MICMAC to know dependant and independent barriers	Developed a hierarchy based model.	Indian manufacturing industries.
Shibin et al(2017)	To develop a Flexible Green supply chain model both barrier and enabler based.	Total interpretive structural modelling(TISM) to identify the relationship between barriers and enablers.	Developed Barrier, enabler framework for Flexible Green supply chain	Manufacturing organizations.
Thakur et al(2016)	To identify and analyse the interrelationships among medical waste disposal care barriers	ISM and Fuzzy MICMAC to prioritize barriers of health care waste management system.	Hierarchical ISM framework developed identifies the interrelationship between the identified barriers.	Health care sector
Nandal et al(2019)	To examine solar power implementation in thermal plants by establishing hierarchical framework that determines the interrelationship between solar power barriers.	ISM to determine the circumstantial relationships among key barriers and MICMAC approach to validate the ISM model.	Developed contextual framework that is validated through MICMAC and identified the most influential barriers that are hindering the installation of solar power in thermal power plants.	Indian thermal power plants.

From the literature review several factors are identified that require considerable amount of time and energy for managers to get adapted to Green supply chain practices. With the development of concise set of GSCM factors, which may provide quicker and easier support to take initiation for practising GSCM in manufacturing industries. The major problem with the available GSCM models is that the factors themselves need an understanding of being applied in the defined sector and also the measurement of the model through statistical techniques. Therefore, this gap led to the formation of three main objectives:

- 1) To identify the key Green supply chain factors of the Indian manufacturing industries from the literature and expert opinion.
- 2) To develop an appropriate hierarchy and contextual relationship of identified factors using interpretive structural modelling (ISM) and to classify these factors using Matrice d' Impacts Croisés-Multiplication Appliquée á un Classement (MICMAC)

- 3) To validate the ISM model using structural equation modeling (SEM).

The subsequent tables 1,2 and 3 present literatures with respect to Green supply chain in Manufacturing industries, SEM applications and ISM applications.

Based on the literature review on ISM, it is understood that there exists scope for selecting appropriate number of facilitators to simplify the situation. Literature also identifies that SEM being implemented independently fails to build a model on logical interpretation. Also applying only ISM model fails to provide the statistical results. Therefore, the integration of ISM and SEM technique builds a model that proves the logical interpretation from experts by subjecting it to statistical validation.

ISM model developed based on expert opinion will identify factors which can be further statistically verified. This has been expressed by various authors in their study Balon (2016), Chin (2015), Deng et al (2019), Mahmoudi et al(2016). Now the challenge lies in validation of theoretical

model developed from ISM due to the limitation, of strong theory to interpret the developed model. The integration of ISM and SEM offers a complete solution to the above problem. In the current study authors have made an attempt to develop one such model that is statistically valid.

### 3. Methodology

A trianalysis method was carried out in this study analysing both quantitative, qualitative data obtained from study. The measureable analysis was based on Questionnaire survey, while qualitative was on Delphi technique on having semi structured interview with panel consisting of members from Industry and academicians. The study consisted of trifold analysis ISM, MICMAC and SEM within Indian manufacturing industries. Although ISM is a competent method to model the facilitators but it increases the complexity of the system by raising the number of facilitators. Therefore, the facilitators modelled from ISM and Micmac needs a statistical validation. In order to overcome this problem SEM and ISM are combined to validate the relationship between success factors. The MICMAC analysis helps to cluster the factors in four quadrants and group them accordingly based on driving and dependence power.

The critical success factors(CSF) are identified from literature review and expert opinion survey. A thorough literature review has been carried out referring research articles for the period 2008 to 2022 from Scopus, Emerald, Taylor and Francis database. This was followed by summarizing expert's opinion from academics and industry. Based on the opinion from academicians and industry experts 28 factors were identified. In order to reduce the factor intricacy and develop a framework further Interpretive structural modelling to conceptually validate the model and Structural Equation modelling(SEM) has

been used to statistically validate the ISM model.

#### **Frequently used GSCM factors from Literature study**

Firms have many objectives such as better image of brand, to get competitive advantage, better utilization of sources, increased profits, etc. In the process of achieving these objectives firms apply various strategies, one such strategy would be to implement GSCM practices. GSCM might be a more effective means to balance ecological, financial and societal performances. (Diabat, Govindan, 2011). Supply chain management has significant impacts on the environment which includes-release of pollutants and emissions, health hazards affecting the workers, wastage of materials, etc. Hence firms are trying to reduce the negative environmental impact by including environmentally friendly strategies into the supply chain. (Sarkis, 2012) Therefore the work carried out focuses on bringing out the most important environmental concerns and strategies pertaining to them and to generate a generalized framework that may be applicable to industries. Therefore, from the literature frequently used factors of GSCM by various authors are identified and listed in table 4.

From the literature the identified 28 GSCM factors are as depicted in table 4, Further these 28 factors are subjected to Pareto analysis to identify vital few that are critical ones and responsible for implementation for green practices in manufacturing industries.

**Table 4.** GSCM factors used by the various researchers

Sl No	Components	Researchers	Frequency
1	Green Purchasing	Famiyeh (2017), Feng (2017), Khan (2017), Khan (2017), Laari (2015), Sharma (2016), Vijayvargy et al., (2017), Younis (2016), Liu (2018), Agi (2017), Ahmad et al., (2021), Abdel-Baset et al., (2019), Çankaya et al., (2018), Cousins et al., (2019), Badi et al., (2019), Sellitto et al., (2019), Seman et al., (2019), Sahar et al., (2020), Ilyas et al., (2020), Novitasari et al., (2021), Younis et al., (2019), Zhu (2010), Thipparat (2011), Choudhary (2011), Azevedo (2012), Babu (2012), Laosirihongthong et al., (2013), Jabbour et al., (2015), Jabbour (2014), Chin et al., (2015), Lee et al., (2013), Hasan (2013)	32
2	Green Manufacturing &Packaging	Feng (2017), Khan (2017), Khan (2017), Laari (2015), Sharma (2016), Liu (2018), Ahmad et al., (2021), Dev et al., (2020), Xie et al., (2019), Cousins et al., (2019), Badi et al., (2019), Sellitto et al., (2019), Seman et al., (2019), Deng et al., (2019), Ilyas et al., (2020), Novitasari et al., (2021), Younis et al., (2019), Shanga (2010), Kumar (2012), Babu (2012), Laosirihongthong et al., (2013), Jabbour (2014), Chin et al., (2015), Lee et al., (2013), Hasan (2013)	25
3	Green Marketing and Distribution	Feng (2017), Khan (2017), Laari (2015), Liu (2018), Esfahbodi (2017), Ahmad et al., (2021), Dev et al., (2020), Çankaya et al., (2018), Sellitto et al., (2019), Burki (2018), Seman et al., (2019), Shanga (2010), Kumar (2012), Choudhary (2011), Perotti (2012), Yang et al., (2013), Laosirihongthong et al., (2013), Jabbour (2014), Chin et al., (2015), Lee et al., (2013), Hasan (2013), Sezan et al., (2013),	22
4	Eco design	Khan (2017), Khan (2017), Sharma (2016), Vijayvargy et al., (2017), Younis (2016), Esfahbodi (2017), Çankaya et al., (2018), Badi et al., (2019), Sahar et al., (2020), Al-Sheyadi et al., (2019), Zhu (2010), Xie et al., (2012), Andreas et al., (2011), Shanga (2010), Zhu (2012), Kumar (2012), Thipparat (2011), Perotti (2012), Caniato (2012), Choi et al., (2015), Jabbour et al., (2015)	21
5	Green Logistics	Feng (2017), Laari (2015), Khan (2018), Sharma (2016), Liu (2018), Ahmad et al., (2021), Çankaya et al., (2018), Cousins et al., (2019), Badi et al., (2019), Trivellas et al., (2020), Seman et al., (2019), Sahar et al., (2020), Ilyas et al., (2020), Novitasari et al., (2021), Younis et al., (2019), Kumar (2012), Laosirihongthong et al., (2013), Jabbour (2014), Chin et al., (2015), Lee et al., (2013), Hasan (2013)	21
6	Customer Cooperation	Khan (2017), Sharma (2016), Vijayvargy et al., (2017), Zhu (2016), Wang (2018), Agi (2017), Çankaya et al., (2018), Sellitto et al., (2019), Kumar et al., (2019), Zhu (2010), Xie et al., (2012), Andreas et al., (2011), Thipparat (2011), Perotti (2012), Azevedo (2012), Yang et al., (2013), Jabbour et al., (2015), Hsu et al., (2013), Ye et al., (2013), Yu et al., (2014)	20
7	Green Procurement	Feng (2017), Laari (2015), Liu (2018), Esfahbodi (2017), Ahmad et al., (2021), Çankaya et al., (2018), Cousins et al., (2019), Seman et al., (2019), Ilyas et al., (2020), Novitasari et al., (2021), Younis et al., (2019), Kumar (2012), Caniato (2012), Sehnem (2012), Laosirihongthong et al., (2013), Jabbour (2014), Chin et al., (2015), Lee et al., (2013), Hasan (2013)	19

8	Institutional Pressure	Govindan (2016), Sharma (2016), Yang (2017), Chu (2017), Vanalle (2017), Gandhi (2016), Esfahbodi (2017), Sriyakul et al., (2019), Saberi et al., (2018), Tseng et al., (2019), Burki (2018), Kumar et al., (2019), Kumar et al., (2019), Zhu et al., (2013), Lee et al., (2013), Ye et al., (2013), Wolf (2013), Dubey et al., (2014)	18
9	Environmental Strategies and Management (Eg 3R)	Khan (2017), Khan (2017), Haseeb (2018), Vanalle (2017), Badi et al., (2019), Sellitto et al., (2019), Al-Sheyadi et al., (2019), Babu (2012), Caniato (2012), Kumar (2012), Huo et al., (2021), Andreas et al., (2011), Choudhary (2011), Azevedo (2012), Sehnem (2012), Yang et al., (2013), Muduli et al., (2013), Laosirihongthong et al., (2013)	18
10	Supplier Cooperation	Sharma (2016), Khaksar (2015), Agi (2017), Sriyakul et al., (2019), Sellitto et al., (2019), Burki (2018), Xie et al., (2012), Kumar (2012), Azevedo (2012), Yang et al., (2013), Wu et al., (2015), Lee et al., (2014), Dubey et al., (2014), Yu et al., (2014), Tachizawa et al., (2014)	15
11	Human and Technological resources	Zaid (2018), Agi (2017), Jabbour (2017), Singh et al., (2020), Kusi-Sarpong et al., (2019), Sellitto et al., (2019), Sahar et al., (2020), Kumar et al., (2019), Kumar (2012), Balasubramanian (2012), Perotti (2012), Wang et al., (2013), Muduli et al., (2013), Hsu et al., (2013)	14
12	Leadership	Govindan (2016), Agi (2017), Ahmad et al., (2021), Huo et al., (2021), Sriyakul et al., (2019), Zulkefli et al., (2019), Singh et al., (2020), Tseng et al., (2019), Kumar et al., (2019), Ilyas et al., (2020), Xie et al., (2012), Balasubramanian (2012), Muduli et al., (2013), Dubey et al., (2014)	14
13	Green Policies	Govindan (2016), Gandhi (2016), Tseng et al., (2019), Ilyas et al., (2020), Zhu (2012), Andreas et al., (2011), Arimura (2011), Perotti (2012), Azevedo (2012), Yang et al., (2013), Laosirihongthong et al., (2013), Hsu et al., (2013), Govindan et al., (2014)	13
14	Environmental Participation, Green Training	Govindan (2016), Younis (2016), Kirchoff et al., (2017), Agi (2017), Jabbour (2017), Tseng et al., (2019), Kusi-Sarpong et al., (2019), Çankaya et al., (2018), Shanga (2010), Balasubramanian (2012), Perotti (2012), Wu et al., (2015), Muduli et al., (2013)	13
15	Financial Implications	Feng (2017), Laari (2015), Wang (2018), Gandhi (2016), Esfahbodi (2017), Kusi-Sarpong et al., (2019), Xie et al., (2019), Sahar et al., (2020), Lina (2011), Balasubramanian (2012), Wang et al., (2013), Ortas et al., (2014)	12
16	Reverse Logistics	Sharma (2016), Younis (2016), Abdel-Baset et al., (2019), Sellitto et al., (2019), Deng et al., (2019), Perotti (2012), Azevedo (2012), Laosirihongthong et al., (2013), Hasan (2013), Ye et al., (2013), Govindan et al., (2014),	11
17	Competition and Uncertainty	Govindan (2016), Sharma (2016), Khaksar (2015), Gandhi (2016), Tseng et al., (2019), Balasubramanian (2012), Chiou (2012), Yang et al., (2013), Lee et al., (2014), Hsu et al., (2013), Ye et al., (2013)	11
18	Investment Recovery	Vijayvargy et al., (2017), Esfahbodi (2017), Çankaya et al., (2018), Sellitto et al., (2019), Zhu (2010), Zhu (2012), Thipparat (2011), Perotti (2012), Choi et al., (2015), Jabbour et al., (2015)	10
19	Environmental Management System	Famiyeh (2017), Khan (2018), Tseng et al., (2019), Abdel-Baset et al., (2019), Al-Sheyadi et al., (2019), Testa (2012), Arimura (2011), Perotti (2012), Wang et al., (2013), Jabbour (2014)	10
20	Internal GSCM	Zaid (2018), Yang (2017), Wang (2018), Saberi et al., (2018), Burki (2018), Zhu (2012), Zhu et al., (2013), Yang et al., (2013), Jabbour et al., (2015), Yu et al., (2014)	10
21	External GSCM	Zaid (2018), Yang (2017), Wang (2018), Gandhi (2016), Saberi et al., (2018), Çankaya et al., (2018), Al-Sheyadi et al., (2019), Zhu (2012), Zhu et al., (2013), Yang et al., (2013)	10
22	Green Product Innovation	Khaksar (2015), Singh et al., (2020), Xie et al., (2019), Çankaya et al., (2018), Sellitto et al., (2019), Novitasari et al., (2021), Chiou (2012), Muduli et al., (2013), Sezan et al., (2013)	9



23	Total Quality Management	Haseeb (2018), Agi (2017), Sriyakul et al., (2019), Jabbour (2014), Dubey et al., (2014)	5
24	Internal Environmental Management	Sharma (2016), Vijayvargy et al., (2017), Çankaya et al., (2018)	3
25	Corporate Social Responsibility	Govindan (2018), Anil Kumar et al., (2019)., Wolf (2013)	3
26	Circular Economy	Govindan (2016), Liu (2018).	2
27	Green Stock	Feng (2017), Shanga (2010)	2
28	Eco-labelling	Zhu (2012)	1

## 4. Pareto chart

A Pareto analysis helps to prioritize decisions and identify the major critical factors that might be responsible for firm's performance. Brooks et al (2014). It is also defined as 80/20 rule as it explains about 80% of the firm's benefit is from 20% of the factors. With this approach among the frequently identified

factors of Green supply chain only vital few that is 20% of the critical factors are responsible for 80% of the firm's success are identified through Pareto analysis. A Pareto chart is constructed as shown in Figure 1 that highlights 20% of the green supply chain factors constituting about 16 factors responsible for 80% of the firm's outcome.

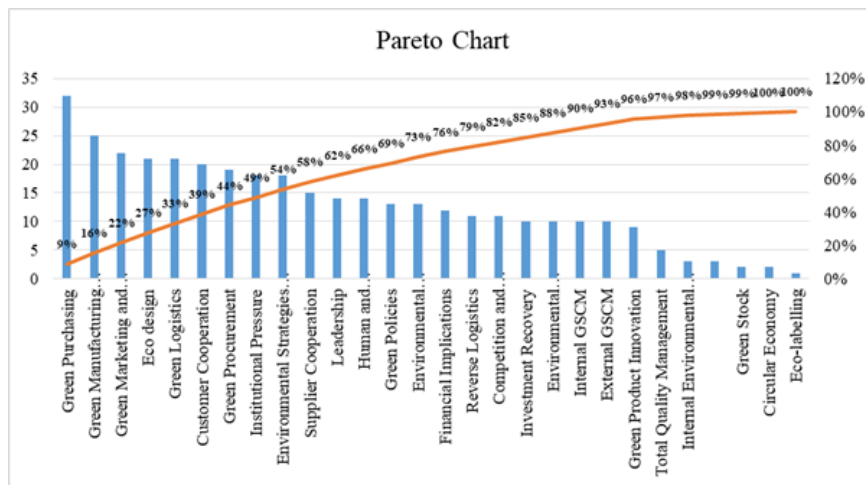


Figure 1. Pareto chart for GSCM Factors

Based on the literature review, we identified nearly 28 GSCM factors in our study. Pareto chart to find out the critical success factors. On the Pareto diagram as shown in figure 1, 28 factors are listed on the x-axis in the order of their contribution to the overall influences in descending order. Hence, using the 80-20 rule, we narrowed down the 28 GSCM factors to 16 critical success factors.

### Interpretive Structural Modelling

Structural Self-Interactive Matrix

The SSIM matrix was developed by plotting the relationship between two facilitators i.e., i and j. The relations were coded with V, A, X and O. SSIM matrix is depicted in table 6.

V is represented when GSCMF i will assist GSCMF j.

A is represented when GSCMF j will assist GSCMF i.

X is represented when GSCMF i and j assist each other.

O is represented when both GSCMF i and j are not related to each other.

An example of the application of GSCMF- GSCMF 6 assists GSCMF 16 and hence it is coded as V.

GSCMF 14 assists GSCMF 7 and hence it is coded as A.

GSCMF 5 and GSCMF 15 assist each other and hence, they are coded as X.

GSCMF 6 and GSCMF 8 are not related to each other and hence they are coded as O.

the relationships between two facilitators are binary coded for codes V, A, X and O respectively, the coding procedure is as shown in table 5. Table 7 represents Initial reachability matrix that follows the binary coding for SSIM.

**Table 5. Binary coded table**

	(i, j)	(j, i)
V	1	0
A	0	1
X	1	1
O	0	0

**Initial Reachability Matrix**

The Structural Self-Interactive Matrix is followed by Initial Reachability Matrix where

**Table 6. Structural Self-Interaction Matrix**

GSCMF Code	RL16	FI15	EPG14	GP13	HT12	L11	SC10	EM9	IP8	GP7	CC6	ED5	GL4	GMD3	GMP2	GP1
GP1	V	X	A	A	A	A	X	A	A	X	V	A	X	V	X	.
GMP2	X	X	A	A	A	A	A	A	A	A	A	A	V	X	.	X
GMD3	X	X	A	A	A	A	O	A	A	A	V	A	X	.	X	V
GL4	X	X	A	A	A	A	O	A	A	X	X	O	.	X	V	X
ED5	O	X	A	A	A	A	A	A	A	X	V	.	O	A	A	A
CC6	V	X	A	O	O	V	O	V	O	O	.	V	X	V	A	V
GP7	X	X	A	A	A	A	X	A	A	.	O	X	X	A	A	X
IP8	V	O	X	V	V	X	V	V	.	A	O	A	A	A	A	A
EM9	V	V	X	V	V	A	V	.	V	A	V	A	A	A	A	A
SC10	X	X	V	A	A	A	.	V	V	X	O	A	O	O	A	X
L11	V	V	X	V	V	.	A	A	X	A	V	A	A	A	A	A
HT12	V	X	V	A	.	V	A	V	V	A	O	A	A	A	A	A
GP13	V	V	V	.	A	V	A	V	V	A	O	A	A	A	A	A
EPG14	V	O	.	V	V	X	V	X	X	A	A	A	A	A	A	A
FI15	X	.	O	V	X	V	X	V	O	X	X	X	X	X	X	X
RL16	.	X	V	V	V	V	X	V	V	X	V	O	X	X	X	V

**Table 7. Initial Reachability Matrix**

GSCMF Code	RL16	FI15	EPG14	GP13	HT12	L11	SC10	EM9	IP8	GP7	CC6	ED5	GL4	GMD3	GMP2	GP1
GP1	1	1	0	0	0	0	1	0	0	1	1	0	1	1	1	1
GMP2	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1
GMD3	1	1	0	0	0	0	0	0	0	0	1	0	1	1	1	0
GL4	1	1	0	0	0	0	0	0	0	1	1	0	1	1	0	1
ED5	0	1	0	0	0	0	0	0	0	1	1	1	0	1	1	1
CC6	1	1	0	0	0	1	0	1	0	0	1	0	1	0	1	0
GP7	1	1	0	0	0	0	1	0	0	1	0	1	1	1	1	1
IP8	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1
EM9	1	1	1	1	1	0	1	1	0	1	0	1	1	1	1	1
SC10	1	1	1	0	0	0	1	0	0	1	0	1	0	0	1	1
L11	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
HT12	1	1	1	0	1	0	1	0	0	1	0	1	1	1	1	1
GP13	1	1	1	1	1	0	1	0	0	1	0	1	1	1	1	1
EPG14	1	0	1	0	0	1	0	1	1	1	1	1	1	1	1	1
FI15	1	1	0	0	1	0	1	0	0	1	1	1	1	1	1	1
RL16	1	1	0	0	0	0	1	0	0	1	0	0	1	1	1	0

**Table 8.** Transitivity Matrix

GSCMF Code	GP1	GMP2	GMD3	GL4	ED5	CC6	GP7	IP8	EM9	SC10	L11	HT12	GP13	EPG14	FI15	RL16
GP1	1	1	1	1	1*	1	1	0	1*	1	1*	1*	0	1*	1	1
GMP2	1	1	1	1	1*	1*	1*	0	0	1*	0	1*	0	0	1	1
GMD3	1*	1	1	1	1*	1	1*	0	1*	1*	1*	1*	0	0	1	1
GL4	1	1*	1	1	1*	1	1	0	1*	1*	1*	1*	0	0	1	1
ED5	1	1	1	1*	1	1	1	0	1*	1*	1*	1*	0	0	1	1*
CC6	1*	1	1*	1	1*	1	1*	1*	1	1*	1	1*	1*	1*	1	1
GP7	1	1	1	1	1	1*	1	0	0	1	0	1*	0	1*	1	1
IP8	1	1	1	1	1	1*	1	1	1	1	1	1	1	1	1*	1
EM9	1	1	1	1	1	1*	1	1*	1	1	0	1	1	1	1	1
SC10	1	1	1*	1*	1	1*	1	1*	1*	1	1*	1*	0	1	1	1
L11	1	1	1	1	1	1*	1	1	1	1	1	1	1	1	1	1
HT12	1	1	1	1	1	1*	1	1*	1*	1	1*	1	0	1	1	1
GP13	1	1	1	1	1	1*	1	1*	1*	1	1*	1	1	1	1	1
EPG14	1	1	1	1	1	1	1	1	1	1*	1	1*	1*	1	1*	1
FI15	1	1	1	1	1	1	1	0	1*	1	1*	1	0	1*	1	1
RL16	1*	1	1	1	1*	1*	1	0	0	1	0	1*	0	1*	1	1

**Level partitions**

The reachability set and antecedent set for each GSCMF are determined using the final reachability matrix. The reachability set includes GSCMFs and other GSCMFs that may aid in their attainment, while the antecedent set comprises GSCMFs and other GSCMFs that aid in their attainment. The intersection of these sets is then calculated for each GSCMF. The top-level GSCMFs in the ISM hierarchy are those with the same reachability and intersection sets. The

hierarchy's top-level GSCMFs would not assist in the achievement of any GSCMFs beyond their own level. It is isolated from the other GSCMFs once the top-level GSCMFs have been discovered (Step 4: Partitioning of reachability matrix). The method is then restarted to determine the GSCMF in the next level. This procedure is repeated until the level of each GSCMF is determined (Step 4: Partitioning of reachability matrix). These stages contribute to the construction of the diagram and the final Framework.

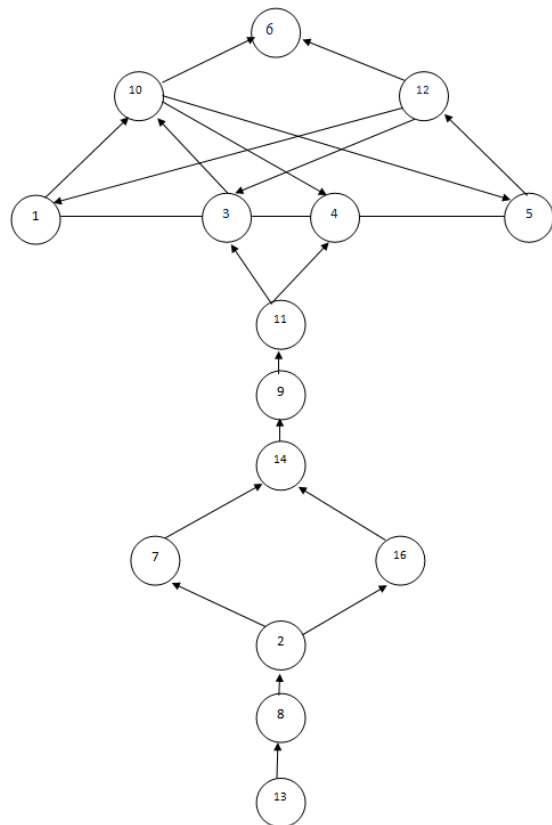
**Table 9.** Level Partitioning Matrix

GSCMF CODE	REACHABILITY SET	ANTECEDENT SET	INTERSECTION SET	LEVEL
GP1	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	1,2,3,4,5,6,7,9,10,11,12,14,15,16	1,2,3,4,5,6,7,9,10,11,12,14,15,16	L3
GMP2	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	1,2,3,4,5,6,7,10,12,15,16	1,2,3,4,5,6,7,10,12,15,16	L8
GMD3	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	1,2,3,4,5,6,7,9,10,11,12,15,16	1,2,3,4,5,6,7,9,10,11,12,15,16	L3
GL4	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	1,2,3,4,5,6,7,9,10,11,12,15,16	1,2,3,4,5,6,7,9,10,11,12,15,16	L3
ED5	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	1,2,3,4,5,6,7,9,10,11,12,15,16	1,2,3,4,5,6,7,9,10,11,12,15,16	L3
CC6	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	L1
GP7	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	1,2,3,4,5,6,7,10,12,14,15,16	1,2,3,4,5,6,7,10,12,14,15,16	L7
IP8	6,8,9,10,11,12,13,14	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	6,8,9,10,11,12,13,14	L9
EM9	1,3,4,5,6,8,9,10,11,12,13,14,15	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	1,3,4,5,6,8,9,10,11,12,13,14,15	L5

<b>SC10</b>	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	1,2,3,4,5,6,7,8,9,10,11,12,14,15,16	1,2,3,4,5,6,7,8,9,10,11,12,14,15,16	L2
<b>L11</b>	1,3,4,5,6,8,9,10,11,12,13,14,16	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	1,3,4,5,6,8,9,10,11,12,13,14,16	L4
<b>HT12</b>	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	1,2,3,4,5,6,7,8,9,10,11,12,14,15,16	1,2,3,4,5,6,7,8,9,10,11,12,14,15,16	L2
<b>GP13</b>	6,8,9,11,13,14	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	6,8,9,11,13,14	L10
<b>EPG14</b>	1,6,7,8,9,10,11,12,13,14,15,16	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	1,6,7,8,9,10,11,12,13,14,15,16	L6
<b>FI15</b>	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	1,2,3,4,5,6,7,9,10,11,12,14,15,16	1,2,3,4,5,6,7,9,10,11,12,14,15,16	L3
<b>RL16</b>	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	1,2,3,4,5,6,7,10,12,14,15,16	1,2,3,4,5,6,7,10,12,14,15,16	L7

### 5. Building the ISM model

The structural model is created using the final reachability matrix (Step 3: Transitivity matrix). An arrow pointing from i to j indicates, there is a relationship between the GSCMFs i and j. A directed graph, or digraph, is what this graph is called. The digraph (Figure 2) is turned into the ISM-based framework when the transitivity is removed (Figure 3). I



**Figure 2.** Digraph

#### ISM based Framework

A digraph (figure 2) is used to illustrate the factors and their relationships in the form of nodal representation. (Mahmoudi et al., 2013).

1. Green Purchasing
2. Green Manufacturing and Packaging
3. Green Marketing and Distribution
4. Green Logistics
5. Ecodesign
6. Customer Cooperation
7. Green Procurement
8. Institutional Pressure
9. Environmental strategies and Management
10. Supplier cooperation
11. Leadership
12. Human and Technological resources
13. Green Policies
14. Environmental participation and green training
15. Financial implications
16. Reverse logistics

From the reachability matrix, a digraph was constructed that represents the facilitators and their interdependence with each other. In the digraph that obtained, Green Supply Chain critical success factors have been classified into 10 levels according to the level partitioning matrix. According to the diagram, the highest success factor is positioned at the top of the digraph and the second-level facilitator is placed at the second position and so on until the bottom level is placed at the lowest position in the digraph. Here, GSCMF 6 lies in the topmost level- Level 1 while GSCMF 13 in the bottom most level, the 10<sup>th</sup> level.

### Interpretive structural modelling Framework

The digraph is transformed into an ISM model by replacing the nodes of the facilitators with their respective names. From this framework, it can be seen that the facilitators are arranged according to their levels. Customer cooperation lies in level one being the most highly independent facilitator whereas green policies lie in the 10th level being the most highly dependent facilitator.

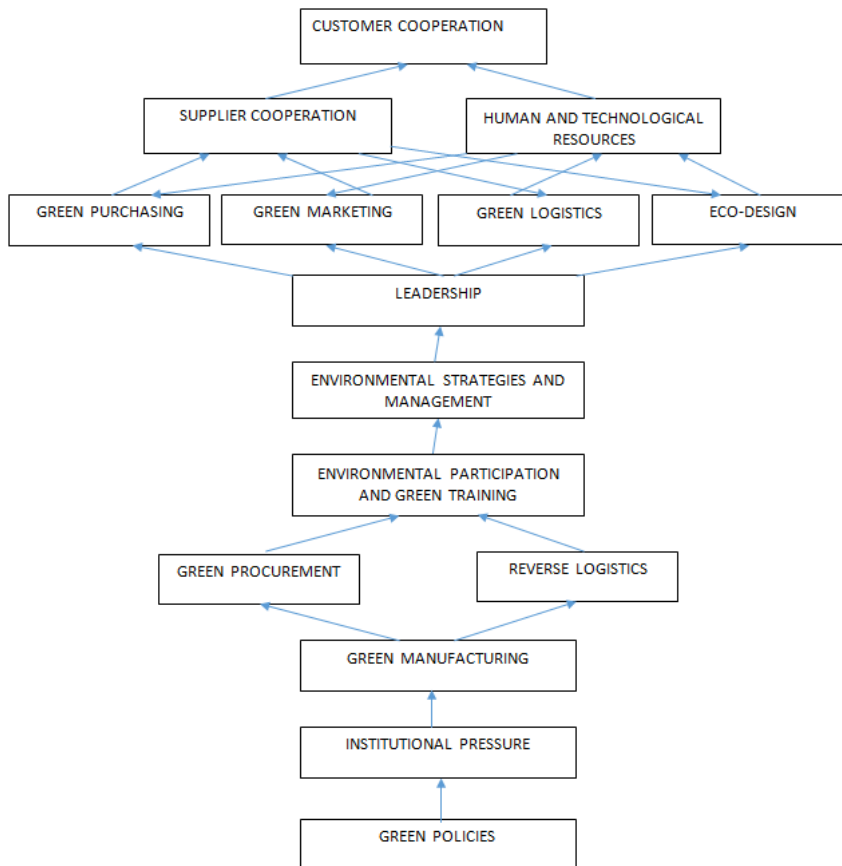


Figure 3. ISM based Framework

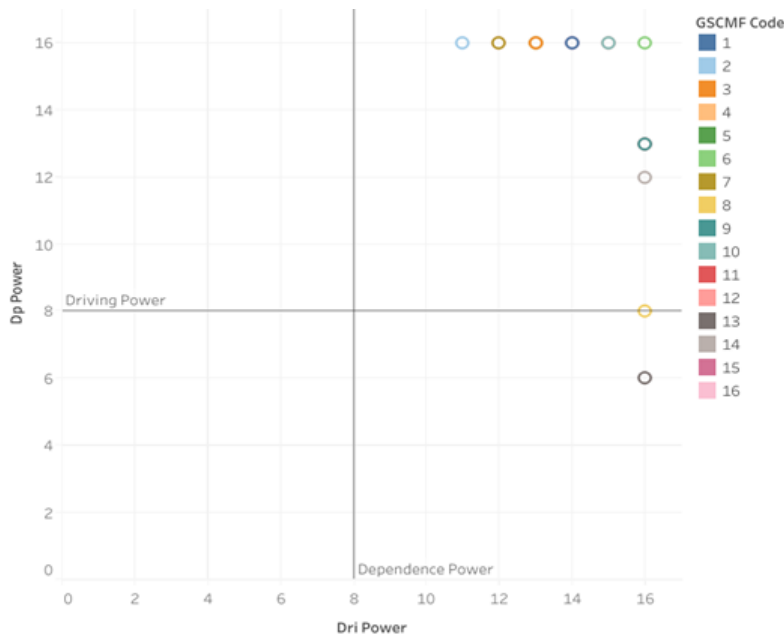
**6. MICMAC Analysis**

Matrice d'impacts croisés multiplication appliquée á un classment (Cross impact matrix-multiplication applied to classification), was developed by Duperrin and Godet (1973) at the CEA between 1972 and 1974 (Sexana et al,1990) to investigate the distribution of associates through response paths and loops for developing hierarchies for members of an element set (Purohit,2017) and is a structural prospective analysis used to investigate indirect relationships (Sexana et al,1990). MICMAC analysis can be used to identify and investigate the elements in a sophisticated and complex system with the goal of separating the variables' driving and dependency powers (Faisal et al. 2007). Variable X affects Y, variable Y affects Z, X and Z have no direct influence on Y, but their association with Y is a cross-correlation, where any modification in X impacts Z. Gray area exploration is another

name for this type of analysis (Dubey et al,2014).

This analysis enhances the ISM technique by examining limitations that are commonly associated with the ISM method: it examines the connection "yes" or "no" and ignores the "gray area" between 0 and 1. (Sushil et al,2012). The construction of a graph that classifies components based on driving and dependence power is a part of the MICMAC analysis. To get at the study's findings and conclusions, MICMAC analysis is utilized to characterize the components and validate the interpretive structural model factors. (Ahmad et al,2019).

According to Figure 3.4, the Micmac analysis shows that most of the facilitators have high driving and dependence power, they were found to be linkage variables, they work as a catalyst to the dependant variables while they are relative to independent variables.



**Figure 4. MICMAC Graph**

Facilitator 2, 7, 3, 1, 10, 6, 9, 14, i.e., Green Manufacturing, Green Procurement, Green Marketing and Distribution, Green Purchasing, Supplier Cooperation, Customer Cooperation, Environmental Strategies and Management, Environmental Participation and Green Training respectively were found to be the linkage variables through the analysis. Facilitator 8 and 13, i.e., Institutional Pressures and Green Policies respectively, has a higher driving power than the depending power. The dependent variables are related to the independent variables and this is possible because of linkage variables.

## 7. Model analysis using Structural Equation Modelling (SEM)

Structural Equation Modelling is a combined technique applying regression and factor analysis to validate survey based results statistically. (Referencing).

Exploratory factor analysis(EFA) is applied on sample size of 511 units (n=511) for the 16 barriers of green supply chain to extract

the factors that are Principal factors using SPSS. In the study Principal component analysis with varimax rotation was used to group the items under common factor by following the principle of Eigen value criterion. The Eigen values with greater than one are considered A total of six factors with eigen value greater than 1 are considered as shown in Table 11. The factors are grouped into six sections namely Green manufacturing, Green logistics, Customer cooperation, Environmental strategies and management, Supplier cooperation, Reverse logistics all of which have an Eigen value of greater than 1 and factor loading of greater than 0.5 with more than three items for each factor. Cronbach's alpha was used to measure the internal consistency of the instrument.

Kaiser Mayer Olkin(KMO) test was conducted to check the adequacy of the collected data. The table 10 presents the statistics of KMO result showing that the data are adequate. Data with KMO values greater than 0.6 are considered adequate. Factor analysis

**Table 10.** KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.811
Bartlett's Test of Sphericity	Approx. Chi-Square	4191.255
	df	253
	Sig.	.000

The outline of Principal Component Analysis is depicted in table 11 that explains the total variance accumulated by six components is 71.9%. Based on EFA, subsequent six Principal components were selected based on Eigen values greater than 1. Further in order to assess the significance of the data through the items, the commonalities derived from the factor analysis were reviewed. The item loading greater than 0.5 were considered (Fornell et al,1981)). For the final instrument 23 items

were extracted based on those variables having a loading of atleast 0.5 on single factor. Table 11 summarized the extraction of six components through factor analysis.

### Model Fit Summary

The values of the model fit are fully satisfactory as per social science research. All the fit indices are within the acceptable range as shown in table 13. (Hair et al 2009).

**Table 11. Total Variance Explained**

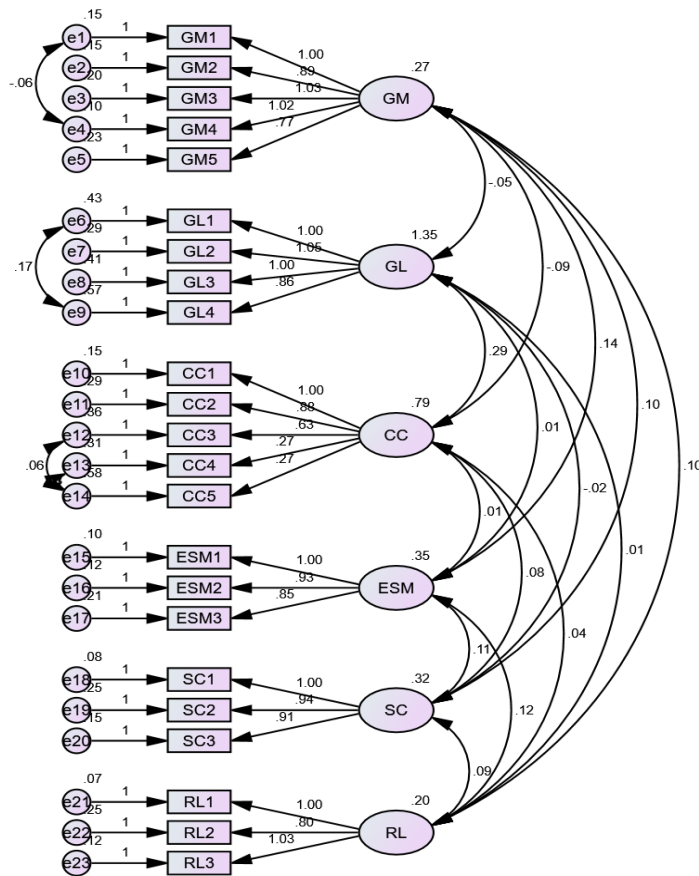
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.520	23.999	23.999	5.520	23.999	23.999	3.501	15.221	15.221
2	3.883	16.883	40.882	3.883	16.883	40.882	3.370	14.650	29.871
3	2.547	11.074	51.956	2.547	11.074	51.956	2.706	11.767	41.638
4	1.658	7.208	59.164	1.658	7.208	59.164	2.444	10.625	52.263
5	1.525	6.632	65.796	1.525	6.632	65.796	2.412	10.488	62.751
6	1.405	6.108	71.904	1.405	6.108	71.904	2.105	9.153	71.904
7	.845	3.673	75.577						
8	.637	2.768	78.345						
9	.609	2.650	80.995						
10	.550	2.390	83.385						
11	.511	2.221	85.606						
12	.443	1.928	87.533						
13	.392	1.703	89.236						
14	.376	1.636	90.872						
15	.350	1.522	92.394						
16	.309	1.345	93.740						
17	.267	1.160	94.900						
18	.249	1.081	95.980						
19	.210	.912	96.893						
20	.194	.843	97.736						
21	.187	.814	98.550						
22	.172	.747	99.297						
23	.162	.703	100.00						

**Table 12. Rotated Component matrix**

	Components					
	1	2	3	4	5	6
GM1	.811					
GM2	.805					
GM3	.804					
GM4	.789					
GM5	.637					
GL1		.916				
GL2		.910				
GL3		.895				
GL4		.875				
CC1			.845			
CC2			.832			
CC3			.751			
CC4			.576			
CC5			.538			
ESM1				.855		
ESM2				.828		
ESM3				.818		
SC1					.857	
SC2					.848	
SC3					.826	
RL1						.838



RL2						.771
RL3						.764
Extraction Method: Principal Component Analysis.						
Rotation Method: Varimax with Kaiser Normalization.						
a. Rotation converged in 6 iterations.						



**Figure 5.** Measurement model of Green supply chain management

**Table 13.** Model fit summary

Model tested	$\chi^2/Cmin$	GFI	AGFI	CFI	TLI	RMSEA
Performance of model	2.317	.907	.952	.932	.918	.064
Criterion for Goodness of Fit	$\leq 3$	$\geq 0.90$	$\geq 0.90$	$\geq 0.90$	$\geq 0.90$	$\leq 0.08$

## 8. Results and Discussion

The study has identified 28 key Green Supply Chain Management Facilitators by reviewing a number of research articles, which were run through Pareto analysis that resulted in the identification of 16 predominant factors.

It is moreover evident that no single GSCM factor would be self-determining for green supply chain implementation in an organization, therefore, it becomes more important to identify the relationship of GSCM factor with each other. ISM methodology is used to develop relationship among various factors for each dimension of GSCM implementation. The practitioners need to concentrate on these factors more cautiously during GSCM implementation in their organizations. On the other hand, academicians may be encouraged to categorize different other issues, which are important in addressing these GSCMF.

ISM model identifies the hierarchy of actions to be taken by practitioners in order to maximize the effect of these GSCMF in order to implement GSCM successfully. Based on the level partitioning matrix, it was found that framework is divided into ten levels where facilitator 13 (Level 10) which is Green Policies was the most dependent while facilitator 6 (Level 1) Customer Cooperation is the most independent.

Micmac Analysis identified 8 facilitators to be linkage variables and 2 facilitators to be dependent variables. The linkage variables were Green Manufacturing, Green Procurement, Green Marketing and Distribution, Green Purchasing, Supplier Cooperation, Customer Cooperation, Environmental Strategies and Management, Environmental Participation and Green Training and Dependent variables were found to be Institutional Pressures and Green Policies. The factors were statistically verified using structural equation modelling

and the model fit satisfied all the fit indices thereby proving the factors to be critically responsible for implementation of Green supply chain.

The ISM model was further validated statistically through Structural equation modelling, where EFA resulted in six components whose Eigen values are greater than 1, The six success factors resulted from EFA are GM, GL, CC, ESM, SC, RL. A final six component model was developed through statistical validation.

## 9. Conclusion

Manufacturing industries are finding it difficult to focus on green supply chain practices due to its multifarious environment. The authors in the study developed a model to address the issue of practising green supply chain activities. The model is built considering the opinion from experts and through literature study, this helped in identification of frequently used success factors which were further confirmed from respective subject experts from industries. Then Interpretive structural modelling was applied to know the relationship between the success factors. 28 success factors identified from literature study were narrowed down to 16 through ISM MICMAC approach. The 16 factor ISM model was statistically validated through structural equation modelling that resulted in critical success factors. The model exhibiting the inter relationship may be used by policy and decision makers to implement green supply chain practices in manufacturing industries. The model developed in limited to its use only to manufacturing sectors in Indian scenario, the results may vary if the model is applied to other sectors. Future studies can be carried out in other sectors to implement green practices in their supply chain.

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## EXPECTATIONS TOWARDS SUPPLIERS IN TERMS OF ENSURING AND IMPROVING THE QUALITY OF PRODUCTS AND PROCESSES

**Abstract:** *The aim of the article is to present current trends in the expectations of producers operating on the B2B market towards suppliers in the field of ensuring and improving the quality of products and processes. The analysis of the literature allows to conclude that the fulfillment of these expectations by suppliers is largely achieved through the implementation of guidelines contained in international organizational standards in the field of quality and environmental management, as well as elements of the Toyota Production System (such as Kaizen, 5S, TPM) or the based on the concept of Lean Management. The results of the empirical research (with the use of the CATI technique) indicate that manufacturing companies that are buyers in their expectations towards suppliers focus mainly on improving the technical quality of products, shortening the time of order fulfillment, reducing operating costs.*

**Keywords:** *Quality, Cooperation, Suppliers, ISO*

### 1. Introduction

Most often, the expectations of customers on the B2B market (especially from industrial sectors, and in particular OEMs - Original Equipment Manufacturers towards suppliers focus on ensuring product quality, guaranteeing timely deliveries and reducing costs (Ekici, 2013). Therefore, these companies impose individualized requirements on their suppliers through detailed specifications specifying not only issues related to quality assurance (guaranteeing the technical quality of products), but also organizational issues related to increasing the effectiveness of processes (e.g. shortening cycles of activities), efficiency (reducing costs), and also the requirements related to the need to reduce the burden on the environment (Forkmann et al., 2016). These requirements are increasingly important criteria for the initial and periodic assessment of suppliers (Taherdoos and Brard, 2016). This approach

is a significant incentive for suppliers to make efforts to improve their operations by introducing systemic quality and environmental management, as well as operational improvement tools, such as elements of the Toyota Production System or Lean Management projects. The topic of cooperation with suppliers is relatively widely discussed in the literature (He et al., 2022; Baghizadeh et al., 2021; Zimon and Madzik, 2020), but it is still important and up-to-date due to the changing trends and threats resulting from the current ongoing crises (Deligiannis et al., 2023). As Allenbacher and Berg (2023) rightly point out, it is now crucial for manufacturing companies to implement the adopted strategies beyond the firm level. Manufacturing companies therefore use different concepts and methods to get suppliers to follow the broader strategy outlined in the supply chain (Zhang et al., 2020). This is an important issue as many studies suggest that direct suppliers can be a

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catalyst for the diffusion of requirements to sub-suppliers further upstream in the supply chain (Allenbacher and Berg, 2023; Grimm et al., 2016). Therefore, it seems particularly important for manufacturing companies to formulate clear guidelines on quality, environmental or operational issues that should be followed by suppliers. This will not only affect the effectiveness of cooperation within the consignee-supplier, but may also improve the functioning of the entire supply chain (Li et al., 2017). As rightly emphasized by O'Connor et al. (2020), activities contributing to closer cooperation with suppliers within the supply chain increase its innovation, responsiveness and profitability. In view of the above considerations, the aim of the article is to identify the requirements of manufacturing companies towards suppliers. The obtained research results will allow for a better understanding of the expectations of manufacturing companies as part of relations with suppliers, which, as noted earlier, affects supply chain management strategies. (Lu, et al., 2022). In order to achieve this goal (based on a wide literature review), eight key requirements of manufacturing companies towards suppliers were identified. These are respectively:

- Improving the technical quality of products (Kang and Um, 2023),
- Shortening the time of order fulfillment (Harbi et al., 2018),
- Reducing operational costs by reducing the level of non-compliance and waste (Yoo et al., 2019),
- Reducing the risk of non-compliance in operational processes (Zimon and Madzík, 2020),
- Reducing the risk of hazards related to products (Wieteska, 2020; Li and Chen, 2019),
- Improving the environmental performance of products (Wang et al., 2021; Salem et al., 2023),

- Reducing the negative impact of processes on the environment (Bartos et al., 2022, Zimon et al., 2022),
- Improved standardization of activities (Zimon et al., 2020).

The research covered Polish large and medium-sized manufacturing companies operating on the B2B market. All the analyzed enterprises implemented the requirements of the ISO 9001 standard, more than half of them implemented the requirements of ISO 14001, some of the surveyed enterprises implemented concepts such as TPS or Lean Management. This is an important fact, because the research results available in the literature indicate that the use of management concepts and systems has a positive effect on building proper relationships with suppliers. (Dellana et al., 2020; Zimon et al., 2020; Rojo-Gallego-Burin et al., 2020).

## 2. Methodology of Research and Results

In order to determine the importance of expectations towards suppliers in terms of ensuring and improving the quality of products and processes, empirical study was carried out. These studies were performed using the Computer Assisted Telephone Interview (CATI) technique. The study covered 150 manufacturers operating on the B2B market (employing over 49 employees) from the automotive, electromechanical and chemical sectors. The study was commissioned to a specialized research agency, which made a targeted selection of companies registered in the Bisnode database. All companies participating in the study implemented a quality management system based on the requirements of the international management standard ISO 9001. The surveyed enterprises assigned the indicated

expectations towards suppliers in terms of ensuring and improving the quality of products and processes the appropriate ranks on a scale from 5 (the most important criterion) to 1 (the least important criterion).

Detailed study results are presented in the tables 1-4.

The conducted cross-sectional analyzes of the results of empirical research allow to indicate interesting observations.

**Table 1.** The importance of expectations towards suppliers in terms of ensuring and improving the quality of products and processes (general, comparison between enterprises due to the origin of capital; rank averages)

Expectations towards suppliers	General N=150	Origin of capital	
		Polish N=79	Foreign N=71
Improving the technical quality of products	4.77	4.74	4.82
Shortening the time of order fulfillment	4.71	4.75	4.66
Reducing operational costs by reducing the level of non-compliance and waste	4.65	4.63	4.67
Reducing the risk of non-compliance in operational processes	4.41	4.41	4.41
Reducing the risk of hazards related to products	4.39	4.37	4.41
Improving the environmental performance of products	4.37	4.34	4.42
Reducing the negative impact of processes on the environment	4.23	4.24	4.22
Improved standardization of activities	4.21	4.23	4.19

Improving the technical quality of products as an expectation towards suppliers is particularly important for large organizations with foreign capital, as well as for companies from the automotive and electromechanical sectors. In turn, shortening the time of order fulfillment is very important for large producers with Polish capital and companies from the automotive sector. Companies that have implemented the concepts of Toyota Production System and Lean Management clearly focus their expectations towards suppliers in terms of reducing operating costs by reducing the level of non-compliance and waste. The study results indicate that medium-sized organizations (employing 50-250 employees) and companies from the automotive sector attach greater importance to reducing the risk of non-compliance in operational processes. On the other hand, large producers (employing over 250 employees) and business organizations that have implemented the

Toyota Production System and Lean Management concepts focus on expectations towards suppliers in terms of reducing the risk of product-related hazards. Improving the environmental performance of products by suppliers is of particular importance in the case of large producers, as well as for companies from the chemical sector. It should also be noted that for medium-sized producers and for enterprises that have implemented an environmental management system as expectations towards partners who are the source of purchases, it is important to reduce the negative impact of processes on the environment as well as to improve the standardization of processes.

Analyzing the results of the research and the emerging trends in the scope of expectations towards suppliers, it should be assumed that they will increasingly focus on:

- ensuring the quality of products (reducing the risk of non-compliance and improving safety) and the possibilities of their

improvement (especially through closer cooperation in the field of joint research and development works),

- reducing the negative impact of products and processes on the environment (over 50% of the surveyed buyer entities have implemented an environmental management system, especially

representatives of the chemical and automotive sectors), and

- increasing the level of efficiency of processes by shortening their cycles (about 20% of the surveyed organizations have implemented elements of TPS and implement Lean Management projects, especially in the automotive sector).

**Table 2.** The importance of expectations towards suppliers in terms of ensuring and improving the quality of products and processes (comparison between enterprises by number of employees; average ranks)

Expectations towards suppliers	General N=150	Number of employees	
		50-250 N=65	Over 250 N=85
Improving the technical quality of products	4,77	4.71	4.83
Shortening the time of order fulfillment	4.71	4.65	4.76
Reducing operational costs by reducing the level of non-compliance and waste	4.65	4.65	4.64
Reducing the risk of non-compliance in operational processes	4.41	4.46	4.37
Reducing the risk of hazards related to products	4.39	4.28	4.46
Improving the environmental performance of products	4.37	4.25	4.47
Reducing the negative impact of processes on the environment	4.23	4.28	4.20
Improved standardization of activities	4.21	4.26	4.17

**Table 3.** The importance of expectations towards suppliers in terms of ensuring and improving the quality of products and processes (comparison between enterprises by sector; rank averages)

Expectations towards suppliers	General N=150	Sector		
		Automotive N=63	Electromechanical N=36	Chemical N=51
Improving the technical quality of products	4,77	4.83	4.81	4.68
Shortening the time of order fulfillment	4.71	4.85	4.55	4.65
Reducing operational costs by reducing the level of non-compliance and waste	4.65	4.73	4.55	4.62
Reducing the risk of non-compliance in operational processes	4.41	4.53	4.30	4.33
Reducing the risk of hazards related to products	4.39	4.47	4.39	4.26
Improving the environmental performance of products	4.37	4.34	4.36	4.42
Reducing the negative impact of processes on the environment	4.23	4.29	4.12	4.24
Improved standardization of activities	4.21	4.29	4.12	4.17

**Table 4.** The importance of expectations towards suppliers in terms of ensuring and improving the quality of products and processes (comparison between enterprises due to the implemented tools for improving products and processes; rank averages)

Expectations towards suppliers	General N=150	ISO 14001 N=76	TPS N=39	Lean Management N=24
Improving the technical quality of products	4.77	4.80	4.84	4.85
Shortening the time of order fulfillment	4.71	4.65	4.79	4.79
Reducing operational costs by reducing the level of non-compliance and waste	4.65	4.66	4.68	4.73
Reducing the risk of non-compliance in operational processes	4.41	4.35	4.45	4.32
Reducing the risk of hazards related to products	4.39	4.39	4.50	4.64
Improving the environmental performance of products	4.37	4.32	4.44	4.32
Reducing the negative impact of processes on the environment	4.23	4.50	4.30	4.36
Improved standardization of activities	4.21	4.25	4.36	4.32

### 3. Conclusion

The results of the conducted study indicate that the surveyed enterprises, as the most important expectations towards suppliers, focused on improving the technical quality of products, shortening the time of order fulfillment, reducing operating costs by reducing the level of non-compliance and waste. The study results also indicate that the expectations of the surveyed manufacturers towards suppliers in terms of reducing the risk of non-compliance in operational processes, reducing the risk of hazards related to products (possibility of technical non-compliance) as well as improving the environmental performance of products should also be considered significant.

Recapitulating the above considerations, it should be stated that the requirements imposed on suppliers by OEMs in the field of implementing systemic quality and environmental management, as well as improving the efficiency and effectiveness of processes brings significant benefits to supply chain participants

The effective implementation of the quality

management system undoubtedly contributes to ensuring the technical quality of products by supervising operational processes and reducing the level of risk of hazards.

In turn, the effective implementation of environmental management system contributes to reducing the negative impact on the environment by reducing the consumption of natural resources, emissions of harmful factors and waste. By effectively implementing system solutions in the field of quality and environmental management, as well as elements of TPS and Lean Management projects, suppliers can achieve significant benefits. These benefits include:

- a higher level of product quality assurance,
- increase in effectiveness (measured by the degree of achievement of the assumed objectives, improvement of efficiency) and efficiency of processes (by reducing the costs of activities by increasing the efficiency of employees / infrastructure, or eliminating unnecessary activities and unused / not fully used resources),

- shortening delivery cycles, reducing the negative impact on the environment (of processes and products).
- Meeting customer requirements by suppliers can therefore turn into mutual benefits, the achievement of which is based on building cooperation. This cooperation is based on building trust between partners and ensuring continuity of processes in supply chains.

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## ANALYSIS OF CUSTOMER SERVICE QUALITY MANAGEMENT IN IMPLEMENTATION OF TSM KODAWARI AT TAM WORKSHOP

*Abstract:* Toyota Astra Motor (TAM) workshop is a Toyota vehicle repair shop that provides vehicle repair services. Currently the service is not only in the form of quality results from vehicle repairs, but other services such as vehicle completion time, repair costs and personal service.

*Research aims:* For Toyota, all of these services are summarized in the TSM Kodawari which is the basis of service, but the high expectations of customers make every workshop must continue to make continuous improvements.

*Design/Methodology/Approach:* For this reason, it is necessary to analyze the TAM workshop service which has been carried out using the Service Quality (Servqual) method, which is a direct assessment from customers and employees of the TAM workshop which is seen as gap 1 and gap 5 with the aim of reinforcing the already good service to continue to achieve customer satisfaction.

*Research findings:* Human resource management approach will also be given to sharpen the discussion of research results. Improvements in gap 1 are in the tool and method factors on the E2 dimension and in gap 5 on the method factors on the E3 dimension.

*Theoretical contribution/Originality:* Suggestions are given to the research findings to continue to achieve customer satisfaction.

**Keywords:** workshop, gap, customer, kodawari, servqual

### 1. Introduction

The rapid development of the automotive world in Indonesia has made many automotive repair shops continue to make improvements in their services along with service users who are increasingly critical and have high expectations for repairing their vehicles and the services provided by the workshops.

Customer dissatisfaction can have an impact on the loss of customers and can even change vehicle brands. For this reason, it is very important to make continuous improvement and innovation to create customer satisfaction.

Toyota-Astra Motor (TAM) Workshop is a car repair shop that serves the repair of Toyota brand vehicles, which is the largest automotive company in Indonesia, located in Sunter, Jakarta. With the increasing number of requests for periodic vehicle repairs and

other Toyota vehicle repairs, TAM Workshop must continue to improve customer satisfaction.

Based on the existing service standards at TAM Workshop, TSM Kodawari makes services that are directed and controlled, but actually, complaints are still obtained from the Post Service Follow Up (PSFU) TAM Workshop which is part of the service to find out customer responses after 3 days of the vehicle. has been repaired by calling directly to the customer making the need for improvement in the services provided by TAM Workshop. It is necessary to conduct research to determine the extent of the TAM Workshop services that have been provided in accordance with the service dimensions contained in the Service Quality (Servqual) method, by providing direct questionnaires to customers.

The objectives of this research are:

- 1) Measuring the perception of workshop management/employees on the expectations of workshop service users.
- 2) Measuring the perceptions and expectations of service users on service quality.
- 3) Measuring the size of the gap between the perceptions of the management/workshop employees and the expectations of service users regarding the quality of workshop services.
- 4) Measuring the size of the gap between perceptions and expectations of service users regarding the quality of workshop services.
- 5) Provide suggestions for improvement of service quality based on TSM Kodawari.

Theories from experts on quality management, especially regarding service quality and human resource management, as well as the results of previous research within the last 3 years will be the main

reference in this research. The most fundamental difference in this research compared to research in the field of quality management, especially service quality, is the use of the TSM Kodawari which is the basis for services that must be obeyed in the TAM workshop as one of the tools to discuss the results of this research.

## **2. Literature Review**

Human Resource Management (HRM) and Service Quality. Previous experts in textbooks on HRM and quality management as well as the majority of research on quality management concluded that HRM and service quality are two things that greatly influence organizational performance. Without good management of resources (including human resources), it will not produce the company's performance as expected. And one of the company's performance will be obtained from consumer satisfaction from the high quality of service. To obtain high quality services, the aspect of human resources plays a very important and very central role.

From the results of previous research, it was revealed that there was a positive and significant relationship between service quality, employee satisfaction and loyalty. Good service quality is obtained from high satisfaction and loyalty from employees and this all increases the effectiveness of human resource management (HRM) which in turn will improve the company's performance. In the results of this study also that customer satisfaction also has a positive relationship with service quality, employee satisfaction and loyalty to effective HRM. Customer satisfaction is the key element that increases satisfaction and employee loyalty that increases effectiveness of human resources (Decha, Khlungsaeng, Bousri & Pulphon, 2020).

The results of other studies show that there is a close relationship between service quality and HRM practices, where good and effective HRM practices can significantly improve service quality which can increase the company's competitiveness in general, good HRM practices can also contribute to human resource development which aims to maintain competent employees and develop employee capabilities needed to meet a high quality of service, then good HRM practices will produce highly competent employees employees, committed to learning, and higher job satisfaction, thus achieving higher levels of productivity and in turn effectively meet organizational goals (Khassawneh & Mohammad, 2021).

Other research results also show that there is a statistically significant relationship between products (either goods or services), company policies, solving problems that occur in the field, personal interaction and empathy from employees towards customers, the benefits felt by the customer from the service/product, the dimensions of service quality and and customer satisfaction, the most important thing is that customers think that products must be of good quality, develop and provide recommended services quality factors efficiently and effectively help in obtaining customer satisfaction that leads to customer loyalty, to create customer loyalty, the company must understand customer perceptions of dimensions of service quality so that this service quality dimension can be used as a strategy reference in meeting customer needs (Rashid & Rokade, 2019).

Other studies that discuss the relationship between service quality and customer loyalty in Nigerian hospitality shows that there is a positive relationship between service quality and customer loyalty, this study also found a positive relationship between the existence of a customer's brand with customer loyalty where the customer brand be a mediating factor of the relationship between service

quality and customer loyalty. where is the service quality has a direct effect on hotel customer loyalty while customer brand also affects customer loyalty even though not directly, this means that hotel managers must focus on improving service quality because it has a direct effect on customer perceptions which in the long term can increase customer loyalty (Silas, Dung & Bagobiri, 2022).

In general, from all research references, three of which we have described above, it shows that human resource management is indeed a very important aspect in improving the quality of management. What distinguishes this research from previous research is that we analyze the implementation of TSM Kodawari through the Servqual method approach, in contrast to other studies that have not analyzed the implementation of TSM Kodawari through this Servqual method approach.

Servqual. Measuring service quality means evaluating/comparing the performance of a service with a set of predetermined standards. Servqual is a multi-item scale measurement model that is intended to measure the expectations and perceptions received by customers, and the gaps that exist in the service quality model. Servqual defines the evaluation of customer quality in terms of the gap between the level of expectations and the level of perception received by the customer. Measurement can be done with a Likert scale, where respondents just choose the degree of agreement / disagreement with statements regarding the delivery of service quality. Measurement of service quality must be carried out and improved periodically. So, the questionnaire used must be continuously developed and adapted to the situation at hand. Servqual has several drawbacks. Servqual assumes that customer satisfaction is linearly related to the performance of service attributes. The implication is that low customer satisfaction results from low attribute performance, therefore these low

performance attributes are the focus of improvement efforts. This assumption is not entirely correct. Focusing on improving certain service attributes does not always lead to increased customer satisfaction if these service attributes are not considered important by customers. On the other hand, customer satisfaction can sometimes be improved only by a small increase in a pleasant service attribute that the company did not expect to provide. In addition, Servqual provides important information about the gap between the level of customer expectations and the level of customer satisfaction, but Servqual cannot provide a solution on how the gap can be overcome. In services, there are main dimensions needed by every service user. Simplification of these dimensions can be divided into 5 main dimensions, namely:

- 1) Reliability, related to the company's ability to provide accurate service from the first time without making any mistakes and deliver its services in accordance with the agreed time.
- 2) Responsiveness, with regard to the willingness and ability of employees to help customers and respond to their requests, and inform when it will be provided and then provide prompt service.
- 3) Assurance, namely the behavior of employees is able to foster customer trust in the company and the company can create a sense of security for its customers. Assurance also means that employees are always courteous and have the knowledge and skills required to deal with any customer questions or concerns. This dimension has four sub-dimensions, namely:
  - a) Competence, expertise and skills that must be possessed by service providers in providing their services to customers.
  - b) Credibility, honesty and responsibility of the service

provider so that customers can trust the service provider.

- c) Courtesy, ethics of courtesy, respect and friendliness of the service provider to its customers.
  - d) Security, a sense of security, a feeling of being free from fear and free from doubts about the services provided by the service provider to its customers.
- 4) Empathy, means the company understands the problems of its customers and acts in the interests of customers, and gives personal attention to customers and has safe operating hours.
  - 5) Tangibles, relating to the attractiveness of the physical facilities, equipment and materials used by the company.

And in the service gap there are 5 main gaps, in the research at TAM Workshop the gaps that can be studied are gap 1 and gap 5, namely:

- 1) Gap 1, between customer expectations and management perceptions (knowledge gap). This gap means that the management perceives customer expectations of service quality inaccurately
- 2) Gap 5, between the perceived service and the expected service (service gap). This gap means that the perceived service is inconsistent with the expected service.

TSM Kodawari. TSM Kodawari is a program to realize/realize an accurate response to customer requests and meet daily vehicle delivery times by consistently providing "minimum standards" of high-quality, accurate service based on customer expectations and desires. TSM Kodawari is applied to every Toyota dealer around the world through kaizen assessment and activities, dealer execution and carrying out the 77 kodawari items set by Toyota aimed

at six service operations in total from maintenance reminder & appointment to follow-up after service. The six service operation processes are:

- 1) Maintenance Reminder & Appointment.
- 2) Appointment Preparation.
- 3) Reception.
- 4) Production.
- 5) Submission.
- 6) Follow-Up After Service.

### 3. Research Method

A research method is indispensable in a scientific research plan. This method must be arranged systematically and directed to get research results that are right on target in accordance with the problem and research objectives. The steps that will be carried out in the process of this research later, are:

- 1) Research studies are the initial stage to conduct this research, where this research understands the problems that arise in the place where it will be used as a case study.
- 2) Literature study is carried out to obtain various information about theories that can be used to solve the problems faced, as well as to develop insightful knowledge from researchers. Literature study is done by reading scientific journals that are relevant to the problems at hand. The concepts used in this study include customer satisfaction, service quality, TSM Kodawari TSM and improvement of the concept of 7 Basic of quality tools.
- 3) The field study aims to observe the object to be studied, namely the services at the TAM workshop.
- 4) Problem formulation is an activity carried out to formulate, namely the problems that occur at this time are the incompatibility of customer expectations for the services provided by the TAM workshop or the need for

improvement in adjusting Toyota's service standards to higher customer expectations. This can be seen from the results of PSFU which states that service dissatisfaction is quite high because complaints or customer requests/expectations have not been resolved, both technically and non-technically.

- 5) Research objectives. At this stage the researcher formulates what the research objectives are.
- 6) The research design, there are 3 designs, namely:
  - a) Research model design, namely modeling services into 5 service dimensions
  - b) Identification of the research model, which describes each service dimension according to the Kodawari items.
  - c) The design of the assessment mechanism, namely how to assess the service in the form of a questionnaire.
- 7) Preparation of questionnaires, namely making questionnaires for employees, customers and levels of interest related to gap 1 and gap 5.
- 8) Determination of the number of samples, using the formula and characteristics of the study can be determined the number of samples as many as 100 samples. Questionnaires for customers were made into a questionnaire of perceptions-expectations and questionnaires of importance. As for employees, the questionnaire is about their opinions regarding customer expectations
- 9) Data collection is the collection of primary and secondary data.
- 10) Validity test, which is to test whether the data obtained is valid
- 11) Reliability test is to test whether the data obtained is reliable

- 12) Analysis and Discussion, namely analyzing data that is valid and reliable to be studied using theories that are relevant to the research problem and the discussion provides recommendations so that the results of this research can be applied in the company.
- 13) Conclusions and suggestions, namely concluding regarding the purpose of this research and providing suggestions for steps that can be taken to carry out the recommendations for the company.

#### 4. Result and Discussion

From testing the data from the questionnaire results, it is found that the data is valid and reliable. From the data processing of the questionnaire results obtained results for the level of customer importance, customer expectations value, customer perception value and employee perception value as shown in the following tables:

**Table 1.** Level of Customer Importance

DIMENSION		QUESTION	LEVEL OF IMPORTANCE
TANGIBLES	T1	Clear directions or information to make it easier for customers to service vehicles	4.5
	T2	Cleanliness of customer toilet facilities	4.62
	T3	Quality of entertainment (Wifi, Audio, internet service, kids corner, etc.) in the waiting room	4.64
	T4	Quiet atmosphere (not noisy) in the waiting room	4.54
RELIABILITY	R1	Ability of repair shop workers to analyze problems correctly	4.78
	R2	Adequate and good service equipment and supplies.	4.74
RESPONSIVENESS	RS1	Workshop staff provide clear and easy-to-understand information	4.68
	RS2	Explanation of officers regarding vehicle maintenance or repairs carried out and estimated costs	4.66
	RS3	Availability of workshop staff in serving customers	4.79
	RS4	Punctuality in vehicle delivery ( <i>on time delivery</i> ) after repairing the vehicle	4.69
ASSURANCE	A1	Knowledge and expertise of workshop workers	4.58
	A2	Discipline of workshop workers	4.72
	A3	Courtesy and friendliness of repair shop workers	4.64
	A4	Honesty of repair shop workers	4.78
	A5	Attitude of workshop workers towards maintenance and vehicle repairs	4.72
	A6	Staff explanation regarding job guarantees when delivering vehicles	4.78
EMPATHY	E1	Ease of contacting TAM <i>Workshop</i> if there are complaints	4.79
	E2	Ease of meeting <i>Service Advisors (SA)</i> or other workshop staff	4.5
	E3	Availability of written information what matters to the customer	4.6
	E4	Careful attention to the customer	4.78

Source: Data Processing



**Table 2.** Customer Expectation Value

DIMENSION		QUESTION	EXPECTATION VALUE
TANGIBLES	T1	Clear directions or information to make it easier for customers to service vehicles	4,86
	T2	Cleanliness of customer toilet facilities	4,82
	T3	Quality of entertainment (Wifi, Audio, internet service, kids corner, etc.) in the waiting room	4,78
	T4	Quiet atmosphere (not noisy) in the waiting room	4,82
RELIABILITY	R1	Ability of repair shop workers to analyze problems correctly	4,90
	R2	Adequate and good service equipment and supplies.	4,85
RESPONSIVENESS	RS1	Workshop staff provide clear and easy-to-understand information	4,77
	RS2	Explanation of officers regarding vehicle maintenance or repairs carried out and estimated costs	4,86
	RS3	Availability of workshop staff in serving customers	4,82
	RS4	Punctuality in vehicle delivery ( <i>on time delievery</i> ) after repairing the vehicle	4,78
ASSURANCE	A1	Knowledge and expertise of workshop workers	4,87
	A2	Discipline of workshop workers	4,77
	A3	Courtesy and friendliness of repair shop workers	4,84
	A4	Honesty of repair shop workers	4,85
	A5	Attitude of workshop workers towards maintenance and vehicle repairs	4,87
	A6	Staff explanation regarding job guarantees when delivering vehicles	4,89
EMPATHY	E1	Ease of contacting TAM <i>Workshop</i> if there are complaints	4,85
	E2	Ease of meeting <i>Service Advisors (SA)</i> or other workshop staff	4,82
	E3	Availability of written information what matters to the customer	4,81
	E4	Careful attention to the customer	4,92

Source: Data Processing

**Table 3.** Customer Perception Value

DIMENSION		QUESTION	PERCEPTION VALUE
TANGIBLES	T1	Clear directions or information to make it easier for customers to service vehicles	4,40
	T2	Cleanliness of customer toilet facilities	4,54
	T3	Quality of entertainment (Wifi, Audio, internet service, kids corner, etc.) in the waiting room	4,47
	T4	Quiet atmosphere (not noisy) in the waiting room	4,33
RELIABILITY	R1	Ability of repair shop workers to analyze problems correctly	4,44
	R2	Adequate and good service equipment and supplies.	4,54
RESPONSIVENESS	RS1	Workshop staff provide clear and easy-to-understand information	4,55
	RS2	Explanation of officers regarding vehicle maintenance or repairs carried out and estimated costs	4,72
	RS3	Availability of workshop staff in serving customers	4,41
	RS4	Punctuality in vehicle delivery ( <i>on time delivery</i> ) after repairing the vehicle	4,24
ASSURANCE	A1	Knowledge and expertise of workshop workers	4,43
	A2	Discipline of workshop workers	4,40
	A3	Courtesy and friendliness of repair shop workers	4,56
	A4	Honesty of repair shop workers	4,53
	A5	Attitude of workshop workers towards maintenance and vehicle repairs	4,57
	A6	Staff explanation regarding job guarantees when delivering vehicles	4,44
EMPATHY	E1	Ease of contacting TAM <i>Workshop</i> if there are complaints	4,33
	E2	Ease of meeting <i>Service Advisors (SA)</i> or other workshop staff	4,48
	E3	Availability of written information what matters to the customer	4,23
	E4	Careful attention to the customer	4,54

Source: Data Processing

**Table 4.** Employee Perception Value

DIMENSION		QUESTION	PERCEPTION VALUE
TANGIBLES	T1	Clear directions or information to make it easier for customers to service vehicles	4,72
	T2	Cleanliness of customer toilet facilities	4,86
	T3	Quality of entertainment (Wifi, Audio, internet service, kids corner, etc.) in the waiting room	4,23
	T4	Quiet atmosphere (not noisy) in the waiting room	4,42
RELIABILITY	R1	Ability of repair shop workers to analyze problems correctly	4,77
	R2	Adequate and good service equipment and supplies.	4,65
RESPONSIVENESS	RS1	Workshop staff provide clear and easy-to-understand information	4,74
	RS2	Explanation of officers regarding vehicle maintenance or repairs carried out and estimated costs	4,65
	RS3	Availability of workshop staff in serving customers	4,67
	RS4	Punctuality in vehicle delivery ( <i>on time delivery</i> ) after repairing the vehicle	4,79
ASSURANCE	A1	Knowledge and expertise of workshop workers	4,44
	A2	Discipline of workshop workers	4,37
	A3	Courtesy and friendliness of repair shop workers	4,53
	A4	Honesty of repair shop workers	4,60
	A5	Attitude of workshop workers towards maintenance and vehicle repairs	4,33
	A6	Staff explanation regarding job guarantees when delivering vehicles	4,53
EMPATHY	E1	Ease of contacting TAM <i>Workshop</i> if there are complaints	4,60
	E2	Ease of meeting <i>Service Advisors (SA)</i> or other workshop staff	3,79
	E3	Availability of written information what matters to the customer	4,30
	E4	Careful attention to the customer	4,51

Source: Data Processing

Value of service quality:

- a) Gap 1: This gap is the difference between employee perception scores and customer expectations. The highest gap is obtained in the service dimension E2
- b) Gap 5: This gap is the difference between perception and expectation scores multiplied by the level of importance. The highest gap is obtained in the service of the E3 dimension.

## 5. Discussion

Servqual score at Gap 1: From the data processing, the highest gap value in gap 1 is the service dimension E2 or the ease of meeting a Service Advisor with a score of -1.03. This happens because:

- 1) There is no application that supports making technical reports on the computer in the Service Advisor room
- 2) Customers have difficulty meeting Service Advisors because customers are not directed when entering the Service Advisor room, this happens because of the absence of an officer who directs customers, this task is usually carried out by security officers but at the same time security officers are parking the customer's vehicle

Servqual score at gap 5: From the data processing, the highest gap value in gap 5 is the service dimension E3 or the availability of written information that is important for customers with a score of -2.27. This happens because:

- 1) There is no standard for writing a good and clear report because the technician manually fills in the results of his work, sometimes the writing is not clear
- 2) Lack of availability of written information that is important to

customers, this happens because there is no job advice obtained from technicians not known by customers because they are included in the Service Advisor report

From the results of the Servqual score on the service dimension E2, you must create a system/application for making technical reports making SOPs involving drivers in directing customers who come when security officers are busy.

From the results of the Servqual score on the dimensions, there needs to be a rule that technicians must write the results of his work in capital letters and complete and always include complete information whether there is a job suggestion or no job suggestion.

Apart from the analysis of the data obtained from the results of data processing and direct observations in the field, it can be seen that the human resource factor plays a very important role in producing good service performance in addition to equipment (in this case a computer) and procedures (SOP). The number and qualifications of human resources who provide services must be in accordance with service needs, in this case it appears that the number of employees serving is still limited where security officers are still on double duty to park vehicles and serve advisors and technicians have not done their job perfectly in terms of job reporting. The number and qualifications of good service personnel will improve service performance which will also foster customer loyalty and will ultimately improve the company's overall performance.

## 6. Conclusion

The conclusions that can be obtained from this research are:

- 1) The perception of the workshop employees on the expectations of service users or customers can be

measured according to the dimensions of service quality (Servqual) with the highest value on the T2 dimension. and the lowest value on the E2 dimension.

- 2) Perceptions and expectations of service users or customers on service quality can be measured in accordance with the dimensions of service quality (Servqual) with the highest value of perception on the RS2 dimension while the lowest perception on the E3 dimension. The highest value of expectations is on the E4 dimension and the lowest value of expectations is on the A2 . dimension
- 3) The gap that occurs between the perception of the management/workshop employees on the expectations of service users regarding the quality of workshop services or gap 1 can be measured by the highest value on the T2 dimension and the lowest dimension on the E2 dimension.
- 4) The gap between perceptions and expectations of service users regarding the quality of workshop services or gap 5 can be measured with the highest value on the RS2 dimension and the lowest dimension value on the E3 dimension.
- 5) Suggestions for improving research results to improve service quality based on TSM kodawari

Suggestions/recommendations that can be given are as follows:

- 1) The company's Information Technology Department must

provide the system/application needed by the Service Advisor and move the computer equipment that has been used to make technical reports located in the control room to the Service Advisor room.

- 2) Make standard SOPs regarding driver officers to help direct customers who come by greeting first, politely and warmly by inviting each officer to a meeting to discuss problems and making SOPs.
- 3) Make a SOPs for writing the results of work by technicians in the form provided in capital letters and fill in completely regarding the results of the work and publish it with a signature, this shows that each technician understands and agrees with the new SOPs.
- 4) Make SOPs for completing work which are required to include all information regarding work suggestions even though there are no suggestions that can be proposed to the information system on the computer application so that customers can get information on documents that customers get regarding their vehicles after repairs whether there are work suggestions or not as customer references for further repair.
- 5) For further research, it is hoped that this research on the implementation of TSM Kodawari TSM can be more comprehensive by expanding its scope to other parts not only in the workshop or adopting TSM Kodawari in companies other than Toyota Astra Motor.

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# **14. International Quality Conference**



**SCIENTIFIC FOCUS 3**

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## ENSURING THE COMPETITIVENESS OF INDUSTRIAL ENTERPRISES IN TERMS OF METHODS FOR ASSESSING THE QUALITY OF INDUSTRIAL PRODUCTS

**Abstract:** *The article examines the model of the quality management system based on international standards ISO 9000 series is generally recognized in the world. It is being implemented at enterprises of all forms of ownership operating in various countries and sectors of the economy. The standard has gained such wide popularity due to its versatility and approaches to quality management, which have shown their effectiveness and efficiency in practice.*

*In the modern world, the basis for ensuring a competitive advantage of an enterprise in the market is the continuous improvement of its management system and products. The ISO 9000 series of standards focuses the organization on continuous improvement and the fullest satisfaction of the requirements of all stakeholders. The quality management system is an important factor of competitiveness. The presence of a quality management system at the manufacturer means, in market language, the ability of this enterprise to meet the requirements of consumers, regulatory requirements from the state and the requirements of the organization for its own activities. In accordance with the General provisions of the standard, this is the main purpose of the quality management system. Modern enterprises operate in a constantly changing market environment. Only those companies that can quickly adapt to changes in the external environment can survive in the competition. In this regard, the quality management system should be flexible and quickly "adjusted" to changes in the requirements of the parties interested in the company's activities. Only such a management system can become a useful tool in the hands of the company's management.*

**Keywords:** *standardization, product quality, quality management system, products, competitiveness, economic efficiency.*

### 1. Introduction

The quality of products is determined by the generalized properties of its production

(reliability, durability, maintainability), which can satisfy certain needs for further operation.

A number of properties characterizes the quality of a product, and properties are indicators that quantitatively characterize one or more properties of this product. Often, density, resistance, etc express the properties of products and their quality criteria.

The quality of mechanical engineering products is an indicator of scientific and technological progress and production culture in mechanical engineering. The level of product quality in the machine-building industry has an important place, which is associated with the need to increase the competitiveness of products in the domestic and world markets. Ensuring and improving the quality of products in mechanical engineering is a complex task. Its solution is to improve the design of machines and their components, the use of new materials and automation of technological processes.

Product quality is a relative concept that can be analyzed quantitatively, that is, by comparison with basic products of similar purpose. The relative component of product quality, which is based on its comparison with the corresponding set of basic indicators, is called "product quality level". The values characterizing the properties of product quality are called quality indicators. They can be absolute, relative or specific. A product quality indicator that can take into account one of its properties is called a single indicator, two or more properties are called complex.

The criterion of the quality level of the product is an integral quality indicator that determines the ratio of the useful total effect of the product to the total cost of its production [1]. Product quality management is carried out through systematic control of compliance of quality indicators with standards, technical characteristics, regulatory documents, targeted impact on the quality of documentation, equipment, tools, materials, components, on the level of qualification of manufacturers.

## **2. Literature review**

The problem of the quality of mechanical engineering products acquires a special role in modern times. The quality of products is the main lever for increasing competitiveness in world markets, as well as one of the main components of economic progress [20]. A special place in the problem of ensuring the quality of mechanical engineering products is occupied by mechanical engineering technology, because new progressive design developments and research are implemented through it.

Mechanical engineering technology is a branch of science about the laws of the processes of manufacturing machines of the required quality, in the prescribed quantity and timing with minimal costs of living and materialized labor, material and energy resources [1]. The main task of mechanical engineering technology is to ensure the planned quality of products in its manufacture. The most effective approach to solving this problem is the technological provision of optimal parameters for the specified operating conditions of the state of the surface layer, the accuracy of the manufacture of parts and assembly of machines.

During use, the surface layer of the product is subjected to the strongest physical, chemical and mechanical effects. Therefore, the destruction of parts in most accidents begins with the surface layer [5]. Based on this, solving the problem of technological quality assurance of parts, it is necessary to develop such technological characteristics that will be able to provide the required parameters of the state of their surface layer, determined by the working conditions of the part, as well as the specified processing accuracy. Special attention should be paid to the formation of the surface layer of parts with various processing methods, the influence of processing methods and the state of the surface layer on the basic

operational properties of machine parts operating under various loads, normal and high temperatures, in non-aggressive and aggressive environments. Attention should also be paid to the basic concepts and indicators of product quality, characteristics of the quality management system and certification of products based on international standards ISO 9000.

It is also important that in recent years the issue of ensuring the quality of machine-building products in developed countries is no longer a concern of individual companies, but is considered as a national issue. For example, in Japan, this issue is considered a major national problem, the United States annually holds a quality month, the Swedish government sponsors a nationwide campaign to improve product quality, and the Netherlands is developing a National five-year plan to improve the quality of products and components. Special attention to the quality of products in developed countries is due to changes in conditions, forms and methods of production due to increased competition in places of sale between leading companies in different countries. Most countries spend a lot of effort on improving the quality of their products, thereby determining their authority and position on the world market, in the fight against competitors.

The problem of ensuring the quality of manufactured products in mechanical engineering is particularly acute in Russia. This problem arises even in a directive economy, when all efforts to ensure and improve the quality of products are planned and controlled by the state [3]. However, at the same time, consumer requests are very poorly taken into account, and the quality of the products themselves is discussed according to the requirements of its consistency with regulatory documents, which, in turn, often lag behind the requirements and wishes of consumers. With a monopoly of producers and the absence of

strong market incentives for qualitative growth-competition - they are not interested in improving the quality of products, spending additional financial resources for these purposes. In this regard, the situation with product quality is aggravated by a growing shortage of goods, when demand increasingly exceeds supply and consumers, deprived of choice, are ready to buy goods of any quality and at set prices. That is why the problem of ensuring the quality of products is important and serious for the development, progress and prosperity of the country's economy.

### 3. Methodology

Market relations have exacerbated the problem of quality and competitiveness of manufactured products. An effective means of solving this problem is the implementation of the provisions of the ISO 9000 series of international standards, which reflect the concentrated world experience in ensuring product quality, and the main emphasis is on measures that guarantee stable output [2].

To achieve this goal, the organization must keep under control all technical, administrative and human factors that affect the quality of products. In order to achieve the goals defined by the company's quality policy, such a quality system should be developed and implemented, which covers 2 interrelated aspects:

- 1) consumer requests and expectations;
- 2) requests and interests of the organization.

Improving the quality of products is a constant well-coordinated work aimed at improving both the technical level of product quality and the quality of its manufacture, as well as improving production technologies and the quality system as a whole. The process of improving the quality system is recommended to be carried out in the

following sequence:

- determine the direction of improvements and the means to implement them;
- to investigate the characteristic features of the problem;
- analyze the collected information, outline changes and, if necessary, experimentally check the options for changes;
- make changes to the improvement object;
- to analyze the functioning of the improvement object after making changes;
- document the found solutions for improvements.

The ISO 9000 standard defines key terms, interprets contractual terms, types of standards, and contains the basic principles for implementing the management's quality policy. It establishes and separates the rules for the use of quality assurance models related to the contract (ISO 9001), formulates three main tasks of the manufacturer in the field of quality, namely:

- 1) to achieve and maintain the quality of products at a level that is able to ensure the continuous satisfaction of the goals of consumers;
- 2) provide the management with confidence that the required quality is achieved and maintained at a given level;
- 3) to provide the consumer with confidence that the intended quality of the supplied products is being achieved or will be achieved; ensuring confidence may mean mutually agreed requirements for providing evidence, if this is provided for by the contract [8].

Methods of assessing the quality of industrial products involve an assessment of the experience and business reputation of business entities. The regulatory framework for this can be the standard: GOST R

66.0.01-Assessment of the experience and business reputation of business entities [21,22]. The standard also approves requirements, models and indicators for assessing the business reputation of companies based on their operational experience. The standard provides a holistic and objective approach to the ranking and selection of organizations during tenders or competitions, and also participates in the assessment of the reputation and financial success of the company. The standard assumes the use of a factor model. A factor system model is a mathematical formula expressing real connections between the analyzed phenomena.

In general, it can be represented as follows:

$$y = f(x_1, x_2, \dots, x_n)$$

Where

y - is the effective feature;

x- factorial features that include weight characteristics that are empirical in nature [21,22].

The problem of effective spending of budgetary funds as a tool for assessing the quality of industrial products in a difficult economic situation is becoming more and more urgent. This determines the importance of evaluating the effectiveness of the use of funds when placing a state and municipal order. The form of a state or municipal order is defined by Article 72 of the Budget Code of the Russian Federation and the holding of tenders and tenders on the basis of Federal Law No. 223-FZ [23]. There are two options for effective spending of budget funds: According to the first option, the achievement of the necessary result occurs using the least funds. According to the second option, the lowest result is achieved using a certain amount of funds. This principle is sometimes implemented in a tender, where the evaluation of proposals takes place according to various criteria, and the goal is to conclude a contract on the best

terms. In accordance with Federal Law No. 44 dated 05.04.2013-"On the contract system in the field of procurement of goods, works, services for state and municipal needs", customers are given the opportunity to take into account factors of experience and business reputation when choosing a contractor during procurement within the "business reputation" criterion of a procurement participant[24]. The standard enables public and private customers to apply professional tools that simplify the procedure for pre-selection of bidders by establishing an objective conformity assessment procedure approved in the Methodology for Assessing the Business Reputation of a construction organization. [21,22].

The Law regulates relations that focus on ensuring state and municipal needs in order to increase the efficiency and effectiveness of procurement of goods, works, services, ensuring transparency and transparency of such procurement, preventing corruption and other abuses in the field of such procurement. The Budget Code of the Russian Federation, defining the efficiency and economy of the use of budget funds as one of the principles of the budget system, establishes the obligation of recipients of budget funds to use budget funds effectively in accordance with their intended purpose [23].

Conducting an assessment of experience and business reputation allows you to conduct:

- comparison of the company's level of development with competitors, adequate positioning of itself in the market;
- independent confirmation of the competence and professional success of the organization, including for participation in tenders for public and private orders within the framework of 44-FZ and 223-FZ;

- assistance to consumers in the competent selection of suppliers of goods, services and works;
- improving the competitiveness of business entities;
- formation of a business reputation management system [23, 24].

Special attention in the ISO 9000 standard is paid to the conclusion of a contract, which, as a rule, is preceded by an assessment of the quality system in force at the enterprise in order to determine the supplier's ability to meet the requirements of standards and additional technical requirements for products or services specified in the technical conditions of the contract.

When developing the international standard ISO 9001:2015, a risk-based approach is used to create a QMS, which is one of the key changes in the new version of the standard. The basics of risk management in the updated version of the standard is integrated into the quality management system as a whole, and taking risks into account when making decisions turns preventive actions into part of the process approach. Risk management activities create the basis for improving the effectiveness of the quality management system, achieving better results and preventing adverse consequences. The organization needs to identify the risks and opportunities to be considered, as well as plan and implement actions to reduce them and evaluate the effectiveness of these actions [4].

However, not all processes in an organization have the same level of risk in terms of their impact on the organization's ability to achieve its goals, and the consequences of inconsistent processes, products, services or systems are not the same for different organizations. In some organizations, the consequences of providing substandard products or providing substandard services can cause only minor inconvenience to customers, while in other

cases, substandard products can lead to far-reaching consequences, up to a fatal outcome[18]. Thus, risk-oriented thinking means that risk must be taken into account quantitatively when determining the seriousness and depth of the approach to planning and managing the quality management system, its processes and activities.

The text of the standard assumes the application of a risk-based approach at all stages of the functioning of the quality management system.

Risk should be considered not only as a negative phenomenon for the enterprise, but also as a positive opportunity to find directions for improving the production process. ISO9001:2015 does not require a full formal risk assessment after completion of the "risk registration" or any other document[10]. As a useful, reference document on risk-based decision-making methods, GOST R ISO 31000-2010 "Risk management. Principles and Guidelines".

Therefore, in the conditions of mandatory transition to the new version of the ISO9001:2015 standard, interest in the use of risk-oriented methods in the construction of QMS will increase, and the developed methods and tools can be widely used. By improving management, ensuring high quality of products and services, increasing customer confidence and satisfaction, increasing the competitiveness of organizations using risk-based thinking.

In modern conditions, it is necessary to improve the quality of products. The quality of modern enterprises is becoming one of the decisive factors for increasing production efficiency and the overall intensive development of the economy[17]. In addition, the production of low-quality products at individual enterprises and in the national economy as a whole caused huge economic losses. Quality determines the level of competitiveness of a modern

enterprise by one in the conditions of increasing competition for sales markets (Galinovsky A.L., 2018).

That is why improving the quality of products is the most important goal that can increase production efficiency. Production efficiency, in turn, is determined by the ratio of the results obtained and production costs [6].

Methods. The need to assess the quality level of industrial products arises during its planning, certification and control (Alekseenko, A.A., & Ratner, S.V., 2014).

When assessing the technical condition of homogeneous machines (parts), a differential, complex and mixed method is used, for heterogeneous machines (parts) – the method of quality indexing. When it becomes difficult to assess quality by quantitative indicators, they resort to expert assessments (Dotsenko, B.I. 1983). The differential assessment consists in the fact that individual indicators are calculated according to the formula:

$$Yk_i = \frac{Pi}{Pi_{\text{bas}}},$$

where Pi is an indicator of the quality parameter of the machine being evaluated; Pi<sub>bas</sub> is the corresponding quality indicator of the basic machine sample.

If the quality indicator has limitations (Pd<sub>i</sub>), then the quality level is determined by the formula:

$$\acute{O}k_i = \frac{Pi - Pd_i}{Pi_{\text{bas}} - Pd_i}$$

For a particular type of machine, all quality indicators are divided into 2 types: main and secondary. The technical level of the machine being evaluated is considered to be lower than the base machine if at least one of the main indicators is lower than a similar base indicator [9]. If the indicators are difficult to divide into main and secondary,



then the assessment is based on complex or mixed quality assessments.

As a comprehensive assessment, a single indicator (P), an integral indicator (Ppi), a weighted arithmetic average (U) or a geometric (V) quality indicator can be used, thus:

$$U = \sum_{i=1}^n m_{iu} \cdot P_i; V = \prod_{i=1}^n (P_i)^{m_{iv}}$$

where  $m_{iu}$   $m_{iv}$  - are the weighting parameters of the quality indicator; n is the number of indicators.

For evaluation by a mixed method, some indicators are combined into groups, while others are not combined. After that, they are compared with the group or individual indicators of the basic variant.

The quality level of heterogeneous machines is assessed by the quality index, which is found as the ratio of the value of the weighted average quality indicator of the evaluated and the base machine. The defect index can also be used to assess the quality of heterogeneous machines. This complex indicator is a weighted average defect rate, which is calculated by the formula:

$$U_{\bar{a}} = \sum_{i=1}^N \alpha_i R_{\bar{a}i}$$

where  $\alpha_i$  - is the weighting coefficient of this type of machines;  $R_{\bar{a}i}$  - is the defect coefficient of machines, which is an indicator of the quality of manufacture of this type of machines; N - is the number of types of machines being evaluated.

Based on the objectives of this assessment and taking into account the significance of the quality indicators specified in the documents for this type of machine, the nomenclature of quality indicators is established [7]. At the same time, international, national foreign and domestic quality standards, documentation for the supply of machines, catalogs, brochures and

standards of manufacturers of this type of machines, patent, competitive and economic documentation are taken into account.

## 4. Conclusion

The quality of products in modern conditions is the most important component of the efficiency and profitability of the enterprise, therefore it is necessary to continue to pay special attention to it [15]. All participants in the production process-from the heads of the enterprise to the specific performers of any operation should be involved in improving the quality of the enterprise.

Improving the quality of products is the most important direction of intensive economic development, is a source of economic growth, is a benefit of social production. In these conditions, the importance of integrated product quality management and production efficiency increases.

The quality management system of various enterprises is individual. However, world science and practice have formed common features of these systems, as well as methods and principles that can be applied to each of them. In this article, the most effective and popular methods capable of assessing the quality level of products were considered [13].

Thus, the level of product quality is a relative characteristic based on a comparison of the values of indicators characterizing the technical and economic perfection of complex indicators of reliability and safety of use of the evaluated products.

The lack of economic efficiency of improving the level of product quality practically does not exist. Even enterprises or companies that produce products that are not of high quality may be interested in improving quality, since this always means conquering new sales markets, expanding production, increasing profits and increasing competitiveness [14]. At the moment, there

is an opportunity to modernize production and improve the quality of products according to all existing indicators. There are enterprises for which improving the quality of products is a secondary task, but the conditions of competition on the world market cause that such enterprises will sooner or later be forced to modernize their production, aiming the work of the enterprise at improving its quality management system [19].

In conclusion, we can conclude that improving the quality of products will always be a positive and cost-effective factor in the development of any enterprise.

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## QUALITY TOOLS AND METHODOLOGIES INFLUENCING THE INVESTMENT AND DEVELOPMENT PERFORMANCE IN AEROSPACE INDUSTRY COMPANIES OF THE EUROPE AND NORTH AMERICA

**Abstract:** Previous research has very rarely aimed to examine the influence of the usage of quality tools and methodologies on investment and development performance. This paper aims to fill the gap in research evidence and is focused on the empirical examination of quality tools and methodologies influencing the investment and development performances on a sample of 173 companies operating in the multinational aerospace industry supply chains in Europe and North America. Europe and North America have been chosen due to their companies' very high incomes in the aerospace industry. By using descriptive statistics, hypothesis testing, correlation and regression analysis, the results are obtained as follows. Results show that examined companies in Europe and America differ regarding all observed quality tools and methodologies, but not in investment and development performance indicators. In that area, there are different patterns. There are evidently the highest correlations between TQM and other tools and methodologies in Europe, while there are not any significant correlations with investment and development performance. The situation in North America differs and there is evidently the highest correlation between Kaizen and basic quality tools and it is clear that there are significant correlations between investment and development performance and quality techniques, such as Six Sigma and TQM. To examine possible influences on quality tools and methodologies for investment and development performance in North American companies, regression modelling has been done, but the expected results have not been obtained. Further analysis is recommended to search for influential factors affecting investment and development performance.

**Keywords:** Quality tools and methodologies, Investment and development performance, Aerospace industry, Hypothesis, Correlation and Regression analysis

### 1. Introduction

The process of creating quality is a complex mechanism whose ultimate goal is the satisfaction of the customer or end user,

starting from the customer requirements transformed through a complex chain of production or provision of appropriate service (Carlgren, 2013). It is followed by continuous quality improvements, which represent processes whose task is to ensure

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the constant development and improvement of all segments of one or more processes, where successful quality improvement consists of continuous improvements, corrective measures and innovation simultaneously (García-Fernández et al., 2022). Numerous empirical studies have made an effort to look into quality management in various contexts (Alherian et al., 2021; McAdam et al., 2019; Sousa & Voss, 2001; Spasojević Brkić & Mihajlović, 2023; Spasojević-Brkić, 2011). Certain number of available studies focus on the relationship between quality management and performance (Ebrahimi & Sadeghi, 2013; Lakhali et al., 2006; Machado et al., 2019; Pambreni et al., 2019; Saragih et al., 2020; V. K. Spasojevic Brkic et al., 2013; Tambare et al., 2022; Xu et al., 2020). Surveys focused on deployment of quality tools and methodologies are rare. Sousa et al., (2005) were focused on the degree of use of quality tools, since they offer integration between a business's internal activities and performance and its external requirements. Spasojevic Brkic et al., (2013) divided quality tools and methodologies into three groups and analysed relationships between these groups and business performance measures. The aerospace industry deserves

special attention since it is arguably the most obsessively safety-conscious sector with strict quality control standards (Brkić et al., n.d.; Tomić et al., 2012). On the other hand, it is evident that United States and European countries remain the prominent aerospace markets, with sales in the United States of about USD 214 billion, followed by Europe, Canada and Japan (OECD, 2007, 2011). There is an evident research gap and accordingly, this research focuses on quality tools and methodologies for investment and development performance that were neglected in previous research. Moreover, this research examines the aerospace industry and companies operating in Europe and North America. This paper is structured as follows: it starts with an introduction, which is followed by previous research analysis, and continued with methodology, results and conclusion sections.

## 2. Previous research

Detailed analysis of the previous research determined quality tools and methodologies, as well as the investment and development performance measures, as in Table 1.

**Table 1.** Overview of previous research on quality tools and methodologies

Quality Improvement Tool or Methodology/Performance	Description	Previous research
Quality Tools	Check Sheet, Histogram, Pareto Chart, Flow Chart, Cause-Effect Diagram, Run Chart, Scatter Diagram, Affinity Diagram, Relations Diagram, Tree Diagram, Matrix Diagram, Priority Diagram, Arrow Diagram and Process Decision Program Chart	(Spasojevic Brkic et al., 2013; Spasojević-Brkić, Tomić, Brkić, et al., 2020; Tari & Sabater, 2004; Tomic et al., 2017; Tomic & Brkić, 2017)
Quality Techniques	Brainstorming, Benchmarking, FMEA (Failure Mode Effect Analysis), QFD (Quality Function Deployment), Cost of Quality, Sampling Plans, Control Charts, Process Capability and Design of Experiments	(Spasojevic Brkic et al., 2013; Spasojević-Brkić, Tomić, Brkić, et al., 2020; Tari & Sabater, 2004; Tomic et al., 2017; Tomic & Brkić, 2017)

Quality Improvement Tool or Methodology/Performance	Description	Previous research
Plan–Do–Check–Act (PDCA) Cycle	Utilization of PDCA on everyday basis in all activities	(Dahlgard & Mi Dahlgard-Park, 2006; Du et al., 2008; Ranjan Senapati, 2004; Spasojević-Brkić, Tomić, Brkić, et al., 2020; Tomic et al., 2017)
Kaizen	Practice of the incremental improvements in all processes	(Doolen et al., 2008; Lagrosen, 2003; Ranjan Senapati, 2004; Spasojević-Brkić, Tomić, Brkić, et al., 2020; Spasojević-Brkić, Tomić, Perišić, et al., 2020; Tomic et al., 2017)
Six Sigma	Use of the Six sigma methodology for breakthrough improvements	(Dahlgard & Mi Dahlgard-Park, 2006; Foster, 2007; Ranjan Senapati, 2004; V. Spasojevic Brkic & Tomic, 2016; Spasojević-Brkić, Tomić, Brkić, et al., 2020; Tomic et al., 2017; Zu et al., 2010)
TQM	Promotion of TQM values in the organization through its activities	(Anil & K.P., 2019; Dahlgard & Mi Dahlgard-Park, 2006; Hackman & Wageman, 1995; Spasojević-Brkić, Tomić, Brkić, et al., 2020; Tomic et al., 2017)
Lean Manufacturing	Practice of lean manufacturing including tools such as 5S, Kanban, or Poke-Yoke	(Dahlgard & Mi Dahlgard-Park, 2006; Jungbae Roh et al., 2008; V. Spasojevic Brkic & Tomic, 2016; Spasojević-Brkić, Tomić, Brkić, et al., 2020; Tari & Sabater, 2004; Tomic et al., 2017)
Investment and Development Performance	<ul style="list-style-type: none"> <li>- Investment in research and development</li> <li>- Expansion of production capacities</li> <li>- Increasing the number of employees</li> <li>- Investment in the process / product innovation</li> <li>- Improvement of technical aspects of processes / products</li> </ul>	(Hong et al., 2019; Lizarelli et al., 2021; Prajogo & Sohal, 2006; Sadikoglu & Zehir, 2010; V. K. Spasojevic Brkic et al., 2013; Spasojević-Brkić, 2011; Zeng et al., 2017; Zhu et al., 2013)

### 3. Methodology

The research covers manufacturing companies in the supply chain of multinational company in the aviation sector, that are located and spread across North America and Europe. The following stages of research are included:

1. Operationalization of research content (questionnaire construction and/or planning of other forms of data collection in the field);
2. Conceptualization of properties and features of the researched problem (trial research on a small sample);
3. Defining, developing and distributing questionnaires and/or other forms of data collection (conducting the data collection process in the field);
4. Setting hypotheses about expected interdependencies within the researched phenomenon of the problem and processing of collected data (setting research hypotheses and testing the set hypotheses with statistical methods);
5. Analysis and evaluation of the research results (if there are certain doubts regarding the conclusions); and
6. Summing up the results and drawing conclusions. Most of the questions in the survey were taken from or constructed on the basis of numerous previous research studies discussed and analyzed in detail in the literature sources in Table 1, which is very important in research of this type. A Likert scale with multiple answers was used, which is a psychometric scale that is today the most commonly used for this type of research and is very often used in surveys, in which respondents determine their level of

agreement or, on the contrary, disagreement with a certain statement or question.

In this paper, the research instrument was delivered via email to exactly 500 production systems and responses were received from 64 European and 109 North American companies.

First, descriptive statistics on the samples from both regions were arranged in order to determine the types of variables.

Then, differences between regions were tested using statistical hypothesis tests depending on variable type to check if differences could be found on all examined constructs.

Afterwards, correlation analysis is done in order to obtain possible regression dependencies between quality tools and methodologies and investment and development performance.

### 4. Results

Descriptive statistics data containing sample sizes; range, minimum and maximum of the average responses values; mean; standard deviation; variance; significance p level and variable type both for European and North American companies are given in Tables 2 and 3. It can be noticed that European data contain one non-parametric variable.

According to the results in Table 2, the Mann-Whitney U test is used for testing the distributions of both populations (Europe and North America), for the variable basic quality tools. Results are given in Tables 4a and 4b. For other statistics, the t test is used, as in Table 5.



**Table 2.** Descriptive statistics for companies in Europe

Variable/Statistic	N	Range	Minimum	Maximum	Mean	Std. Error	Std. Deviation	Variance	p	Variable type
Basic Quality Tools	64	2.5714	2.1429	4.7143	3.7344	0.0679	0.5429	0.2947	0.174	Non-parametric
Quality Techniques	64	1.9167	1.8889	3.8056	2.8372	0.0502	0.4014	0.1611	0.024	Parametric
Plan-Do-Check-Act (PDCA) Cycle	64	3.0000	2.0000	5.0000	3.9896	0.0742	0.5938	0.3526	0.001	Parametric
Kaizen	64	3.3333	1.6667	5.0000	3.7135	0.0806	0.6448	0.4158	<0.001	Parametric
Six Sigma	64	3.0000	2.0000	5.0000	3.2760	0.0896	0.7165	0.5134	<0.001	Parametric
TQM	64	3.0000	2.0000	5.0000	3.6615	0.0662	0.5295	0.2804	0.002	Parametric
Lean Manufacturing	64	3.0000	2.0000	5.0000	3.1146	0.0831	0.6646	0.4417	0.002	Parametric
Investment and Development Performance	64	2.4000	2.2000	4.6000	3.2219	0.0641	0.5128	0.2630	0.003	Parametric

**Table 3.** Descriptive statistics for companies in North America

Variable/Statistic	N	Range	Minimum	Maximum	Mean	Std. Error	Std. Deviation	Variance	p	Variable type
Basic Quality Tools	109	1.4286	3.5714	5.0000	4.3408	0.0246	0.2571	0.0661	<0.001	Parametric
Quality Techniques	109	1.8333	2.2500	4.0833	3.0619	0.0392	0.4088	0.1671	<0.001	Parametric
Plan-Do-Check-Act (PDCA) Cycle	109	1.0000	4.0000	5.0000	4.5505	0.0276	0.2882	0.0831	<0.001	Parametric
Kaizen	109	1.6667	3.3333	5.0000	4.3211	0.0381	0.3979	0.1583	<0.001	Parametric
Six Sigma	109	3.0000	2.0000	5.0000	3.9388	0.0591	0.6173	0.3810	<0.001	Parametric
TQM	109	1.6667	3.3333	5.0000	4.2630	0.0311	0.3242	0.1051	<0.001	Parametric
Lean Manufacturing	109	2.0000	2.6667	4.6667	3.8991	0.0390	0.4070	0.1656	<0.001	Parametric
Investment and Development Performance	109	2.2000	2.0000	4.2000	3.3505	0.0429	0.4482	0.2009	<0.001	Parametric

**Table 4a.** Mann-Whitney U test (Basic Quality Tools)

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig. <sup>a,b</sup>	Decision
1	Basic Quality Tools	Independent-Samples Mann-Whitney U Test	0.000	Reject the null hypothesis.
a. The significance level is 0.05.				
b. Asymptotic significance is displayed.				

**Table 4b.** Independent-Samples Mann-Whitney U Test

Summary	
Total N	173
Mann-Whitney U	5855.000
Wilcoxon W	11850.000
Test Statistic	5855.000
Standard Error	315.536
Standardized Test Statistic	7.502
Asymptotic Sig.(2-sided test)	0.000

Results show that Europe and America differ in terms of Basic Quality Tools.

**Table 5.** T test for other constructs

Testing differences on...				t	p	Significance
Quality Techniques	Europe	vs	North America	3.513	<0.001	Significant
Plan-Do-Check-Act (PDCA) Cycle	Europe	vs	North America	8.340	<0.001	Significant
Kaizen	Europe	vs	North America	7.668	<0.001	Significant
Six Sigma	Europe	vs	North America	6.420	<0.001	Significant
TQM	Europe	vs	North America	9.273	<0.001	significant
Lean Manufacturing	Europe	vs	North America	9.635	<0.001	Significant
Investment and Development Performance	Europe	vs	North America	1.726	0.086	Not significant

The results in Table 5 show that there is a difference regarding all other tools and methodologies but not in investment and development performance.

In Tables 6 and 7, correlation analysis results are given, for European and North American companies with significance levels of 0.01 (2-tailed) marked as \*\* and significance levels of 0.05 (2-tailed) marked as \*.

There are evidently the highest correlations between TQM and other tools and

methodologies in Europe, while there are no significant correlations with investment and development performance. The situation in North America differs and there is evidently the highest correlation between kaizen and basic quality tools and there is a significant correlation between investment and development performance and quality techniques, as well as with Six Sigma and TQM.

**Table 6.** Correlation analysis for European companies

		Basic Quality Tools	Quality Techniques	PDCA	Kaizen	Six Sigma	TQM	Lean Manufacturing	Investment and Development Performance
Basic Quality Tools	Correlation Coefficient		0.774**	0.862**	0.809**	0.383**	0.828**	0.671**	0.235
	Sig. (2-tailed)		0.000	0.000	0.000	0.002	0.000	0.000	0.062
Quality Techniques	Correlation Coefficient	0.774**		0.650**	0.608**	0.148	0.570**	0.466**	0.202
	Sig. (2-tailed)	0.000		0.000	0.000	0.243	0.000	0.000	0.109
Plan-Do-Check-Act (PDCA) Cycle	Correlation Coefficient	0.862**	0.650**		0.483**	0.225	0.647**	0.520**	0.232
	Sig. (2-tailed)	0.000	0.000		0.000	0.074	0.000	0.000	0.065
Kaizen	Correlation Coefficient	0.809**	0.608**	0.483**		0.512**	0.817**	0.665**	0.209
	Sig. (2-tailed)	0.000	0.000	0.000		0.000	0.000	0.000	0.098
Six Sigma	Correlation Coefficient	0.383**	0.148	0.225	0.512**		0.753**	0.657**	0.139
	Sig. (2-tailed)	0.002	0.243	0.074	0.000		0.000	0.000	0.275
TQM	Correlation Coefficient	0.828**	0.570**	0.647**	0.817**	0.753**		0.825**	0.208
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000		0.000	0.099
Lean Manufacturing	Correlation Coefficient	0.671**	0.466**	0.520**	0.665**	0.657**	0.825**		0.215
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000		0.088
Investment and Development Performance	Correlation Coefficient	0.235	0.202	0.232	0.209	0.139	0.208	0.215	
	Sig. (2-tailed)	0.062	0.109	0.065	0.098	0.275	0.099	0.088	

**Table 7.** Correlation analysis for North American companies

		Basic Quality Tools	Quality Techniques	PDCA	Kaizen	Six Sigma	TQM	Lean Manufacturing	Investment and Development Performance
Basic Quality Tools	Correlation Coefficient		0.378**	0.481**	0.827**	0.0071	0.630**	0.423**	0.112
	Sig. (2-tailed)		0.000	0.000	0.000	0.465	0.000	0.000	0.248
Quality Techniques	Correlation Coefficient	0.378**		0.110	0.363**	0.200*	0.335**	0.071	0.250**
	Sig. (2-tailed)	0.000		0.255	0.000	0.037	0.000	0.465	0.009
Plan-Do-Check-Act (PDCA) Cycle	Correlation Coefficient	0.481**	0.110		-0.037	-0.036	0.431**	0.494**	0.026
	Sig. (2-tailed)	0.000	0.255		0.699	0.710	0.000	0.000	0.790
Kaizen	Correlation Coefficient	0.827**	0.363**	-0.037		0.127	0.478**	0.206*	0.114
	Sig. (2-tailed)	0.000	0.000	0.699		0.187	0.000	0.031	0.236
Six Sigma	Correlation Coefficient	0.071	0.200*	-0.036	0.127		0.605**	0.387**	0.192*
	Sig. (2-tailed)	0.465	0.037	0.710	0.187		0.000	0.000	0.045
TQM	Correlation Coefficient	0.630**	0.335**	0.431**	0.478**	0.605**		0.704**	0.249**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000		0.000	0.009
Lean Manufacturing	Correlation Coefficient	0.423**	0.071	0.494**	0.206*	0.387**	0.704**		0.089
	Sig. (2-tailed)	0.000	0.465	0.000	0.031	0.000	0.000		0.355
Investment and Development Performance	Correlation Coefficient	0.112	0.250**	0.026	0.114	0.192*	0.249**	0.089	
	Sig. (2-tailed)	0.248	0.009	0.790	0.236	0.045	0.009	0.355	

**Table 8.** Regression model for North American companies

Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.270 <sup>a</sup>	0.073	0.064	0.433588	0.073	8.386	1	107	0.005

a. Predictors: (Constant), Quality Techniques

Coefficients <sup>b</sup>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.445	0.315		7.757	0.000
	Quality Techniques	0.296	0.102	0.270	2.896	0.005

b. Dependent Variable: Investment and Development Performances

Subsequently a stepwise regression model of performance depending on quality techniques, six sigma and TQM was set up and tested, where significant correlations were recorded, as in Table 8. However, the expected dependence was not obtained since there is a low coefficient of determination.

## 5. Conclusion

Previous research has focused widely on the influence of quality management on performance indicators, but the influence of quality tools and methodologies on investment and development performance is rarely examined.

This paper aimed to fill an evident research gap and focused on an empirical examination of quality tools and methodologies for investment and development performance in the aerospace industry and companies operating in Europe and North America. Those constructs have been tested on a sample of 173 companies operating in the multinational supply chains in Europe and North America, which are the strongest pillars of the aerospace industry in the world. The questionnaire has been used

as the research instrument.

By using descriptive statistics, hypothesis testing, correlation and regression analysis, it was aimed to explore differences in different cultural settings, such as European and North American and possible influences of quality tools and technique usage on performance levels. Obtained results show that examined companies in Europe and America differ regarding all quality tools and methodologies used but not in investment and development performance indicators. There are evidently the highest correlations between TQM and other tools and methodologies in Europe, while there are not any significant correlations with investment and development performance. The situation in North America differs and there is evidently the highest correlation between kaizen and basic quality tools and there are evidently significant correlations between investment and development performance and quality techniques, as well as with Six Sigma and TQM. To examine possible influences of quality tools and methodologies on investment and development performance, regression modelling has been done, but expected results have not been obtained.

Further analysis is recommended to research influential factors affecting investment and development performance. A larger sample would also be beneficial, along with stronger quantification parameters regarding investment and development performance

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## THE ROLE OF THE COST AND QUALITY IN ADDITIVE MANUFACTURING

**Abstract:** *Global competition demands faster and more economically production process, products to be more personalized with modern design, sophisticated and of higher quality. Companies are looking for new solutions and production technologies to achieve these requirements.*

*Although they have been on the market for almost 30 years, it is only in the last decade that additive manufacturing (AM) technologies have reached a certain level of maturity to be accepted in the wide industry. Currently additive manufacturing is in a period of transition from its initial purpose for the rapid prototyping and small series to the serial production of parts. On that path, there are still obstacles that slow it down in the form of costs associated with the production process (machines, materials), the lack of advance process control, traditional approach to R&D, education of engineers and the lack of software integration from design stage to post processing.*

*Main focus of this paper is cost analysis in AM. In this regard paper will give brief overview of some developed cost models which brought significant novelties in the cost models considering the economics of AM and quality. Based on this analysis the paper will present suggestions what should be included in new cost model for production of end usable metal parts produced by PBF technology. Also, some quality inspection methods for AM will be briefly explained.*

**Keywords:** *cost estimation models, additive manufacturing, PBF, quality cost in AM, PBFtechnology.*

### 1. Introduction

From year to year, the market of additive technologies develops with high speed and more and more revenues are generated. Market research indicates that there is room for additional expansion. With such influence, the economic advantages of AM will play a big part on how this technology will be used in the industry, (Liu, 2017). Currently additive manufacturing is in a period of transition from its initial purpose for the rapid prototyping and small series to

the serial production of parts.

This paper presents a part of the research related to the optimization of the production process using new (additive) technologies that provide certain advantages compared to traditional production.

It is indisputable that additive technologies have advantages in relation to traditional production (material removal or injection molding processes) in terms of the speed of prototyping, the possibility of producing ready-made functional parts (end usable parts) and complex geometries and internal

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structures. Economic justification of AM is analyzed through costs manufacturing as well as the quality of the final product as two indicators that have a key advantage in making initial decision about investment into this technology and their further application in production.

Main focus of this paper is cost analysis for PBF (Powder Bed Fusion). In the official ISO/ASTM standardization body classification, PBF technology is one of the seven categories of additive technologies, in addition to Vat polymerization, material extrusion, binder jetting (BJ), material jetting, sheet lamination (SL), DED - Direct Energy Deposition. PBF technology together with BJ, SL and DED belongs to the group of metal additive manufacturing method. It is based on the application of laser or electrical energy sources to polymer or metal powders,

in a layer by layer manner in a protective atmosphere, where energy source follows predefined computed path.

Having in mind industry big expectations and demands, PBF applications becomes challenging regarding cost, quality and lead time. Cost per part dominates the final decision on whether they will be manufactured traditionally or additively, (Ampower Insight, 2018).

To investigate commercial opportunities for specific AM technology (PBF for metal part production) and provide answer whether this technology is adequate to respond to customer technical and economical demands, scenario where AM technologies has advantages over conventional manufacturing will be further explained, figure 1 (Leary, 2020).

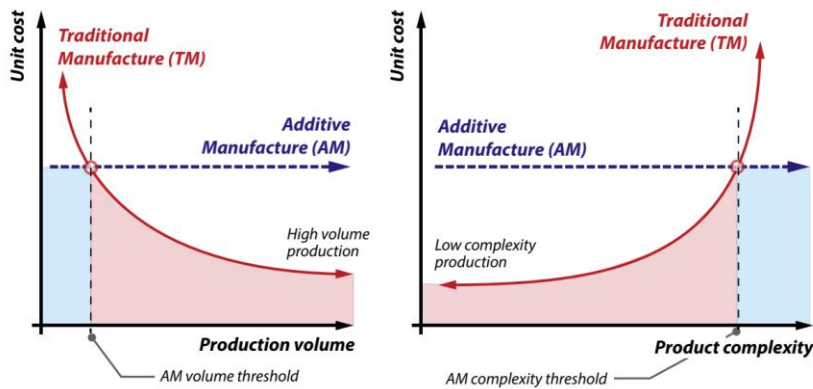


Figure 1. Cost-volume and cost-complexity curves for TM and AM.

Considering traditional manufacturing (TM), with increased number of products costs associated with production process exponentially goes down (economic of scale) and form basis for mass production. As for the part complexity in TM, more part complexities generate higher costs and in that regard there are certain technical limitations beyond which TM is not capable anymore to provide it. On contrary, AM manufacturing cost is not dependent of

production volume and part complexity, figure 1. Cost per part in AM are calculated based on the other parameters what will be explained later in the paper. Based on this simple explanation and graphical representation, is obvious that after some AM volume and complexity threshold (depends of characteristics of the AM and TM processes) AM becomes economically justified and profitable.

This paper is organized as follows. The second chapter analyzes the cost models developed so far with their specifications and quality costs. The following chapter presents a wide range of traditional and modern quality tools for AM, which represent additional cost generators. The next chapter analyzes the production cycle of PBF technology and proposes a new cost model for PBF technology which include quality costs. At the end of the paper, certain conclusions and directions for further research are given.

## 2. Review of the cost model for the AM process

In this chapter, several key/specific cost models related to the PBF process will be analyzed, which have introduced new cost generators as well as quality costs in their formulas. Cost models for AM have experienced their historical evolution, from the first models being related to fixed costs to the new models that are based on the activity-based cost.

For example, (Baumers, Tuck, Wildman, Ashcroft, Rosamond, Hague, 2012) in his model, beside the Activity Based Cost (ABC) estimation approach, for the first time added the cost of the energy consumed in the process. Presented cost model is limited to so called 'well structured' costs (machine, material, labor), while ill structured costs arising from factors such as build failure, machine idleness and inventory expenses are not taken into account.

(Lindemann, Jahnke, Moi, Koch, 2012) also used a ABC estimation approach (cost of the manufacturing is based on the activity duration) and divided cost between building job preparation, building job production, support structure removing and post-process activities. Lindemann et al. (2012) was among the first authors who introduce quality control cost in the post-process activities.

The first author who recognized all the complexity of the PBF process, introduced new cost drivers into the formulation and recognized the problems related to the optimization during the planning stage was Rickenbacker in his paper (Rickenbacher, Spierings, Wegener, 2013). Offered cost model contains seven processes (preparation, build job, setup, building, removal, substrate, post processing), and what makes its model unique are for the first time introduction of the formulas for: cost per part with different sizes, multiple geometries and quantities in the same build job simultaneously. This model, with certain variations, is the starting point for the development of a new cost model that will be presented in this paper.

Another recognition of the role of the quality in the cost model for PBF is presented in paper (Schröder, M. Falk, B. Schmitt, R., 2015) where it is explained as "modern quality management methods for control of the product and process quality" (page 314). His cost model identified seven main processes: design and planning, material processing, machine preparation, manufacturing, post-processing, administration and sales, and quality, which has possibility to apply to different AM systems, such as FDM, SLA, SLS, and Electron Beam Melting (EBM).

In the work (Barclift, M. Joshi, S. Simpson, T. Dickman, C., 2016) for the first time it was proposed the cost model depreciation of the metal powder. All cost models before this model, and for sure almost all cost models that appeared later, consider material cost as fixed cost. Since the metal powder in the PBF process undergo some thermal treatment from heat source (laser or electro-beam) and are used for several times in subsequent processes, initial cost value of the virgin powder is not the same as at the beginning of the process. Study conducted by (Barclift et al., 2016, page 2007) "indicated that cost models applying a fixed material cost can undervalue built parts with

a high-value virgin powder by as much as 3-11% or 13-75% depending on the material and its maximum build cycles in the PBF”.

Some of the new models, for example model from (Lamei, 2021), divided the PBF process on the three activities: pre-processing costs, processing costs and post-processing costs. As for the cost of the activities related to quality, he included testing cost as part of the post-processing costs. Within inspection cost Lamei include all inspection activities for the evaluation of the final product, mainly inspection of dimensional accuracy, mechanical properties, etc. Lamei (2021) included testing (inspection) cost in the post processing phase, after all activities in this phase is completed. The equation are different in case if there is 100% inspection or sampling inspection. This decision is subject of negotiation between manufacturer and customer. If 100% inspection is required equation is:

$$C_T = A \times N + [p \times N \times B]$$

were: CT - testing cost, A -cost of testing one unit (\$/unit), N - Total number of units, p - Probability of a nonconforming unit, B - Cost to repair or replace a single unit.

(Jarrar, Bernard, Belkadi, 2022) presented a cost model consisting of 6 processes (job preparation, machine setup, build job, machine output, post processing, control process) within which he defined key cost generators. In process control was he included the quality control cost (generated through the use of the tools and methods to evaluate different aspects of quality). Jarrar at all (2022) specifically emphasized that post-processing and quality control costs may take up to 50% of the final product cost.

The most comprehensive analysis about quality cost is presented in (Hajalfaud, Baumers, 2020). Hajalfaud and Baumers (2020) also conclude that previously developed cost models did not consider quality costs. So, they made further

investigation about this topic and in their model involved all quality elements along the production chain. Case study showed that about 20% of total cost goes to quality cost.

The authors defined total quality costs (TQC) as function of replacement costs, preventive maintenance costs (C<sub>pm</sub>), inspection cost (C<sub>in</sub>) and revenue from scrap (C<sub>r</sub>) selling in case of failure:

$$T_{QC} = C_r + C_{pm} + C_{in} - C_{sc}$$

### 3. Quality control in AM

Having in mind that AM is finally crossing stage from prototype to production, the process itself must ensure repeatability, consistency, in order to get overall confidence from potential users. In parallel with this it is of the utmost importance to establish standardized quality control process, (Auerbach, 2021).

For this process there are traditional tools adapted for AM and most advanced digital tools in order to respond to all demands coming from AM. Traditional control tools (for Geometrical Dimensioning and Tolerances) mainly register data manually, this job can be labor intensive and not precise enough, and some steps to improve this are needed.

Auerbach (2021) stated that since the AM is characterized as digitalization process, in that sense more modern measuring equipment, the so-called digital tools, must be used.

With the aim of getting higher level of precision and fulfil of standard requirements, different industries and quality control departments turned they attention to Coordinated Measuring Machines (CMMs). It is import to have control tools that can provide interaction with digital environment characterized for AM. Comparison of measured data of final product with CAD models (form design stage) provide new opportunities for data analysis and

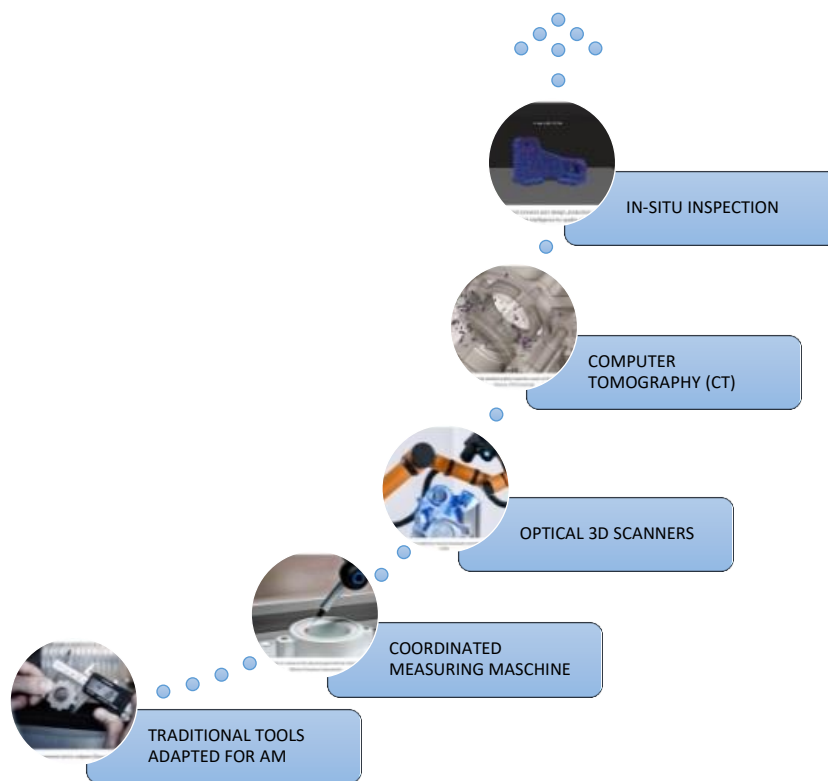
predictions. More advance, non-contact and much faster alternatives to CMMS is 3D scanners.

For the advantages that AM provides in terms of design and complex geometries (lattices structure, and topology optimization), it is necessary to use a special control tool like CT (Computed Tomography). CT is not ideal just for metrology inspection, it have broader capabilities so it can perform non-destructive

testing like internal defects, voids and porosities.

Latest development in the field of sensors, AI, machine learning, cloud computing, closed-loop automation process afford good opportunity for development of in-situ inspection. One of the solutions already available at the market is integration of these tools into the 3D printers.

Exponential curve of the available quality control tools are presented at the Figure 2.



**Figure 2.** Quality control tools in AM

Accoding to (Kim, Lin, Tseng, 2018) in order to improve quality of AM produced parts, new quality control tools should be able to adress issues like: prediction of optimal printing parameter and mechanical properties, real time monitoring and process

control in build job process, feedback interaction between design/printing and part evaluation process, agile part evaluation, high speed fabrication, cyber quality control.

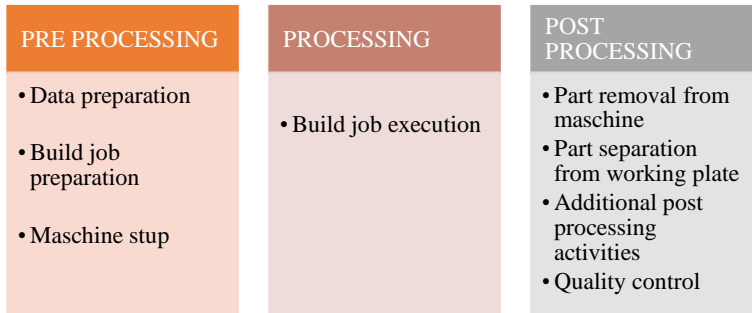
**4. New cost model proposition for PBF technology**

**4.1. PBF production chain**

In order to define the cost model it is necessary to analyze the whole PBF production chain for the fabrication of the metal parts. Briefly explained, the process itself (Figure 3.) begins with the preparation of a 3D model in an adequate software package, then the 3D model is transformed in specialized software to prepare it for 3D

printing (tesselation, build preparation). Next step is loading prepared model in the PBF machine, then goes machine preparation and after that the production of parts layer by layer can start.

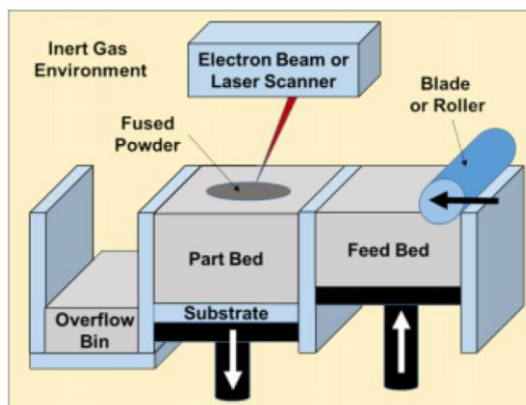
Due to its specificity (support structure elimination, part separation from working plate, residual stress, etc...) PBF process requires post processing activity for improving the overall quality of the end used products. Final parts is submitted to the quality control.



**Figure 3.** PBF production chain

This process requires extensive labor in order to generate a fully-functional component, which additionally increases the

costs of the process. The schematic process of PBF (build job execution phase) is shown in Figure 4.



**Figure 4.** PBF build job execution phase



From the feeding container the thin layer of the powder with recoater are spreading over the surface of the production chamber. Then this layer is exposing to laser or electro beam (Selective Laser Melting (SLM) and Electron Beam Melting (EBM) technology) and after the melting and solidification new layer is formed over the top of the former shaped layer, (Barclift at all, 2016). This process is repeating until the whole part is produced. The size of the part to be produces is limited with the dimension of the production chamber. The rest of the unused and unmelted powder are suing and later using again in the process.

The parameters in this process can be optimized (number of lasers, speed and power of lasers, etc) and thus affect the total production time, production costs as well as the quality of production. The quality of production is especially improved by post-processing activities that are mandatory for PBF technology (stress relief, heat treatment, etc.) and require additional costs.

Advataged that PBF process provide are good dimensional accuracy, repeatability, good material properties with high density as well as possiblity to use wide range of materials and small anisotropy. At the same time there are some disadvantages like need for support structure in order to minimize residual stress, need for post process treatment, staircase effects, etc.

## 4.2. New cost model preposition

Based on the analysis of the aforementioned cost models and discussions with experts in the field of PBF technology, a new model consisting of 3 basic processes (equations) was proposed.

$$C_{total}(P_i) = C_{preproces}(P_i) + C_{process}(P_i) + C_{postprocess}(P_i)$$

In accordance with Figure 3 and Figure 4, within each process there are certain sub-processes that participate in the generation of

total costs and hence the total costs per part can be presented as follows:

$$C_{total}(P_i) = C_{prep}(P_i) + C_{build\ job}(P_i) + C_{setup}(P_i) + C_{build}(P_i) + C_{removal}(P_i) + C_{substrate}(P_i) + C_{postp}(P_i) + C_{quality}(P_i),$$

were:

$C_{total}(P_i)$  – total manufacturing cost per part  
 $C_{prep}(P_i)$  – cost per part for data preparation (CAD model preparation by the operator)

$C_{build\ job}(P_i)$  – cost per part of build job preparation (activities like part orientation, define support structure, model slicing into the cross-sections, all performed by experienced operator in an adequate software tool)

$C_{setup}(P_i)$  – cost per part of setting up the machine (include: machine cleaning and material change, loading of data files, set up of machine parameters, initialization of inert gas, etc)

$C_{build}(P_i)$  – cost per part of building job (it is automated process, cost incurred are related to material, machine, energy, operator and time to build model)

$C_{removal}(P_i)$  – Cost per part of removing working plate from machine (it is labor extensive and hard to manipulate, ask for additional equipment like forklift and jigs/fixtures)

$C_{substrate}(P_i)$  – cost per part of separating parts form working plate/substrate (stress relief for plate, need special tool like EDM for part removal)

$C_{postp}(P_i)$  – cost per part of additional post processing (heat treatment, HIP, shoot penning, etc).

$C_{quality}(P_i)$  cost per part of quality activities (part sampling inspection, material properties analysis, surface and dimensional accuracy, creating quality report cost, quality and process monitoring checks, replacement cost, preventive maintenance cost).

Based on the literature review sub process “Cost of quality activities” consist of two type of activities: 1) labor intensive and sometimes destructive evaluation processes which requires use of digital tools and waste of materials, and 2) control and monitoring activities mainly performed by quality experts.

This paper will not further elaborate each of the above mentioned sub processes equations. Generally speaking cost for every quality activities is calculated as production of time (as duration of activities perform by operator and control tools) and hourly operator rate or hourly cost of using control tools.

## 5. Conclusion and further perspectives

The relevance of the proposed cost model is double. At first place, proposed cost model is a part of an ongoing research focusing on the investigation of economically justification of AM use relative to traditional production and in that process can have decisive role. As second, within AM planning process (and PBF as well) part orientation problems on working plate is essential element which has influence to the final mechanical characteristics of the end-use product. The part orientation problem can be treated as MCDM problem where the cost, among other factors/variables, are taken into the consideration.

In addition to the previously said, this work several cost models in the field of AM have been reviewed, and a cost model using Activity-Based Costing approach is suggested. The main cost drivers within the PBF process chain have been presented and explained, too. Some of the characteristics of the proposed model are as follows:

- Cost in the model should include the entire production cycle for PBF.

- ABC estimation model should be adapted since it is focusing on time duration of the activity what is primary in this model, especially from the labor perspective.
- Build job preparation should be executed in the manner to include all suggestions from (Rickenabuer et al, 2013): mixed part on the build plate, full capacity.
- In addition to (materials, labor, machine costs,...) the new cost model should also include energy cost, powder depreciation cost.
- One of the outcomes should be the cost per part since the companies and customers are interested in estimates of production costs of individual products, and cost per part dominates the final decision on whether they will be manufactured additively.
- Quality cost need to be treated as a separate cost element.
- The proposed model is easy to apply in the quotation process, hence it can support the estimation of costs at early stages.
- Since the proposed model captured all sub processes within PBF it can be used to track the incurred cost of each activity.

Further steps to be performed related to the proposed model:

- Model is focused predominantly on PBF process and for the cost estimation in other AM technologies updates and modification is necessary.
- Quality costs need to be investigate in details and put additionally into the formulation (cost of build failure, cost of redesign due to failures, etc...).

PBF as AM technology for metal end usable part production is very useful and promising technology (considering reduce lead time, producing complex parts, etc) to be consider in forthcoming period as replacement of TM, but before that several aspects, mainly costs and quality, need to be investigate in details. Decision about PBF application whether it is for prototyping process, small or large serial production is subject of further analysis.

Also, it is becoming apparent that more sophisticated quality tools are required and PBF technology is good candidate for application of these quality control tools for real time monitoring, feedback-loops and

predictions of printing parameters.

This paper need to be further expand with case study in order to align presented research with commercial activities in order to get full validation and confirmation of initial posted thesis (commercial opportunities existence for PBF technology for metal part production ). Proposed model can be extended to include cost associated with product lifecycle until the disposal phase. Paper confirmed that not just technical consideration for the AM implantation has to be validated but also economical attributes since it contributes to full commercial success of AM technologies.

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## DETERMINE MUSCLE STRAIN OF ASSEMBLY WORKERS BY APPLYING ADVANCED EMG MEASUREMENT

**Abstract:** Contemporary organizations tend to improve the safety and health of workers through the relief of workers from performing strenuous and tiring activities. Musculoskeletal disorders (MSDs) that occur as a result of repeating the same movement over a long period of time, straining and bending the body or performing assembly activities in an ergonomically inadequate body position represent one of the major problems faced by organizations, which further leads to more and more absenteeism of workers from work, reduced productivity and increased costs.

The main aim of the research paper is to show the results of monitoring of muscle activity during the performing of assembly activities in two scenarios - ergonomic and non-ergonomic. The non-ergonomic scenario involves performing assembly activities at a traditional workstation. On the other hand, in the ergonomic scenario, participants perform assembly activities on the proposed ergonomically designed workstation, in the golden zone and in this way bending, stress and stretching of the body are eliminated.

**Keywords:** assembly workstation, EMG, ergonomics interventions, musculoskeletal disorders, safety 4.0

### 1. Introduction

One of the main goals of Industry 4.0, in addition to improving the effectiveness of production processes, is improving safety and health through the achievement of "zero injuries". This goal can be achieved through the elimination of injuries at work, minimization of occupational and work-related diseases, minimization of discomfort and stress. Safety 4.0 represents a shift towards a more data-driven, technology-enabled approach to workplace safety. Intelligent wearable devices and other modern technologies of Industry 4.0 enable real-time monitoring vital signs and tracking

location of workers and identify potential safety risks (for example, detecting exposure to hazardous materials).

The increased automation of the production process and the application of advanced technologies of The fourth Industrial Revolution contributed the relief of workers from performing strenuous and tiring activities. However, many activities cannot be fully automated and workers are forced to perform assembly tasks that are manual and repetitive over a long period of time, which can lead to health problems that in some cases can cause permanent consequences to their health.

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Assembly activities in the automotive, engineering and electrical industries are a frequent occurrence. Due to increased effort and muscle strain in workers who perform repetitive, complex, tiring and physically demanding assembly activities in non-ergonomic conditions for a long period of time, musculoskeletal disorders (e.g. carpal tunnel syndrome, joint tendonitis, etc.) and other occupational diseases occur. In a real industrial environment, workers most often perform these activities in a standing position at traditional workstations which additionally contributes to the deterioration of their health condition in the form of lower back pain.

In the member countries of the European Union (EU), musculoskeletal disorders are one of the most common diseases. According to statistics, about 60% of workers suffer from this type of professional illness (Assurance Maladie, 2020; Caroly, S., Major, M. E., Probst, I., & Molinié, A. F., 2013).

This group of occupational diseases is associated with a large number of lost working days during the year, and associated with this are significant financial losses suffered by organizations due to a drop in productivity and increased costs due to absenteeism. According to the study (Warner, M., Baker, S. P., Li, G., & Smith, G. S., 1998) due to the appearance of musculoskeletal diseases, there was a decrease in productivity by 65%.

As one of the main risk factors for the occurrence of disorders of the musculoskeletal system, bad posture and an inadequate ergonomically designed workplace are mentioned in the literature (Alexopoulos, E. C., Burdorf, A., & Kalokerinou, A., 2003; David, G., Woods, V., Li, G., & Buckle, P., 2008). While performing manual repetitive, precise assembly activities, the worker's head and neck are bent forward for long periods of time. This non-ergonomic position of the

body causes pain in the neck and back (Chandrasakaran, A., Chee, H. L., Rampal, K. G., & Tan, G. L. E., 2003; Jonsson, B. G., Persson, J., & Kilbom, Å., 1988). Also discomfort is felt in other parts of the body - shoulders, arms, elbows, wrists, hand nerves and muscles or areas around these parts of the body.

In addition to the appearance of acute pain, there may also be the appearance of chronic pain in the mentioned parts of the body, and in some situations, permanent inability to work. According to the studies (Ohlsson, K., Attewell, R., & Skerfving, S., 1989) and (Ohlsson et al., 1995) conducted 39% of assembly workers in the automotive industry reported neck pain, 38% had shoulder pain, and 14% had arm pain. Luopajarvi, T., Kuorinka, I., Virolainen, M., & Holmberg, M. (1979) indicated that 37% of assembly workers complained of neck pain and 5.9% of arm pain.

Based on the above, it can be concluded that there is a need to improve traditional workstations in industrial environment. Good workstation design is crucial for industries that involve manual assembly activities by operators (Hägg, G. M., 2003). Monitoring the operator's muscle activity and identifying when fatigue occurs is of great importance, given that fatigue has a negative impact on the operator's health status (musculoskeletal disorders- back pain, carpal tunnel syndrome), productivity and operator's performance.

EMG as an electrophysiological method enables the registration of action potentials of muscle fibers of motor units that arise during muscle contraction. Using electromyography, muscle activities are monitored during the assembly of parts and components, and the load and strain on the muscles of the neck, arms and shoulders during these activities is determined.

The main aim of the research paper is to show the results of monitoring of muscle

activity during the performing of assembly activities in two scenarios - ergonomic and non-ergonomic in order to establish the risks that lead to the occurrence of musculoskeletal disorders and other occupational diseases among workers who perform assembly activities at traditional workstations.

The non-ergonomic scenario involves performing assembly activities at a traditional workstation in conditions that simulate conditions from a real industrial environment. On the other hand, in the ergonomic scenario, respondents perform assembly activities on the proposed new modular ergonomically designed workstation. In that case, the respondents perform assembly activities in the golden zone and in this way bending, stress and stretching of the body are eliminated.

Ergonomic interventions at the new workstation involve adjusting the height of the work surface, providing adjustable seating, and ensuring that tools and equipment are within easy reach.

This paper presented the results of monitoring the muscle of participants who perform assembly activities for a long period of time in an no ergonomic body position, in order to determine the ergonomic risks to the workers.

The motive for writing the paper lies in the fact that neglecting ergonomics in workstation design can indeed result in work-related musculoskeletal disorders and another occupational and work-related diseases. Poor workstation design can force workers to assume awkward postures, perform repetitive motions, or use excessive force, all of which can increase the risk of injury. For example, if the workstation is too high or too low, workers may have to hunch over or reach up, putting strain on their back, neck, and shoulders.

## 2. The experimental study

### 2.1. Literature review

Assembly workers occupational diseases and serious illnesses of workers, which can even lead to the disability of workers, which further leads to more and more absenteeism of workers from work, reduced productivity and increased costs. Neglecting ergonomic in workstation will result in workrelated musculoskeletal disorders. MSDs (including carpal tunnel syndrome, tendonitis, tennis elbow and back pain) are a particularly common problem among assembly workers, as their work often involves repetitive frequent motions, awkward postures, and forceful exertions (Choobineh, A., Lahmi, M., Shahnava, H., Khani Jazani, R., & Hosseini, M., 2004; Faucett, J., Garry, M., Nadler, D., & Ettare, D., 2002). These conditions can be painful and debilitating, making it difficult or impossible for workers to perform their duties and causing absenteeism.

According to the results of a Norwegian survey, the majority causes of MSD were: 65 % pain in the neck or shoulder region and 78 % arm pain (Mehlum, I. S., Veiersted, K. B., Wærsted, M., Wergeland, E., & Kjuus, H., 2009). Upper extremity disorders are a significant problem in assembly workplaces, both in terms of their commonness and the associated costs (Xu, Z., Ko, J., Cochran, D. J., & Jung, M. C., 2012). The costs associated with upper extremity disorders can be significant. Workers with these conditions may require time off from work for medical treatment or recovery, which can lead to reduced productivity and increased costs in organizations (“Ergonomics in the workplace”, 2019). In this context, many studies have proposed basic design rules or guidelines to ensure that assembly workers are able to work in safe and comfortable positions that minimize the risk of musculoskeletal disorders. These guidelines

typically focus on ergonomic workstation design, which involves designing workspaces that are tailored to the physical and cognitive abilities of workers.

EMG signals are used to monitor workers' muscle condition. According to (Graham, R. B., Agnew, M. J., & Stevenson, J. M., 2009; Lundberg, U. et al., 1999) the level of muscle activity varies depending on the complexity of the task performed and the position in which the worker performs the activities. According to (Sommerich, C. M., Joines, S. M., Hermans, V., & Moon, S. D., 2000) surface EMG (sEMG) is a very reliable and valid tool for measuring muscle activity in a industrial environment. Using this method, it is possible to determine the maximum lifting load, lifting height, and the number of repetitions that the workers are able to handle before experiencing fatigue, all for the purpose of avoiding overexertion (Freitas et al., 2019).

In studies (Bongers, P. M., Ijmker, S., Van den Heuvel, S., & Blatter, B. M., Griffiths, K. L., Mackey, M. G., & Adamson, B. J., 2007) surface EMG was applied to investigate the effects of workstation redesign on muscle strain in workers performing assembly activities and it was concluded that muscle strain in the upper extremities and shoulders, including the trapezius muscles, was significantly reduced after the redesign.

In a study (Björklund, M., Crenshaw, A. G., Djupsjöbacka, M., & Johansson, H., 2000) the effect of a repetitive low intensity task to fatigue on shoulder position sense was investigated. Molinari, F., Knaflitz, M., Bonato, P., & Actis, M. V. (2006) assessed the changed spectrum of the EMG signals when fatigue occurred during dynamic muscle contraction. Also, EMG electrodes were used in a specially designed laboratory experiment simulating roofing jobs to examine the effects of common risk factors based on lower back muscle activity and working frequency (Wang, D., Hu, B., Dai,

F., & Ning, X., 2015). The authors (Heydari, A., Nargol, A. V., Jones, A. P., Humphrey, A. R., & Greenough, C. G., 2010) conducted a large-scale study involving more than 100 workers (some with chronic pain symptoms and some not), testing the lumbar paraspinous muscles as a predictor of low back pain risk. Two years later, the research was conducted again on the same participants, and a subgroup of respondents with a higher risk of back pain was identified. In some scientific research papers, sEMG has been combined with observational assessments and self-assessments, in order to obtain a comprehensive picture of the extent to which muscle strain occurs in workers performing assembly activities.

## 2.2. Methodology

The traditional workstation where workers perform activities in a real industrial environment is fixed and not adapted to the individual anthropometric characteristics and capabilities of the operator. Also, workers in the industry most often perform assembly activities in a standing position for a long period of time, and this has a negative impact on their health conditions. In order to overcome the shortcomings of the traditional workstation, the authors proposed a new workstation that is aligned with ergonomic and lean principles and adapted to the individual characteristics and capabilities of the operator.

Studies (Corlett, E. N., & Eklund, J. A. E. 1983; Devereux, J. J., Vlachonikolis, I. G., & Buckle, P. W. , 2002) have shown that in an ergonomically designed workplace, the risk of musculoskeletal disorders is reduced, the safety and health of workers is improved, stress is reduced, and this further positively contributes to increasing the efficiency and productivity of operators. Authors (Choobineh, A., Lahmi, M., Shahnava, H., Khani Jazani, R., & Hosseini, M., 2004) concluded that the neglect of ergonomic



principles at the workstation leads to work injuries and musculoskeletal disorders. (Brito, M. F., Ramos, A. L., Carneiro, P., & Gonçalves, M. A., 2017) showed that when designing a workstation, special attention should be paid to ergonomic aspects.

Performing activities in the golden zone reduces stretching, bending, reaching for materials and parts, and eliminates poor posture, which further contributes to increased efficiency and reduced activity time (Heilala, J., & Voho, P., 2001; Yusuff, R. M., & Abdullah, N. S., 2016) pointed out the importance of adapting the workplace to the physical characteristics, requirements, abilities and skills of workers.

### 2.3. Case study

The experimental study was conducted in the period March 2022-March 2023 in the laboratory for ergonomics and collaborative robotics at the Faculty of Engineering, University of Kragujevac.

#### Participants

15 respondents participated in both scenarios. The subjects were undergraduate, master's and doctoral students at the Faculty of Engineering, University of Kragujevac, male gender, right-handed, aged between 18 and 30, who do not suffer from musculoskeletal disorders and have no serious back or spine problems. All participants voluntarily participated in the experiment and signed the consent that they allow the data to be used for further analysis. Before performing the experiment, the subjects were familiarized with the procedure and their basic data (age, year of birth, height and weight) were collected.

#### Equipment

The experiment was performed using an EMG device. The EMG device used for advanced measurements was MuscleBAN BE, produced by the company PLUXSignals from Portugal (slika 1.). This portable and wearable device measures electromyography and motion data, enabling a wide array of biomedical research and physiotherapy applications („Plux Biosignals, MuscleBAN BE Data Sheet“, 2021). As the main features of this device, we can state that it is light and small, so it can be worn without causing the test subjects any discomfort or interfering with their work during the experiments.



**Image 1.** The MuscleBAN BE device (The image of the rash („Plux Biosignals, MuscleBAN BE Data Sheet“, 2021))

The Bluetooth capability at up to 10 meters means that there is no need for wires, which would similarly impede the workers during the experiment and increase its complexity. The signal noise is 3 mV, giving us the margin of error, though the very large number of data points (over 5 million measurements) obtained during each session should greatly reduce the effects of statistical noise on results. The main device's characteristics, taken from its instruction manual, are presented in table 1. („Plux Biosignals, MuscleBAN BE Data Sheet“, 2021).

**Table 1.** The main device’s characteristics

Communication	Bluetooth Low Energy
Range:	up to ~10m (in line of sight)
On-board Sensors	1 EMG; 1 Triaxial Accelerometer ( $\pm 4g$ ); 1 Triaxial
ACC resolution	14-bit
MAG resolution	16-bit
EMG resolution	12-bit
EMG signal noise	3 $\mu$ V
Battery	155mA 3.7 LiPo rechargeable (enables up to 8h in continuous operation)
Medical grade charger	guarantees galvanic isolation
Size	28x70x12mm
Weight	25g

The device was then turned on and connected via Bluetooth to a computer with OpenSignals software and the subject was asked to perform some basic movements such as raising the hand in order to confirm that it was working as intended. When the subject was ready, the recording of data via OpenSignals was started and the session could begin. (Jonsson, 1988). Also, during the experiment both the traditional and the proposed new ergonomically designed workstation were used Trigno Research+ (Delsys, SAD) equipment used to record, measure and wirelessly transmit sEMG signals from the Trigno EMG sensor to the base station (Jonsson, B. G. et al., 1988). The equipment consists of a base station, an EMG sensor, a laptop on which the software is installed, which has the role of collecting, processing and analyzing the data. The main specifics are that the Trigno Avanti™ sensors support a low-noise, high-fidelity sensing circuit for detecting EMG signals when muscles contract from the surface of the skin. The maximum distance for successful data transmission between the sensor and the base was 10 meters. Trigno Avanti™ sensors were placed on the trapezius muscles on the subject's neck on the left and right side. Maximum muscle contraction was taken into account when placing the sensor itself. The recorded signals will be analyzed in real time using LabChart software. Figure 2. shows the

Trigno Research+ equipment used during the experiment - a box as a base station and EMG sensors



**Figure 2.** Trigno Research+ equipment

Also, as part of the research, an EEG cap with an amplifier was placed on the head of the subjects as part of a separate experiment that was conducted in order to monitor the brain activity of the subjects. In the experiment, 3 IP cameras were used, which had the role of monitoring the positions of the workers' bodies from three different positions - one camera was placed in front of the workers, and the remaining two cameras were on the left and right sides of the workers.

**Experiment scenario**

The experiment was conducted twice in two different scenarios - ergonomic and non-ergonomic. In both scenarios, the experiment consisted of two sessions lasting 1.5 hours (90 minutes) each, during which the respondents performed the activities of assembling electronic components according to predetermined rules. The participants assembled the finished product by inserting

blue wires from the container into a part made of plexiglas and closing the switch according to the diagram displayed on the monitor (in the ergonomic scenario) or according to paper instructions (in the non-ergonomic scenario). Participants in the experiment first received initial instructions, and after that, they performed assembly activities for 15 minutes in order to practice.

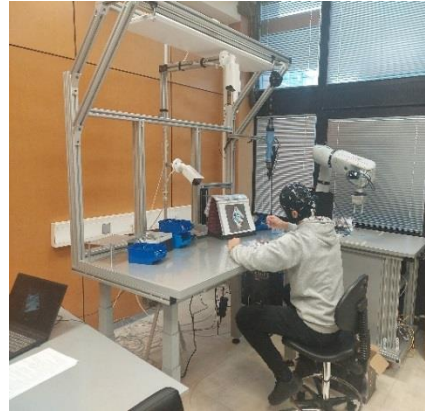
Between sessions, participants had a short break of 15 minutes. Thus, including the time necessary to prepare the experiment, set up the equipment and prepare the subject. The experiment in the ergonomic scenario and the non-ergonomic scenario were not performed on the same day.

In the non-ergonomic scenario, participants perform assembly work activities at a traditional workstation (Picture 3.). In this scenario, conditions from a real industrial environment were simulated i.e. 2D schematics and 3D images of the participants assembling the final product were displayed in paper format on a binder that was placed on a stand to the right of the subject. Additional difficulties encountered in this type of scenario are related to the constant turning of sheets of paper showing 2D schematics and 3D images after each completed product.

In the non-ergonomic scenario, the Plexiglas parts were located in a box next to a traditional assembly workstation so that subjects had to bend over to reach this part. The parts and components necessary to perform the assembly activities were placed outside the green zone and the subjects had to stretch their body to reach them. Also, the problem was that there were wires of various colors in the containers and not only the blue wires that were used during the experiment, which made it even more difficult for them to carry out the activity.

After finishing the part, the subjects bent down to drop the finished product into the box next to the table. In the non-economic

scenario participants were exposed to noise while performing activities.



**Picture 3.** Participant performs an experiment on a traditional assembly workstation

The experiment in an ergonomic scenario was realized on a proposed innovative modular assembly workstation, which is designed in accordance with the lean principles, main ergonomics principles and adapted to the needs and requirements and individual characteristics of the operator (Picture 4.). Anthropometric properties and measurements are essential factors to consider when designing a new workstation. Anthropometry is the scientific study of the measurements and proportions of the human body, and it plays a critical role in designing workstations that are ergonomic and safe for workers (Wojcikiewics, 2003). In order to design a workstation that is suitable for at least 90 percent of male and female body sizes, designers must take into account a variety of anthropometric factors, such as body height, weight, arm length, and leg length.

At the new workstation, the subjects had the possibility to adjust the height of the table and chair to match their height, and the control zone was adjusted to the individual reach of the dominant hand and individual preferences. In new assembly workstation all

components storage containers are arranged taking into account that the zones of the handling area are different for each person to reduce bending, straining and stretching of the body. The flexible arrangement of containers for storing parts and components on the newly designed workstation provides the ability to change the layout and organization of the work environment and adapt to the individual reach of the examinee. At the proposed assembly workstation, respondents perform activities in a combined (sitting and standing position) without feeling tired, exhausted and physically strained.

In the ergonomic scenario, the participants performed assembly activities based on information about 2D schemes and 3D images that they received from the touchscreen screen in front of them. Also, in the ergonomic scenario, the Plexiglas parts were placed on the right side of the subject within the golden zone to avoid unnecessary bending of the body. The container with the blue wires used during the experiment was placed in accordance with lean and ergonomic principles to avoid unnecessary reaching and stretching of the body. The experiment was performed in a ideally laboratory conditions.

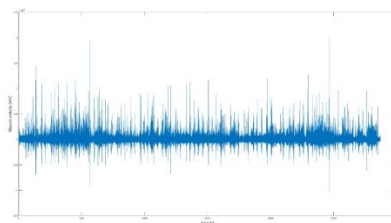


**Picture 4.** Participant performs an experiment on a proposed modular assembly workstation

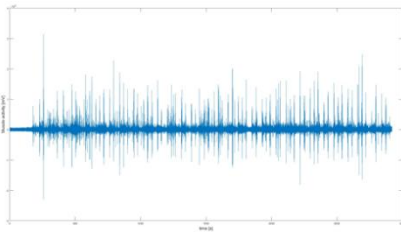
Using innovative EMG technologies, muscle activity was measured in real time during both scenarios individually. Before placing the MuscleBAN device, the skin around the subject's upper trapezius muscles was first cleaned and disinfected, and then a gel for isotonic recording electrodes was applied to it. During the experiment GEL101A electrode paste was used, which is specially formulated with 0.5% saline added to a neutral base to create an isotonic, 0.05 molar NaCl, electrode paste. Unlike agar or saline pastes, this paste has a virtually unlimited shelf life, making it suitable and efficient to use in long-running experiments (ELECTRODE GEL, ISOTONIC, n.d.). After the gel has been applied and any excesses of it removed, the MuscleBAN BE EMG device was placed and secured via strong tape to both sides of the trapezial muscles.

### 3. Results and discussion

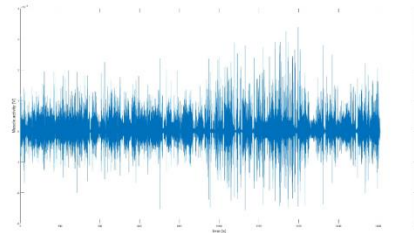
Figures 5. and 6. show the raw signals of monitoring muscle activity on the left and right hand of one subject using the MuscleBAN BE device and Trigno Research+ equipment



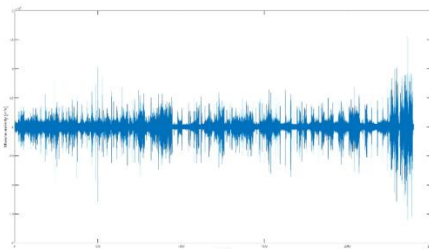
**Figure 5.** Raw sEMG signal using the MuscleBAN BE device in non-ergonomic scenario (left hand)



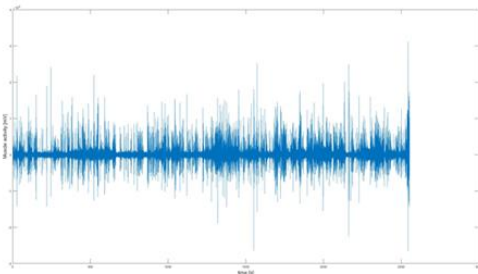
**Figure 6.** Raw sEMG signal using the MuscleBAN BE device in non-ergonomic scenario (right hand)



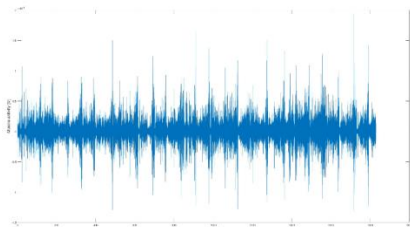
**Figure 10.** Raw sEMG signal using the Trigno Research+ equipment in non-ergonomic scenario (right hand)



**Figure 7.** Raw sEMG signal using the MuscleBAN BE device in ergonomic scenario (left hand)



**Figure 8.** sRaw EMG signal using the MuscleBAN BE device in ergonomic scenario (right hand)



**Figure 9.** Raw sEMG signal using the Trigno Research+ equipment in non-ergonomic scenario (left hand)

Raw s EMG signals are the basis for conducting time analysis, frequency analysis and feature analysis in the following period.

## 4. Conclusion

In the context of Industry 4.0, a human-centered workplace is one that incorporates advanced technologies and digital systems in a way that supports workers and enhances their capabilities, rather than replacing them or making their jobs more difficult. By leveraging the power of new technologies, organizations can improve their occupational safety and health practices and create safer and more pleasant workplaces.

Workers who perform repetitive and tedious activities at a traditional assembly workstation for long periods of time are at risk of developing musculoskeletal disorders, such as carpal tunnel syndrome, tendinitis, and back pain. These conditions can cause physical discomfort and pain for workers, and can lead to reduced productivity, absenteeism, and even long-term disability.

Monitoring muscle activity and implementing preventive activities in order to reduce the occurrence of musculoskeletal disorders and other occupational diseases to which workers who perform assembly activities are exposed is very important. Using EMG equipment, the electrical activity of muscles during contraction and relaxation was measured for assessing the load and strain on the muscles. By analyzing

the EMG signals, it can be determined whether the muscles are being overloaded or strained.

The directions of future research are related to the detailed analysis of data obtained by monitoring muscle activity in real time in order to and observation assembly activities by video-camera in order to optimize the worker's body posture and avoid uncomfortable or unsafe postures and to

improve health and safety of workers who perform repetitive, tiring and monotonous assembly activities for a long period of time in an unergonomic position. In this way, the risk of musculoskeletal disorders will be reduced and the overall performance of the system will be improved. The results will be compared with the results obtained using the ergonomic methods RULA and REBA.

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## INDUSTRY 4.0 AND INDUSTRY 5.0 – OPPORTUNITIES AND THREATS

**Abstract:** *Industry 4.0, also known as the fourth industrial revolution, is a concept that refers to the application of high technologies, such as the Internet of things (IoT), cybernetics, machine learning, and automation, in production and business processes. One of the main goals of Industry 4.0 is to create "smart factories" that can adapt to changing market conditions and customer needs and increase efficiency and productivity through advanced technologies. This is achieved by connecting machines, devices, and systems to the internet, allowing them to communicate and share data in real-time. This enables the factory to be more responsive to demand changes and optimize production processes. Industry 4.0 also has the potential to change the way we work and interact with machines, through the use of advanced technologies such as augmented reality and human-machine interfaces. This can lead to more flexible and efficient work processes and create new opportunities for workers to develop new skills.*

**Keywords:** *Industry 4.0; Industry 5.0; Challenges; Smart factory; Human-centric*

### 1. Introduction

Staying at the top is becoming increasingly difficult and challenging due to rapidly growing and variable digital technologies and artificial intelligence-based solutions. The world of technology, mass customization, and advanced production is undergoing a rapid transformation. Robots are becoming even more important as they can now be connected to the human mind through brain-machine interfaces and advances in artificial intelligence. Digitalization has created a new paradigm in production, where factories are becoming more modern and sophisticated. Although the manufacturing industry aims to establish nearly fully automated factories in order to achieve savings, it has raised concerns about the elimination of human jobs.

In 2011, the German government created the term Industry 4.0 to describe the increasing trend of automation and data exchange in manufacturing technologies (Lu, 2018). This term is widely used by the European Commission and the EU government to direct policy towards the development of innovation and digitization of European, namely small and medium-sized enterprises (SMEs) (Probst et al., 2018). Implementing Industry 4.0 requires significant transformations throughout the organization (Schneider, 2018; Sony & Naik, 2020). New technologies also require new workforce competencies (Pejic-Bach et al., 2020). Industry 4.0 brings a new concept of business, the so-called "smart factory" concept.

Smart factories operate as smart systems that rely on the ability to exchange information about inventory status, and order changes,

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aiming to achieve decentralized coordination between the processes themselves (Castelo-Branco et al., 2022). These types of factories increase business productivity, therefore, Industry 4.0 has certain limitations - the lack of collaboration between humans and machines.

Industry 5.0 changes the paradigm and provides a solution by reducing the focus on technology and emphasising the potential for progress based on collaboration between humans and machines. In modern business with continuous technological advancements, Industry 5.0 is necessary for gaining competitive advantages and economic growth for organizations. The concept of Industry 5.0 was introduced in 2015 and has the greatest impact on production automation, using artificial intelligence (AI) to improve production process performance. This revolution aims to shape and transform business activities through the use of smart tools (Halim & Javaid, 2019), to put the well-being of people at the centre of production systems and provide the opportunity for sustainable development for all of humanity (Leng et al., 2022).

Overall, current literature and research on Industry 5.0 are relatively scarce, and the industry is still emerging. This paper aims to analyze the potential applications of Industry 4.0 and 5.0 and the concept of human-machine collaboration.

## 2. Literature review

The new industrial revolution called Industry 4.0 encompasses almost all areas of industry and science in the context of automation and reducing the need for human labour (Buntak et al., 2021), which in some business systems, such as logistics, can significantly reduce costs and increase efficiency. However, parallel to the development of technological innovations within Industry 4.0 such as the Internet of Things, Digital

Twins, Big Data, artificial intelligence etc, a challenge arises related to data security (Kovačić et al., 2022) since these technologies function based on sharing data between different machines and devices, and access to such data by third parties can result in the risk of taking control and potential damage. Nonetheless, despite the described risk, according to (Flores et al., 2020), the emergence of new technologies and new risks related to new technologies also leads to the need to change the existing competencies of human resources, which require new knowledge based on managing new technologies, rather than simply executing tasks, which is a result of automation and reduced need for the workforce. Damayanti's research conducted in 2021 supports these conclusions: Speaking specifically about the new competencies required by employees, it is important to emphasize that these competencies are primarily related to increasing IT skills, primarily programming and maintenance of such technologies in the context of replacement and repairs, as emphasized by (Alhloul & Kiss, 2022). However, since the use of automated systems exclusively means the potential risk of reduced need for human labour, there is a significant risk of a lack of social responsibility, primarily towards the social component. Nevertheless, it should be emphasized that, from a system management perspective, the significant use of automated systems can contribute to increasing the organization's competitiveness and the ability to personalize products that customers demand from the organization, as written by (Saniuk et al., 2020).

The challenges described are becoming the basis for a new industrial revolution called Industry 5.0, which is based on collaboration between humans and automated systems (Xu et al., 2021). In other words, the concept of exclusive automation is being abandoned and a shift is being made towards

reintroducing humans as the centre of the process, with automated systems no longer operating independently but serving as an aid to humans, which significantly improves the quality of work performed as described by (Nahavandi, 2019). This reintroduces the creative component into the process, which has been significantly neglected until now since automated systems have not had the ability for creative thinking, as creative thinking is currently exclusively a human characteristic (Leng et al., 2022).

On the other hand, as stated in the research (Basten et al., 2020), increasing the competitiveness of organizations through the implementation of new technologies can lead to a widening gap between employees who possess the necessary knowledge and skills to work in Industry 4.0 and those who do not. Therefore, to reduce this gap, it is necessary to invest in education and workforce development to create qualified experts for Industry 4.0, as emphasized in the research (Ceric & Kascelan, 2020).

In conclusion, Industry 4.0 refers to the trend of automation and data exchange in manufacturing, which has great potential for reducing costs and increasing efficiency but also poses challenges in terms of data security. The application of new technologies also requires the development of new competencies for employees, as well as investment in education and workforce development to reduce the gap in skills and knowledge needed for work in Industry 4.0.

Besides, speaking in general terms, Industry 5.0 represents a continuation of Industry 4.0 and the technologies that were characteristic of Industry 4.0 is still being used, with the difference being that they are now being utilized by humans (Maddikunta et al., 2022). Nevertheless, one of the technologies that stand out, in particular, is artificial intelligence since it enables the analysis and execution of a large number of activities in a very short time with human instructions. This approach significantly impacts the

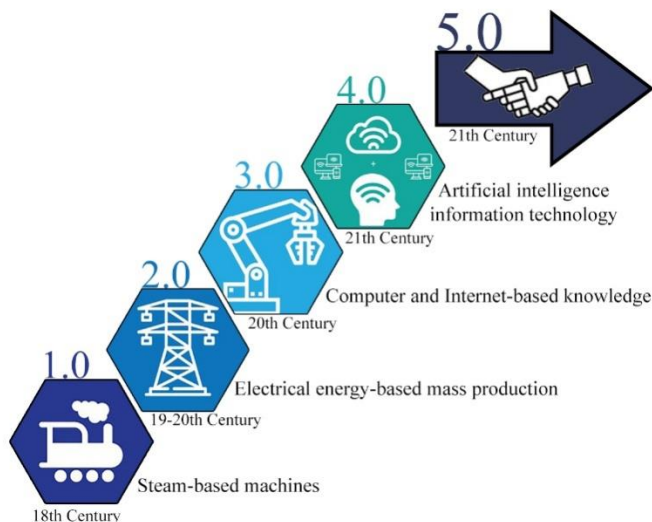
ability to collect and analyze large amounts of data in a short period, which is the basis for making decisions about future actions as discussed by (Stone et al., 2020). However, since Industry 5.0 is still in its early stages and some countries have not fully utilized the potential offered by Industry 4.0, it is expected that the full potential of Industry 5.0 technologies will only be seen in the future, according to (Leng et al., 2022).

### 3. Industrial revolution

Looking back to 1780, the first industrial revolution (Industry 1.0) was born with the generation of mechanical energy from water, steam, and fossil fuels (Nahavandi, 2019). The next shift towards the manufacturing industry between 1871 and 1914 was called Industry 2.0, which enabled a faster transfer of people and innovative ideas. This revolution was a period of economic growth and increased business productivity, which also led to rising unemployment as machines replaced factory workers (Amr, 2022). Almost a century later, in the 1970s, industrialists began to use electronics and computers in manufacturing. The Third industrial revolution (Industry 3.0) utilized microprocessors, information technology, and robots for high-level automation in production. Soon after, there was an increase in globalization and outsourcing of production due to the availability of skilled labour and lower production costs. Industry 4.0 means the integration of intelligent machines and systems and bringing changes to production processes to increase manufacturing efficiency. Industry 4.0 refers to resilient technology, new ways of working, and the role of people in the industry. Industry 4.0 brings about a wide range of innovations in the operations and factories of different industries and services, affecting the functioning of entire societies. At its core, it represents a trend towards automation and data sharing in production

technologies and processes, utilizing cyber-physical systems, the Internet of Things, cloud computing, cognitive computing, and

artificial intelligence (Grabowska et al., 2021).



**Figure 1.** From Industry 1.0 to Industry 5.0 (Autor)

Industry 5.0 is an emerging technology that advances the design of the previous generation, with a focus on efficient and intelligent machines. The concept of Industry 5.0 was deliberated among participants from research and technology organizations at the Directorate "Prosperity" of the European Commission's DG for Research and Innovation from July 2 to July 9, 2020. The EC document presents assumptions about the concept of Industry 5.0, emphasizing the critical directions for change to achieve a more sustainable and human-centred industry (Breque et al., 2021). As a new and enhanced version of Industry 4.0, Industry 5.0 is being promoted as a model that will bring further prosperity and competitiveness to businesses while promoting a human-centric economic model.

#### 4. Distinguishing Industry 4.0 from Industry 5.0

In today's world, people work alongside machines and are connected to smart factories through intelligent devices. The world of technology, mass customization, and advanced manufacturing is going through a rapid transformation. Robots are becoming even more important because they can now be connected to the human mind through brain-machine interfaces and advancements in artificial intelligence. Today, robots are intertwined with the human brain and work as collaborators, not competitors. The Industry 5.0 revolution will likely stimulate more advanced human-machine interfaces using artificial intelligence algorithms (Grabowska et al., 2021). Industry 4.0 and Industry 5.0 refer to the integration of advanced technologies into the manufacturing process, but there are some key differences between them.

Industry 4.0 refers to the current trend of automation and data exchange in manufacturing technologies. It includes developments such as the Internet of Things (IoT), artificial intelligence (AI), and machine learning (ML). The aim of Industry 4.0 is to create "smart factories" that can adapt to changing market conditions and customer needs and increase efficiency and productivity by using advanced technologies.

Industry 5.0 is built on the foundations of Industry 4.0 but takes it to a higher level by integrating even more advanced technologies such as quantum computing, 5G networks, and blockchain. The goal of Industry 5.0 is to create an even more flexible, efficient, and sustainable production process. By bringing human workers back to the factory floor, Industry 5.0 will pair humans and machines to further leverage the human brain and creativity to increase process efficiency by combining workflows with intelligent systems. While Industry 4.0's primary focus is on automation, Industry 5.0 will be characterized by a harmonious integration between humans and autonomous machines. The autonomous workforce will possess the ability to perceive and understand human intentions and desires. Humans and robots will work together as collaborators, without fear, but with a sense of ease, knowing that their robotic counterparts can comprehend and effectively cooperate with them. While Industry 4.0 focuses on automation as its main concern, Industry 5.0 will be a symbiosis between humans and autonomous machines. The autonomous workforce will be perceptive and informed about human intentions and desires. The human race will work together with robots not only without fear but also peacefully, knowing that their robotic collaborators understand them adequately and have the ability to effectively cooperate with them. This will result in an extremely efficient production process with added value, thriving reliable autonomy and reduced waste and associated costs. Industry

5.0 will redefine the word "robot" as not just a programmable machine capable of performing repetitive tasks, but as an ideal human companion for certain scenarios. Cobots, the next generation of robots, will already know or quickly learn what to do and will be aware of human presence, taking into account safety and risk criteria. They can perceive, understand and sense not only the human being but also the goals and expectations of the human operator. Like an apprentice, cobots will watch and learn how an individual performs a task and when they learn, they will perform the desired tasks like their human operators. Therefore, humans experience a different sense of satisfaction while working together with cobots (Nahavadi, 2019).

Contrary to the depiction of the future in science fiction movies, digitization will not render human workers in industrial production obsolete. Instead, it will integrate intelligent automation, devices, and systems in the workplace to enhance collaboration between humans and machines. This will allow highly skilled workers to lead smart machines and robots and work more efficiently alongside cobots.

Industry 5.0 would solve the need for personalization and mass customization of products for customers. This would stimulate and apply human intelligence and thought processes in computers - a process known as cognitive computing. Robots and automation are playing an increasingly important role in modern factories. Smart factory cobots would also be smart enough to understand the needs of the human operator, decide if they need assistance, and assist them accordingly. Cobots (robots designed to work alongside humans) can assist the human factor in factories in various ways, including:

**Improving safety:** Cobots can take on tasks that are dangerous or too strenuous for humans. For example, cobots can lift heavy objects, perform hazardous tasks in

dangerous environments (such as in mines or on oil rigs), or work in conditions with high temperatures or high levels of pollution.

**Improvement of product quality:** Cobots can be programmed to perform tasks with a high degree of precision, reducing the likelihood of errors and increasing product quality.

**Increased flexibility:** Cobots can be quickly reprogrammed to work on different tasks, making the production process more flexible and adaptable.

**Improving employee satisfaction:** Cobots can take over tasks that are uninteresting for humans, allowing them to focus on more creative and challenging tasks. This can lead to increased employee satisfaction and reduced stress.

**Cost reduction:** Although the initial investment in purchasing and implementing robotic equipment is high, the use of robotic technology can lead to long-term cost savings. Cobots can reduce labour costs, reduce material losses, and increase production process efficiency.

To better utilize human creativity and brainpower and improve operational efficiency, I would combine intelligent systems with existing workflows. This would shift the focus in factories away from mass production, automation, and digitization, which were the key elements of Industry 4.0. In summary, cobots can aid the human factor in factories in numerous ways by increasing efficiency, safety, and product quality. This will lead to better integration, allowing for faster and better automation in combination with the power of the human brain. It also means that robots will not take over control of production plants shortly, as previously feared in the era of Industry 4.0.

In conclusion, Industry 5.0 represents a more advanced and holistic approach to production, aiming not only to increase efficiency and productivity but also sustainability and a human-centric approach. This involves combining the best of both

worlds - human and machine - to increase productivity (Grabowska et al, 2021).

#### **4.1. The concept of people and machines**

Industry 4.0 is based on the concept of smart factories. Smart factories are factories equipped with modern technology and systems that enable high automation and optimization of production processes. The following key drivers can be identified:

- **Internet of Things (IoT):** IoT enables the connection of different devices, sensors, and machines into a unified system and the exchange of data between them. This enables a high level of automation as well as real-time monitoring of machine performance and maintenance.
- **Artificial Intelligence (AI):** AI enables machines to learn and improve their performance over time based on the analysis of large amounts of data. AI can be used for optimizing production processes, reducing material losses, monitoring and predicting failures, and other purposes.
- **Robotics:** Robotics is crucial for the automation of production processes. Robots can be used for various tasks, including lifting and moving heavy objects, assembling products, inspecting quality, and other tasks typically performed manually.
- **Cloud technologies:** Cloud technologies enable the storage and processing of large amounts of data remotely. This allows for real-time monitoring of machine performance as well as data analysis to improve efficiency and reduce costs.
- **Advanced sensors:** Advanced sensors enable the measurement of various parameters in real-time, including temperature, humidity, pressure, speed, and other

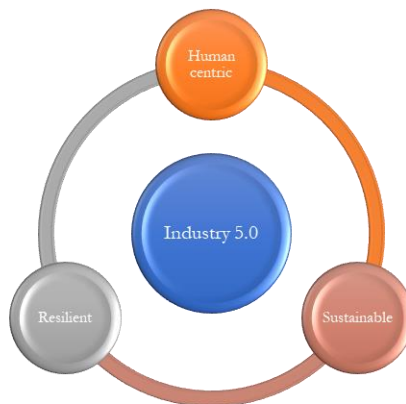
parameters. This enables monitoring of performance and prediction of failures before they occur.

- Digital simulation: Digital simulation allows for testing and optimization of manufacturing processes before they are implemented in practice. This can help reduce costs and increase production efficiency.

Industry 5.0 is characterized by its focus on sustainability, which means it's not only

concerned with increasing efficiency and productivity, but also with reducing the impact of production on the environment, utilizing more renewable energy sources, and promoting a circular economy. These technologies enable high automation and optimization of production processes, resulting in increased efficiency, cost reduction, and improved product quality.

Three fundamental principles of Industry 5.0. (Figure2) are human-centricity, sustainability, and resilience(Gonçalves, 2022):



**Figure 2.** Industry 5.0 with tree key drives (Zizic et al., 2022)

One empty single line should be left before table and after it's title. Table headings should be placed above the table, as shown in this template. The width of all lines in tables including all borders should be 1/2 pt. Text and numbers in tables should be typewritten in Times New Roman, 9 pt.

Figures and tables should not be placed at the end of the current section. It is recommended that footnotes be avoided. Instead, try to integrate the footnote information into the text.

Human centricity is one of the key principles of Industry 5.0, which places people and their needs at the centre of the manufacturing process. This approach recognizes that

technology should serve people and society and emphasizes the importance of adapting technology to meet the needs of workers, rather than forcing workers to adapt to technology. Manufacturers must recognize the potential of technology to enhance the work environment, while also addressing concerns around autonomy and privacy (Amr, 2022).

Sustainability is one of the three fundamental principles of Industry 5.0, which aims to use resources that meet the current needs of the manufacturing industry. The collaboration between humans and machines promotes flexible business models and reducing waste and overproduction is essential. The

promotion of local production can help to make the economy more sustainable. Industry 5.0 fosters the development of sustainable policies, such as minimal waste creation and efficient management, using corporate technologies. It emphasizes creative research and knowledge to drive innovation and evolution.

The principle of resilience is one of the three pillars of Industry 5.0, which emphasizes the need to enhance the robustness of production and supply chains. This makes them more resistant to disruptions and able to secure and support critical infrastructure during crises. This principle complements the sustainability principle. As environmental shocks become more prevalent, companies will need to be flexible enough to handle the unforeseen consequences of unpredictable weather conditions.

#### **4.2. Benefits of implementing Industry 5.0.**

Industry 5.0 represents a new paradigm of industrial production that involves collaboration between humans and machines to create highly customized and personalized products. Although this paradigm is still in its infancy, there are some predictions about its development and use in the future:

- **Increased production flexibility:** Industry 5.0 enables the production of personalized products in smaller batches, which increases the flexibility of the production process. This should lead to a reduction in product storage and transportation costs, as well as a reduction in waste.
- **Increased efficiency:** Integration of digital and physical systems allows for the optimization of production processes and reduces unnecessary energy consumption. This should lead to a reduction in production costs and an increase in efficiency.

- **Increased collaboration between humans and machines:** Industry 5.0 enables real-time collaboration between humans and machines, which should lead to increased productivity and reduced errors.
- **Reduced need for physical labour:** The introduction of automation and robotics in production reduces the need for physical labour. This could lead to increased productivity and reduced costs.
- **Potential for new types of business:** Industry 5.0 enables the creation of new types of businesses, such as personalized products and services, which could lead to economic growth and the creation of new jobs.

Industry 5.0 is expected to introduce a new position in the production process: Chief Robotics Officer (CRO). The CRO will be a specialist in robotics and the interaction between robots and humans. Their role will be to make decisions about adding or removing machines or robots from the factory floor in order to optimize performance and efficiency. The CRO will have expertise in robotics, artificial intelligence, human factors modelling, and human-machine interaction. With access to collaborative robotic technologies and leveraging advancements in computing, the CRO will be well-positioned to positively impact environmental management. This will ultimately lead to increased sustainability by reducing pollution and waste and preserving the planet.

Contrary to the assumption that people will lose their jobs due to artificial intelligence, many studies have shown different results. It is estimated that future technologies will contribute to expanding the global production workforce by up to 4% by 2030, from the current 1.2 billion people (McKinsey Global Institute, 2017). Supply chain management in all industries would



also become more agile and innovative due to increased investment in research and development, intelligent sales and marketing, distribution, and value-based pricing.

However, it should be noted that Industry 5.0 is still evolving and it is difficult to accurately predict its future benefits and challenges

## 5. Conclusion

Based on the analysis presented in this paper, it can be concluded that in Industry 4.0, companies worldwide are automating their production setups and connecting smart devices to enable digital communication between them. This has allowed machines to perform repetitive and laborious tasks. The upcoming Industry 5.0 will focus on bridging the gap between robots and highly skilled human workers to produce and deliver the best individual products, services, and customer experiences. Here, human intervention would be more intellectual than physical.

Industry 5.0 will bring unprecedented challenges in the field of human-machine interaction, as machines will be brought very close to the everyday life of every person. Moreover, it is expected that Industry 5.0 will open up many job opportunities in the field of human-machine interaction and computer analysis of human factors.

Industry 5.0 will revolutionize production systems worldwide by taking away "boring", dirty, and repetitive tasks from the human

workforce wherever possible. Intelligent robots and systems will penetrate supply chains and manufacturing facilities to an unprecedented level. This will be enabled by the introduction of cheaper and highly capable robots made of advanced materials such as carbon fibre and lightweight yet strong materials, supported by highly optimized batteries, reinforced with cyber attacks, with stronger data handling processes (data and artificial intelligence) and networks of intelligent sensors. Industry 5.0 will increase productivity and operational efficiency, be environmentally friendly, reduce workplace injuries, and shorten production cycles. However, contrary to the desire for digitalization and automation of work processes, Industry 5.0 will create surplus jobs. A large number of new jobs will be opened up in the field of intelligent systems, artificial intelligence and robotic programming, maintenance, discovering new types of robots for production, etc. In addition to all the above, tasks that are currently being repeated in certain processes will no longer need to be performed by humans in the future. This will enable creativity to be encouraged in the work process, encouraging everyone to innovatively use different forms of robots in the workplace. However, as a direct impact of Industry 5.0, a large number of start-up companies will build a new ecosystem of providing customized robotic solutions, in terms of hardware and software, worldwide. All of this will further stimulate the global economy and increase the inflow of money worldwide.

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## **ADVANTAGES AND DISADVANTAGES OF TECHNIQUES AND PROCESSES OF 3D PRINTING IN INDUSTRIAL APPLICATION**

***Abstract:** The fourth industrial revolution is underway, which places the greatest emphasis on the digitization of processes in production and services. Technology is developing more and more every day, and so is its influence in production activities and industrial applications. The focus is on innovative technologies, including 3D printing. Industry 4.0 is closely related to sustainable production, as it optimizes energy and resources. Smart factories are being created, which operate in accordance with the postulates of energy efficiency, better competitive advantages in the conditions of global business, in a virtual business environment, where additive manufacturing is included. The aim of this paper is, in summary, to examine the impact that 3D printing has in production, in the context of advantages and disadvantages of techniques and processes in industrial application.*

***Keywords:** 3D printing, Industry 4.0, Sustainable production, Advantages and disadvantages*

### **1. Introduction**

Industry 4.0 is considered a new driver of industrial development and the fourth industrial revolution, an upgrade of the previous three (Iivari et al., 2020). It is seen as an advanced manufacturing model that is represented by intelligent, virtual and digital performance in large industries. The new industrial model itself includes an integrated structure throughout the factory and potential technologies in various areas of industrial activity, and these technologies are in line with the principles of Industry 4.0 design, which are also responsible for ensuring the innovative performance of this new industry. Sustainable industrial production within Industry 4.0 can be seen in the context of creating smart factories and accompanying processes: energy efficiency, waste reduction, employee safety, increased job opportunities, smart production, virtual

processes, extended value network, additive manufacturing, etc. In these conditions, 3D printing or additive manufacturing finds its great application in various industries. Companies around the world are increasingly oriented towards smarter, digital production, and the relevance of industrial 3D printing is primarily reflected in the reduction of operating costs and shorter production time (Hao et al., 2020).

### **2. Industry 4.0**

The history of the industry since its inception has been marked by great changes, the acquisition of great knowledge, events and discoveries that changed the structure of cities, their populations, the types of products they offer and the way they offer them, innovations in the development of production processes and the way employees work, between many other aspects. It can be

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verified as a result of the combination of three fundamental aspects: knowledge, experimentation and entrepreneurial innovation (Ramya et al., 2016). These aspects have effectively contributed to the development of new products and services. Industry has its evolution distributed in different stages of equal importance, from the first to the fourth revolution. Industry 4.0 fully utilizes all the foundations of the previous industrial revolutions, but with higher rates of integration, digitization, virtualization, technologies and fast times, we see that the industry has undergone many changes and improvements in each of its phases, products have evolved, ways have changed distribution, customer requirements, people work, internal and external aspects. Knowledge of Industry 4.0 and all its possibilities in different areas is essential to fully exploit its potential, and also for those who want to realize a form of cooperation in the new industry. It is important that they know all the new possibilities it presents. Some of the technologies of Industry 4.0 that have the greatest impact in the framework of the production planning process and the realization of production activities, according to the aforementioned claims, would be (Hamilton, 2020, Wu, 2016):

- Cloud Computing,
- Big Data,
- Digital Twin,
- 3D printing,
- Artificial intelligence.

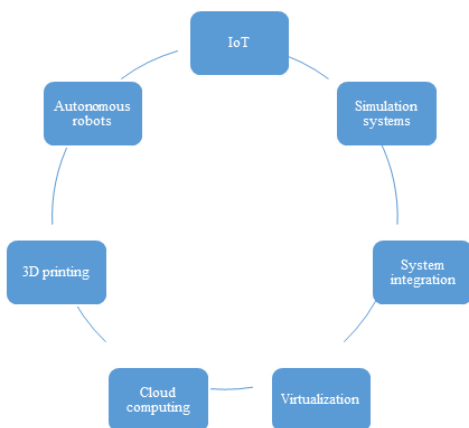
## **2.1. Sustainable manufacturing in industry 4.0**

We are witnessing the accelerated digitization and transformation of business processes in the conditions of globalization. New forms of business are being developed, largely based on and guided by the postulates of preserving the environment, energy and natural resources. Sustainable production becomes imperative. It

encompasses the methodology of green production and also adds other dimensions to it. Sustainable production focuses on the entire life cycle of a product, starting from the manufacturing process to its "end of life", followed by remanufacturing and recycling (Arena et al., 2009, Miśkiewicz et al., 2020).

Sustainable manufacturing is viewed from different dimensions depending on its purpose and application; however, widely accepted dimensions among industry participants are environment, society, economy, technology and performance management. Of the mentioned dimensions, environment, society and economy are considered as the "three pillars" of sustainable development and are often known as the "triple bottom line". The main goal of sustainability could be seen in the context of designing and developing production processes and products, where there is no impact on the environment and 100% product recycling is achieved. On the one hand, technological progress enables the development of processes and products to achieve sustainable development, while digital technologies must be in cohesion with sustainability. Industry experts and researchers use Industry 4.0 technologies to understand all the challenges and details related to sustainable production. It is believed that environmental challenges such as climate change, resource depletion and environmental protection will be solved by Industry 4.0 technologies. This creates a new perspective for Industry 4.0, which has traditionally been about digitizing operations and reaping benefits. However, for this to happen, there should be complete coherence and convergence of Industry 4.0 technologies. Figure 1 shows the important technological drivers of the fourth industrial revolution, which is expected to play a significant role in achieving sustainable manufacturing of the future (Novikova, et al., 2012, Rojko, 2017).

The transformation of a production unit into an intelligent factory requires both horizontal and vertical integration, whereby all production participants are integrated. Seamless integration, provided by Industry 4.0 technologies and information and communication technology platforms, increases the transparency of production processes and supply chain activities, thus helping to optimize all energy and resources. Such connected operations produce vast amounts of data related to every aspect of production. When all such data are transformed into useful information, they will play a key role in the development of strategies from an environmental, social and economic perspective (Miśkiewicz et al., 2020).



**Figure 1.** Industry 4.0 and sustainable manufacturing

Regarding the environmental dimension of sustainable production, Industry 4.0 helps reduce waste generation through its simplified production process and efficient recycling and remanufacturing initiatives. For example, transparency in any production operation or process is significantly increased by incorporating different types of sensors. Such sensors also provide valuable information including behavior, usage, failure models, performance indicators,

emissions, performance under critical conditions, etc., of the product during its life cycle. Such information is used to develop better products and processes using various simulation systems, to mitigate negative impacts on the environment, without impairing its competitiveness. Such integrated systems also help in monitoring and managing the losses incurred in the life cycle of the product, both in the production phase and in use. Therefore, with full transparency, manufacturers can design new products that are more competitive and environmentally friendly, achieving sustainability (Melnik, 2018).

From an economic point of view, Industry 4.0 with the help of the Internet of Things, artificial intelligence, machine learning, machine vision and data analytics, enables the development of equipment at much lower costs through efficient use of energy and resources. Manufacturers are continuously exploring ways to reduce their operating costs involved in manufacturing activities. However, challenges such as waste generation (arising from production and maintenance activities), reduced productivity and increased energy consumption threaten the strategies that manufacturers have developed to reduce costs. With proper implementation of Industry 4.0 technologies, manufacturers will be able to see optimized and non-optimized processes in their value chain. In addition, strategies such as the use of new and cleaner manufacturing technologies and the use of 3D printing will also help manufacturers reduce waste generation (Ngo et al., 2018).

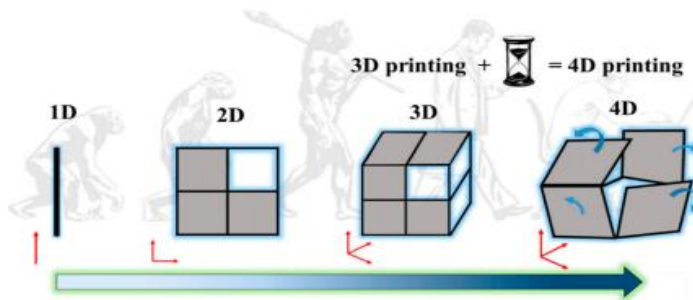
Regarding the social dimension of sustainable production, Industry 4.0 helps develop better products, which in turn benefits society as a whole. In addition, many better jobs will be created. Industry 4.0 technologies are expected to play a significant role in driving sustainability in industrial production. However, it is still too

early to talk about aligning technologies with sustainable development goals. To realize this, manufacturers need to transform their factory into an intelligent factory with full horizontal and vertical integration. Manufacturers want to understand the benefits of Industry 4.0 to transform themselves into a smart factory aligned with sustainable goals (Miśkiewicz et al., 2020).

### 3. 3D printing in manufacturing

3D printing in manufacturing has experienced a major expansion in recent years, which continues to this day. In addition to this name, it is often associated with the term additive manufacturing. For almost 40 years, this technology has been on its development path - from the technology that was originally used for prototyping to today's use in various industries (Gao et al., 2015). We have witnessed the use of this

technology in a large number of companies around the world, on a different or similar scale. Uses can be related to utility tools, visual and functional prototypes, or even end-use parts. Common types of 3D printing technology include SLA (stereolithography) three-dimensional engraving technology; FDM (Fused Deposition Modeling) selective coating of filamentous material; SLS (Selected Laser Sintering) selective sintering of powder materials; production of laminated objects; Selective powder bonding technology for 3D printing etc. (Gibson et al., 2015, González-Henriquez et al., 2022, Hao et al., 2020)). As the potential applications for 3D printing increase, companies are beginning to find ways to create new business models and opportunities with said technology. Thus, 4D printing is already under development (Figure 2) (Mahmood et al., 2022).



**Figure 2.** The evolution of printing to 4D printing that adds a time dimension (Mahmood, 2022)

The basic specification is that the 3D printer moves in three dimensions to form 3D structures. The term 4D printing refers to the addition of a fourth dimension, time, which essentially means that these 3D printed objects transform and change shape over time under the influence of external stimuli such as water, light, heat, pH, electricity, magnetic fields, and so on. The resulting object would be called a 4D printed object that was printed with a 3D printer, but using 4D printing materials. Accordingly, 4D

printing material is essentially a material that can transform or change its shape over time when exposed to external stimuli (Ryan et al., 2021).

One of the first industries to recognize the potential of 3D printing is the aerospace industry, as well as the defense industry. Thus, the importance is reflected in research projects, but also in real applications, such as: functional prototypes, tools, light components. 3D printing in the aerospace industry is not limited to prototypes. Real,



functional parts are also 3D printed and used in airplanes. A few examples of parts that can be produced using 3D printing include air ducts (SLS), wall panels (FDM), and structural metal components. The advantages of 3D printing within these industries are reflected primarily in the satisfaction of low-volume production, where highly complex parts are produced in small quantities. Using technology, complex geometries can be created without investing in expensive equipment and tools. This provides OEMs and suppliers with a cost-effective way to produce small batches of parts in a cost-effective manner. Reducing the weight of an aircraft can significantly reduce its carbon dioxide emissions, fuel consumption and payload (Joshi et al., 2015, Mallakpour et al., 2021).

Because the 3D printing process works by producing parts layer by layer, the material is generally only used where needed. As a result, it produces less waste than traditional methods. The range of materials available for 3D printing is constantly increasing, creating advanced applications in aerospace. One of the key benefits of 3D printing is part consolidation: the ability to integrate multiple parts into a single component. Reducing the number of required parts can significantly simplify the assembly and maintenance process by reducing the time required for assembly. The average lifespan of an aircraft can range between 20 and 30 years, making maintenance, repair and overhaul an important function in the industry. Metal 3D printing technologies such as direct energy deposition are commonly used to repair aerospace and military equipment. Turbine blades and other top equipment can also be renewed and repaired by adding material to the worn surfaces. 3D printing, especially of metals, is increasingly being used in rocket production. The technology allows engineers to innovate the design of rocket parts and produce them in a shorter time frame. The injector head is

one of the basic elements of the power module, which pushes the fuel mixture into the combustion chamber. Traditionally, injector heads are made from dozens or even hundreds of parts, which need to be machined and welded together. 3D printing allows these components to be manufactured as a single piece. 3D printed plastic parts can be useful for aerospace applications, such as aircraft interiors. The interior of a commercial aircraft cabin will need to be updated periodically, a process that may involve replacing components such as wall panels. The need for customization means that parts will usually be produced in small quantities. Fast deadlines are also essential.

When it comes to defense, 3D printing has the potential to change the way end-to-end parts for military equipment are manufactured. Current defense applications range from complex carriers and small surveillance drones, to jet engine components and submarine hulls. Electronic 3D printing is a young but growing area of interest for defense companies. With this technology, engineers are now able to design and manufacture prototypes of complex arrays and antennas themselves. For manufacturers, this means they can speed up the product development process by eliminating the need to outsource high-value projects to third parties. Aerospace companies can also benefit from 3D printing by using the technology to produce custom tooling such as templates and on-demand devices. Relying heavily on spare parts, airlines increasingly require short turnaround times for this application. To meet this demand, aerospace suppliers must find ways to provide manufacturing services faster. Additive manufacturing enables rapid production of spare parts when needed. This, in turn, reduces the need for huge inventories, helping to reduce inventory costs and ensuring that parts are produced locally. The spare parts supplier uses 3D printing to produce custom parts and tooling,

with the technology helping to significantly reduce lead times and simplify complex supply chain logic. With this strategic approach, the company is able to improve its turnaround time by rapidly producing spare parts for maintenance operations.

The aerospace and defense industry makes up a significant portion of the additive manufacturing market. The reasons for this are simple: additive manufacturing offers enormous value, from improving aircraft performance to offering a more agile approach to spare parts production. The move to manufacturing, however, requires additive manufacturing to overcome certain challenges. These include certification of 3D printed parts, better process repeatability and safety. Nevertheless, with significant investments in the development and certification of 3D printing processes and materials, the future of 3D printing for the aerospace and defense industry certainly looks bright (Zhang et al., 2021).

The automotive industry is a growing user of additive manufacturing. In fields such as motorsports and racing, design tools such as generative design and topology optimization are slowly changing traditional approaches to part design (Lee et al., 2017, Li et al., 2018). While prototyping currently remains the main application of 3D printing in the automotive industry, companies are increasingly finding other use cases, such as tooling. In addition, several automotive companies are beginning to find innovative end-use applications for 3D printing. Prototyping has become a key part of the product development process, offering a means to test and validate parts before they are manufactured. 3D printing offers a fast and cost-effective approach to designing and manufacturing parts. By eliminating the need for tooling, product teams can significantly accelerate product development cycles. The ability to build designs quickly gives designers more flexibility when testing multiple design options. 3D printing allows

designers to make quick changes and modifications to designs in a fraction of the time. 3D printing offers car manufacturers a cost-effective and flexible way to produce personalized parts for the interior and exterior of vehicles. Additive manufacturing enables the production of highly complex parts that are still light and durable. Prototyping has been the primary use of 3D printing for automotive applications. With the ability to produce multiple iterations of a design in less time, 3D printing is an efficient tool for product development. The technology has now evolved to the point where it can be used to create functional prototypes using high performance materials (Ligon et al., 2017, Liu et al., 2021, Wohlers, 2018, Zhai et al., 2014). With 3D printing technologies such as FDM and SLS, automotive companies are able to produce accessory tools at minimal cost, significantly increasing factory efficiency. The tools can also be customized for improved functionality at a significantly lower cost than conventional methods.

Within conventional manufacturing, mass production of spare parts is common. However, this often results in long delivery times and high inventory costs. Additive manufacturing has the potential to transform the way spare parts are manufactured and distributed — through on-demand manufacturing. This means that parts are produced locally, at the moment of demand. Coordinating supply and demand in this way could not only drastically reduce inventory costs, but also lead time to the end customer. One of the main obstacles to using additive manufacturing for manufacturing is the large production volume typically required for the automotive industry (over 100,000 parts per year). However, in recent years there have been great improvements in the speed and size of industrial printers, as well as greater availability of materials. As a result, additive manufacturing becomes a viable manufacturing option. 3D printing is

gradually changing the way vehicles are developed today. Whether it's a commercial vehicle, truck or race car, the technology offers automotive engineers and designers the tools to test the limits of design and performance. However, the key drivers behind the increased adoption of 3D printing in the automotive industry are the ability to accelerate time to market and reduce product development costs (Pasricha, 2018).

The medical and dental industry is one of the fastest growing industries adopting additive manufacturing. From medical devices to prosthetics, bioprinting, the applications of additive manufacturing for the medical industry are varied and wide. The geometric freedom afforded by additive manufacturing and the ability to provide more personalized patient care in a cost-effective manner are extremely attractive. Combined with CT scanning, 3D printing can be used to provide patient-specific solutions such as implants and dental appliances. 3D printing is an ideal technology for creating or optimizing designs for medical devices. Thanks to low-cost rapid prototyping, medical device manufacturers have more freedom to design new products, helping to bring new medical devices to market much faster. The medical industry can take advantage of 3D printing capabilities to create patient-specific devices. For example, devices such as prosthetics and implants can be produced faster and more affordably than traditional manufacturing methods. 3D printing can be used to create custom prosthetic and orthopedic devices from a number of certified biocompatible plastic or metal (eg titanium) materials. When it comes to implants, 3D printing is currently being used to make hip and knee replacements, skull reconstruction implants, and spinal implants. While 3D printing cannot yet be used to 3D print body parts, the technology can be used to create artificial living tissues that can mimic the characteristics of natural tissue. Known as bioprinting, this technology is used for

research and testing, with great potential for regenerative medicine. 3D bioprinting is already used to produce relatively simple artificial tissues and structures such as cartilage, skin and bone, as well as blood vessels and heart patches (Tamay et al., 2019, Wang et al., 2021, Yan et al., 2018).

Hospitals are increasingly incorporating 3D printing into their labs to create patient-specific anatomical models. Based on the patient's MRI and CT scans, these models are typically created using full-color 3D printing techniques such as injection molding to ensure they remain highly accurate and realistic. Surgeons can then use these 3D printed organ replicas to plan and practice a surgical operation before performing it. This approach has been proven to speed up procedures, improve surgical precision and minimize invasion. The primary benefit of 3D printing for this sector is its ability to provide more personalized healthcare, in addition to the ability to improve pre-surgical planning and drive device innovation. However, for 3D printing to truly transform the medical and dental market, there are still key challenges that will need to be addressed, most notably the certification of 3D printing processes and devices. Additionally, current trends suggest that the use of 3D printing in medicine and dentistry will continue to advance, paving the way for more advanced applications and new treatment solutions (Yan et al., 2018).

Further, to remain competitive in an ever-changing market environment, retailers and consumer-facing industries must be able to adapt in an agile manner to evolving consumer demands and industry trends. Additive manufacturing meets these needs, providing a cost-effective approach to product development, testing and manufacturing. From consumer electronics to toys and sportswear, key players in the consumer goods industry are increasingly recognizing 3D printing as a valuable addition to existing manufacturing solutions.

Before any new product can be launched, its design must first be validated, tested and approved. This process happens in the product development phase. Prototypes and models are a vital aspect of this process, as they are typically used for market research, testing and validation. 3D printing significantly accelerates this process by enabling rapid production of prototypes and models. Using the technology, product designers and engineers are able to develop and test multiple iterations of repetitive testing in a much shorter time frame. Perhaps the biggest impact of 3D printing for consumer goods lies in the potential to create personalized products, tailored to the needs of consumers. With traditional manufacturing, where products are usually mass-produced, producing customized products in small batches is very inefficient and not cost-effective. These limitations are eliminated by additive manufacturing. Companies are already using opportunities to provide customized service to customers (Tay et al., 2017, Wu et al., 2016).

The industrial goods sector includes the production of machine components, tools and equipment used in the production of other goods. With increasing production costs and the digitization of production, industrial manufacturers must constantly evolve to maintain operational agility and reduce costs. Manufacturers are therefore increasingly turning to 3D printing to remain agile, fast and innovative. As we've seen in other industries, rapid prototyping is a key use case for 3D printing for the industrial goods sector. Design changes that would take months using conventional manufacturing methods can be implemented much faster, often in less than a week, using 3D printing.

Most companies in the industrial goods sector prefer 3D printing the most because of its ability to shorten delivery times. Because 3D printing requires no tools, manufacturers can reduce the time it takes to produce parts,

bypassing the time-consuming and expensive step of tooling. 3D printing is a cost-effective technology for producing parts with complex geometries. Designs that would otherwise be impossible to produce with conventional manufacturing can now be produced using 3D printing. Because 3D printing can produce physical parts from digital files in hours, companies can take advantage of a new model of on-demand part manufacturing. Major industrial goods companies are already exploring additive manufacturing as a means of producing end-to-end parts. The ability to 3D print production aids, such as templates, gauges and accessories, opens up new opportunities for manufacturers of industrial goods. In addition to templates and accessories, 3D printing is revolutionizing the production of hard tools such as molds, which are used in injection and die-casting. Traditionally, CNC-milled molds can undergo multiple design iterations, taking weeks, if not months, before the final design is achieved. This results in a time-consuming and very expensive process with significant material waste. Now, 3D printing technologies can be used instead, allowing tooling companies to not only reduce material waste but also improve mold functionality. This can be achieved by integrating cooling channels of a more complex shape into the design, thereby significantly improving the cooling characteristics of the mold. Thanks to on-demand 3D printing, manufacturers can produce spare parts quickly and economically. This approach is useful, for example, when obsolete equipment requires a replacement that may be out of production or difficult to obtain. 3D printed parts are said to reduce costs and lead times from weeks to hours while bringing greater operational agility. For industrial manufacturers, 3D printing offers new ways to improve production processes, develop new business models and drive innovation (Ngo et al., 2018).

#### 4. Advantages and disadvantages of techniques and processes in the industrial application of 3d printing

The main advantages of 3D printing are indicated to be cost reduction, less waste, time reduction, gaining competitive advantage, error reduction, confidentiality, on-demand production. The advantages of 3D printing make it one of the most promising technologies. Additive manufacturing technology is one of the biggest advantages of 3D printing, it opens up a completely new way of creating products and offers many advantages over traditional manufacturing methods (Gao et al., 2015, Gibson et al., 2015, González-Henríquez et al., 2022)).

Many different types of 3D printing technologies are currently available. Through rapid design, a high level of accuracy and the ability to make decisions based on information, the following advantages of 3D printing make this technology a future perspective for many companies around the world, but also highlight its importance in future production techniques: cost reduction, shorter production time; waste reduction; creation of more pronounced competitiveness and advantages in relation to rivals; the possibility of errors is reduced in the production process; confidentiality of intellectual property because everything remains within the company; production processes on demand. These are the most important and main advantages, and they will be described in more detail below (Hao et al., 2020).

Cost reduction (less machine, material and labor costs). Cost reduction is of great importance for business unrelated to the manufacturing sector. 3D printing can help reduce those costs. Machine operating costs play a very important role in the total costs

of the production process. While the energy required to create parts in an industrial environment can be high, the ability to develop and create complex parts and products in one step creates an increased level of efficiency and saves time. Therefore, the cost of running the machines is offset by the savings made during the production process. One of the good things about 3D printing is the fact that labor costs are low, unlike traditional manufacturing where different people may be required to operate different machines or a production line is needed to put the product together. Each 3D printer will require an operator to start the machine and start the automated process of creating the uploaded design. Therefore, labor costs are significantly lower than traditional production. The range of 3D printer filaments used for 3D printing is growing and this has allowed the price to decrease in recent years.

*Time reducing.* One of the great advantages of 3D printing is that parts and products can be produced much faster than with traditional methods. Complex designs can be created as a CAD model and then transformed into reality in just a few hours.

A more pronounced competitive advantage. By being able to reduce the time of the prototyping phase, companies around the world and from various industries can deliver better, improved products in a shorter period of time. But it also allows products to be developed early, more often prototyped until the product is perfected and ready for production allowing for an efficient product launch. Being able to create life-size prototypes allows designers to think differently about the products they design. One of the benefits of 3D printing is that it allows for the rapid creation of products that people can physically hold, eliminating any confusion or miscommunication. While it may be a prototype and open to change, it at least provides a glimpse of what the product

will look like, offering a truer representation than a description.

*Testing the market with 3D printing.* Understanding whether a product will be successful requires a lot of research, especially when it comes to traditional manufacturing methods. However, creating prototypes through 3D printing will allow companies to get feedback from potential customers and investors in a way that could never be achieved before. The product can be customized and changed up to the last minute, which is something that traditional manufacturing methods do not offer. This means that 3D printing offers a unique and valuable way to identify whether a product has the potential to go to market and be successful at the same time.

*Reduction of potential errors.* When it comes to designing parts and products, designers must consider efficiency. Many parts and products require a large number of steps using traditional manufacturing methods to be produced. Therefore, each step can lead to an error, with the risk of starting over, which can lead to problems with the entire production process. A one-step manufacturing process is more beneficial. There are many industries that have a long and multi-stage production process. One of the advantages of 3D printing is that the product is created in one step, without operator interaction during this process. This removes the dependence on numerous production processes and improves control over the final product. During the traditional manufacturing process, faulty prototypes cost time and money. 3D printing can remove risk because the design can be verified by creating a production-ready prototype before moving on to the final creation. This helps build confidence in the design before investing.

*Intellectual property protection and data confidentiality issues.* Continuous prototyping and manufacturing within the company using 3D printers ensures that the

design never leaves the company premises, protecting intellectual property. Every innovative design is kept within the company, so there is no longer any need to pay attention to confidentiality issues.

*Production processes on demand.* The possibility of complete freedom in design is a great advantage of 3D printing. It also allows designers to customize the design. As 3D printing is perfect for one-off manufacturing and building individual parts in a single process, this means that customization can be exploited. Therefore, many industries, such as medical and dental, have embraced 3D printing and design due to the ability to create custom implants and aids. Traditional methods relied on molds and cutting, making customization a time-consuming process.

But there are also evident disadvantages of 3D printing, which must be taken into account. Some of the shortcomings noted are: the initial costs of purchasing a 3D printer (the return on investment is fast and efficient, but it is still necessary to make an initial investment); 3D printing in manufacturing very often requires post-processing to be of real use; the time factor is also of great importance in the sense that depending on the size and quality of the printer, printing can take from several hours to days, but when the printer makes a mistake when it is almost finished printing, it has to be started from the beginning; utilization by the 3D printing process requires a number of special skills related to 3D modeling; 3D technology can create product designs and prototypes in hours because it uses only one step. It eliminates many stages used in traditional manufacturing. As a result, it does not require much labor cost. As such, the adoption of 3D printing can reduce manufacturing jobs. For countries that rely on large numbers of low-skilled jobs, a decline in manufacturing jobs could

dramatically affect the economy (Mahmood et al., 2022).

## 5. Conclusion

It can be summed up in a barrage of concluding remarks that 3D printing in production goes beyond the limits of rapid prototyping. New opportunities for mass production and fully virtual inventory could soon become a reality. It points to the value of 3D printing for existing production flows. Although there are several drivers of this transition, they can be summarized in two groups. Process innovation refers to the greater flexibility and agility that 3D printing brings to manufacturing and supply chains. It includes digitization and decentralization of production, as well as the ability to create tools and spare parts on demand. Product innovation refers to expanded design capabilities to create innovative new parts and products, including complex lattice structures and other geometries, weight reduction, customization, part count reduction, and multi-material 3D printing (Mallakpour et al., 2021). The potential of

3D printing technology is just beginning to be fully realized.

There is a wide and varied range of benefits of 3D printing. Many different industries are starting to introduce 3D printing into their processes in an attempt to get the maximum benefit from using the technology. The ability to print complex shapes and interlocking parts without the need for any form of assembly is what makes 3D printing so unique. It is possible to create small, complex shapes at very low cost and in a short time. The ability to develop and produce objects of various shapes without the need for special tools offers businesses a greater level of flexibility when it comes to production and helps reduce costs. A significant advantage of 3D printing is that it improves innovation and performance of on-demand production. Despite the fact that 3D printing is a relatively new technology, it has quickly become significant, primarily due to cost reduction. Also, this technology is becoming more accessible to almost everyone. It can be said that 3D printing has revolutionized the industry in an extraordinary way.

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## A CONCEPTUAL REVIEW ON THE NECESSITY OF 3D PRINTING FEATURED CONSTRUCTION IN ERITREA

**Abstract:** Since the end of 2022, Eritrea is seeking for a drastic change in technology and development as the colonization and subsequent wars have lasted for more than a century eventually come to an end. As a developing country, the need for human shelter raising and consequently expecting rapid change in the building construction methods and the relevant real estate deals. Thus, the adaptation of fast building techniques aids to stabilize the housing issues and to mitigate with currently facing tenant problems. This paper investigates the effect of introducing 3D printing technology in construction sector, and to create an awareness amongst the builders and investors about the advantages and disadvantages of 3D printing in terms of many different materials and methods implicated in the construction practices. Further, it clarifies the challenges to be faced besides the benefit of saving potential time coupled with effective cost reduction. So far in Eritrea, conventional building methods are mostly practiced, this work focused on a better validation with the advanced printing technologies. Furthermore, the ultimate objective of this research is to develop a theoretical frame work that open an eye for investors, who can support the initial phase of the printed house as a model and extends for the future developments of housing projects. In addition, it convinces the reader through accepting that the construction facilitated with 3D printing is an improved practice and fastest way to cope up with currently existing housing problems.

**Keywords:** 3D printing in construction, challenges in construction, conventional building methods, Effects of 3D printing, time and cost benefits

### 1. Introduction

Modern building techniques are around for higher output and operations which aim to boost the productivity of construction, efficiency, user satisfaction, environmental performance, better quality, sustainable development and predictability of delivery

time (Bilal A et al 2020). They are capable of maintaining different factors and avoiding steps in construction to overcome the problems that could a raise from the conventional method. Some of the problems are thought by Nils O et al 2021 they have environmental friendly problems like noise and dust along with resource-saving problems such as large template quantity and

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low construction accuracy. Industries have begun to re-establish their production systems with the developing technology (Asena K et al 2022). Currently we are at the era of Industry 4.0, sometimes referred to as the Fourth Industrial Revolution builds upon the established digitalization but includes a synthesis of technologies transforming entire systems of production, management and governance. Currently, emerging technologies include materials science, quantum computing, artificial intelligence (AI), Internet of Things (IOT), autonomous vehicles, robotics and 3D printing (Nils O et. al 2021). Applying the technologies, Industrialization of the building and construction process is aimed in increasing the productivity and efficiency of the building houses.

One of the current trends of modern construction is concrete 3D printing, also known as rapid prototyping technology, which is computer-controlled technology that uses 3D data and makes an object from a three-dimensional model by deposition of materials (Lotfi and Sameh ,2020; Nils and Ali,2019; Amr A et al, 2021). The first 3D printer was invented in 1984, since it was the fastest growing technologies by 2000, has become relatively friendly to use, as it allows to create the design on the computer, and comparatively the production cost was very less as it utilizes plastics and waste materials to form the concrete of 3D houses. And suddenly it became affordable and viable for a wide range of design, models, etc (Abhishek and Aditi, 2021; Izabela H et al, 2016). 3D printing technology is increasing its impact from time to time. Up to now Intentionally or not almost everyone must have enjoyed the great impact of this technology. (Jatin A et al 2021, Andreas and Miranda 2013), listed out some of the major sectors that imply to the future of 3D printing technology like prototype making, bio-organ printing and dental implants, safety, domestic applications, parts

manufacturing for industries, food printing, jewelry designing and housing and construction in which being economic and fast is the primary factor where existence and demand resides on.

Construction projects can have different degrees of making building jobs, As Nils O et al 2021 supports construction industries are generally categorized into as traditional, non-volumetric pre-assembly, with volumetric pre-assembly volumes and modular building. Traditional, “one-of-a-kind” construction utilizes component manufacture and sub-assembly in which raw materials and components are brought to the site where the value-adding actions are carried out. (2) Non-volumetric pre-assembly describes when two-dimensional elements are prefabricated and assembled on-site (walls, floors, etc.). (3) With volumetric pre-assembly volumes of specific parts of the building are produced off-site and assembled onsite within an independent frame. (4) Finally, modular building describes construction where most of the production is carried out off site leaving only assembly and finishing operations to take place on-site.

3D Printing in the construction industry is revolutionary and enormously getting attention from every part of the construction industry of the world. However, a 3D concrete printer costs a lot, ranging in between \$180,000-1 million US dollars (woodgroupmortgage.com), such a huge money usually is possessed by construction industry (Yanhua Z,2022). The construction industry has an annual revenue of nearly 10 trillion USD, which represents around 6% of the global GDP. Indeed, the engineering and construction industry is a cornerstone of the national and international economy. Lowering labor for safety reasons, reducing construction time on site, reducing production costs, and/or increasing architectural freedom provide an additional income to the construction industry (Lotfi

and Sameh 2020). 3D printing is a promising technology for buildings. Compared with traditional buildings, 3D building printing can save 50%-75% of the time value, 50%-80% of the labor cost and 30%-60% of the

material cost. According to experts' estimation, 3D building printing can save 30%-50% of the total cost (Amr A et al, 2021).



**Figure 1 (a-b).** 3D concrete printing in the construction application (source: googleimages)

The currently practiced construction technique in Eritrea is modular building. It is implemented by creating the parts required for the building off-site i.e. governmental workshops and then brought them on-site. This technique applies partially 3D printing approach to build the components to be assembled. Further, it requires a way to drive the parts to construction site by the trucks, which require the consumption of fuels. Finally, it involves some cranes and man power to assemble the parts. Xtreme et al 2021, clearly stated that concrete 3D printing can be preferred over precast, hence it enhances additional benefits in which it doesn't require assembly and can be set up in remote areas where normally trucks cannot drive.

### 1.1. Types and methods

The concrete 3D printing equipment consists of three parts: frame structure, control system, and feeding and extrusion system. The frame structure is responsible for the support and movement of sprinkler head device in space and the control system controls the movement of the printing device and the extrusion of concrete while the feeding and the extrusion system mainly to solve the problem of uneven feeding caused by concrete pumping and improve the extrusion accuracy to achieve precise printing as shape and diameter of the extrusion nozzle are of great importance (Yanhua Z et al 2021). Till now there exist two types of systems majorly: gantry system and robot system (Lotfi and Sameh 2020, Jian Y et al 2022).

Robot system consists of a cylindrical like 6-axis robotic arm which has several joints enabling it to telescope and rotate with

multiple degrees of freedom, and a rotating printer nozzle attached at the end (Xtreme et al 2021). However, it is unsuitable for large buildings as it suffers from limited work space (Lotfi and Sameh 2020). The gantry system is a common system which allows Cartesian motions of the nozzle in the 3 axes (x, y, z). This comes in rail and fixed frame work version. The challenges with this

technology include transportation, installation and size. Gantry printer are usually used because they are easily scalable in size and they are superior to robotic printers if the design of the printer target is not complex. This is because the robot costs more and the load on the robot arm is usually lower than gantry printer (Jian Y et al 2022).



**Figure 2.** Gantry system (a) and Robot system (b) (source: www.Google.com)

Robot system consists of a cylindrical like 6-axis robotic arm which has several joints enabling it to telescope and rotate with multiple degrees of freedom, and a rotating printer nozzle attached at the end (Xtreme et al 2021). However, it is unsuitable for large buildings as it suffers from limited work space (Lotfi and Sameh 2020). The gantry system is a common system which allows Cartesian motions of the nozzle in the 3 axes (x, y, z). This comes in rail and fixed frame work version. The challenges with this

## 2. Implementation of 3D Printing Technology

### 2.1. Methods concrete of 3D printing and its Pros and Cons

The methods of implementing a 3D concrete printing are generally categorized into five classes based on the working principle and raw materials required for printing. Thus they arise to different resolutions and strength. These methods are FDM (Fused Deposition Modelling), SLA (Stereolithography), SLS (Selective Laser Sintering), EBM (Electron Beam Melting), LOM (Laminated Object Manufacturing). The table 1 summarizes the working principle, raw materials to be used, the strength and resolution of the printed concrete according Asena k et al 2022. Moreover, the roughness of the printed concrete is provided so as the attractiveness of the printed concrete can be imagined.

**Table 1.** Different methods of 3D concrete printing

Method	FDM	SLA	SLS	EBM	LOM
Working Principle	Extrusion Stacking Technique	Solidification of photopolymer material with UV light	Sintering of powder with CO <sub>2</sub> laser	Electron Beam Melting	Laser Cutting and Gluing of Sheets
Material Used	ABS, polyamide, polycarbonate, polyethylene, polypropylene and investment casting wax.	Resin-based materials, acrylic, epoxy, Polypropylene.	Polyamide, polystyrene, carbon fiber and aluminum added polyamide, polycarbonate, stainless steel, cobalt chrome, nickel chrome, titanium, ceramics.	Cobalt chrome and titanium alloys, ceramics.	Paper, plastic foam, metal and ceramic powder impregnated materials.
Resolution	Medium	Good	Weak	Weak	Medium
Strength	Good	Medium	Good	Good	Medium
Roughness	Medium	Good	Weak	Good	Medium



**Figure 3.** Geometric freedom of complex structures using 3D concrete printer (a, source:www.sculpteo.com), (b, source:www.googleimages.com), (c, source: www.sculpteo.com) and (d, source:googleimages.com).

**Table 2.** Advantages and disadvantages of concrete 3D printing technology.

S.No	Advantages	Disadvantages
1	Eco-friendly: Designing zero waste projects, reducing carbon emissions, and using innovative and recycled materials with new technology to enhance sustainability can achieve a type of future housing consistent with trends towards sustainability within the forces of demand (Mahdi R M 2021).	Unemployment: In Eritrea Majority of the local people who are skilled in conventional method of building which has no alternative skill. But Using 3_D printing unemployment would arise.
2	Accuracy: According to the preset computer program, layer by layer construction, to a large extent to avoid human error, to ensure the quality of the finished product (Jian Y et al 2022).	Power: 3D printers consume way more energy than what we can think of as according to a research it consumes 100 times more electrical energy compared to conventional methods (Abhishek and Aditi 2021).
3	Over All Cost: Compared with traditional buildings, 3D building printing can save 50%-75% of the time cost, 50%-80% of the labor cost and 30%-60% of the material cost. According to experts' estimation, 3D building printing can save 30%-50% of the total cost (Jian Y et al 2022).	Maintenance Cost: High initial costs for equipment and ongoing maintenance costs (Amr A et al 2021).
4	Unusual shapes (complex geometries): 3D printing can produce shapes that are impracticable or too costly to manufacture by increasing degree of freedom (Abhishek and Aditi 2021).	Knowledge: Skilled labours are required as the knowledge of CAD and 3D Printing software are required (Abhishek and Aditi 2021).
5	Immediacy: 3D printing can be done according to different requirements, thus reducing inventory, and can also be formed once, without assembly, realizing immediacy from printing to delivery (Jian Y et al 2022).	Reliability: Limitation in material flexibility means that only specific material can move through a machine and can still be used in the desired manner without damaging or deforming the specific machine (Amr A et al 2021).

**2.2. Challenges in 3D printing technology adaptation**

Despite of the difficult situations occurrence Prototypes and projects built over the past few years have demonstrated both the viability and potential of 3DCP technologies

to be as a solution for any construction company (Nadja et al 2020). Any construction sector has to face the challenge that is arising and so for the 3\_D printing construction sector. As LotfiRomodhan et al 2020, challenges are categorized in to four classes: material, printer, design and



construction, and regulations. The material challenge includes printability, build ability and open time.

Printability and build ability refer to the ability of the extrusion nozzle to allow the thick paste to pass through and result the material to mold or maintain shape. At the end the period required for printability and build ability will be known as open time, which will decide the acceptable tolerances as delays may cause concrete hardening. The printability refers to the ability of the extrusion nozzle to allow the thick paste to pass through while the build ability is the ability of the material to mold or maintain shape and, open time is the period when the printability and build ability are consistent with in acceptable tolerances as delays may cause concrete harden. The second challenge is the cyber security, where it needs a special concern as the 3D model is automated and all information is available, size of the construction project in relation to the size of the printer is also another challenge. Design and construction is the third challenge. This includes exclusion of building services, structural integrity and suitability of the construction site. Exclusion of building services, such as electrical and mechanical, is a challenge. Constructions are held in an open environment where environmental temperature is a main factor to be considered during operation. Areas such as the Danakil Depression in Eritrea will require a special care during 3D printing. Additionally, the site conditions may be irregular that hinder the movement and installation of the 3D printer. The fourth challenge is the Lack of codes and regulations pose additional challenges to 3D printing in construction as it is any newly developing technological inventions serious design of codes and regulations requires a special attention. Moreover, Guangchao et al 2019 describes there is also an additional challenge to be faced using real time detection and adjustment function of 3D printing system, the printing speed, the

motor state and the system temperature are detected and adjusted that becomes another challenge to face.

### **3. Economical and Other Conservative Benefits**

#### **3.1. Economical Benefits**

Since every 3D printing technology makes use of different raw materials (polymers, sand, clay, concrete, concrete and gypsum mixture, cement mixtures, destroyed construction wastes), where some are to be collected in open environment and some are available at lower costs. Thus it lowers the expense of the printed house (Amr A et al 2021) but it makes it difficult to estimate the overall cost unless there are specific category and price ranges (Ahmed S et al 2019). Moreover, different method (FDM, SLA, SLS, LOM and EBM) is also another factor to be considered as differ in their working principle and raw material demand. The destruction and restoration of buildings follow a large amount of waste where they are disposed usually. 3DCP can make it get recycled and to be used as a raw material in 3D concrete printing decreasing in building expense (Abhisheke P et al 2021). The reduction in construction time is translated into lower costs as labor rates does not require that much time (Xtreme et al 2021). This is because it controls the main factors that affect the cost of the construction, such as : less formwork, less labor (it only takes two to four people to set up and operate the 3D concrete printer), shorter supply chain, lower logistics costs (3DCP equipment can be easily transported from one site to the next), design flexibility (geometric freedom; e.g., the ability to print houses with walls that are curved or straight), faster construction time, and greater efficiency (minimal waste of materials) (R M Mahdi 2021). The presence of Eritrean cement factory i.e. GEDEM cement factory will

make the construction expenses get lowered. While the people income is limited as a result of the neither peace nor war situations but with this Eritrean new development and technology phase, the income of the people is expected to increase and thus citizens and nationals would afford the house in an easy manner increasing the demand of concrete printing.

### **3.2. Time Benefit**

3DCPs are well known with the potential to dramatically lower the cost of construction, with respect to the foundation, walls and roof of the house. The time required to print the outer shell of a small-sized house (e.g., 1,200 square feet) – foundation, walls and roof - can be as little as 24 hours (possibly spread across several days depending on local weather and other conditions) (R M Mahdi 2021). In a similar manner to achieve with conventional construction methods it takes four to six months. It's a time saving due to printer's ability to operate 24 hours per day for the whole week. Thus contract delays related to deliveries and coordination are accomplished on time (Amr et al 2021). All in all, the reduced time results from not having to use concrete form molds, eliminating the time required to frame a house, the speed of 3DCP and reduced labor per house (xtreme et al 2021). Moreover, 3DCP is driven by computer aided Design (CAD) building information Modeling (BIM) software that also speeds up construction instead of printing out hard copies of architectural plans for various trade workers to use to construct a building (Xtreme et al 2021). This may lead to the easy and fast development of new Asmara city as the old town is collapsing which is considered as a monumental to the state.

### **3.3. Case studies of 3D Printing in Construction**

According to Mahdi RM 2021, “Tabasco”, Mexico construction aiming to build 50 homes to support poor communities in the country where each house total area of 120 m<sup>2</sup> consisted of 55m<sup>2</sup> internally designed of a living room, kitchen, bathroom, and two bedrooms where they were provided at a cost of \$6,000 per residence. Which can be concluded that the cost is affordable for the citizens. The residences were characterized by large curved rooves that extended at the front and back to act as a buffer against heavy rain, and the bases of structures and walls were strengthened against seismic activity to increase durability. Perforated concrete blocks along the top of the walls are used for natural ventilation, while the interior space is open plan, for increased airflow, with interior walls curved for easy cleaning.

In 2014, the Chinese WinSun Decoration Design Engineering Company has printed ten houses and each is approximately 100 m<sup>2</sup> in only 24 hours. These houses are constructed from waste material made of recycled rubble, fiberglass, steel, cement, concrete, and binder and the cost of each small dwelling is less than \$5,000 because of the fast process and the low labor costs. In 2015, the WinSun printed an apartment building of six stories (1,100 m<sup>2</sup>) fabricated using construction waste of concrete, fiberglass, sand, and a special hardening agent. (is is considered valuable in terms of recycling materials. Accordingly, 60% of the materials are needed to construct a home with 70% of the time saving compared to conventional construction [Rawan A et al 2020].

Dubai's Office of the Future was printed using WinSun's tilt-up technology where the floor, walls, and ceiling are all printed on their side layer by layer and then tilted vertically. The 250 m<sup>2</sup> office is constructed

and completed within 17 days at a cost of \$140000 using a special cement after being tested in china and United Kingdom. The cost was cut by more than 50% compared to conventional buildings of similar size [Rawan A et al 2020].

According to Alshugairi (ARAM TV, 2019), the kingdom of Saudi Arabia, the ministry of settlement, it took to about 26 hours to build a house using a 3D concrete printer as it was assembled on conventional foundation which took additional 12hours. Further he specified the technique applied and the duration of the process in relation to the ability of 3D printer.

India is one of the world's largest nominal GDP and third largest by purchasing power parity by 2017. It is one of the fastest growing major economics and is considered a newly industrialized company (16) Thus building expense and material cost is expected to be lower than that of the Eritrean expense. Abhishekhe P et al 2021 evaluated time and cost effectiveness of a 600 square feet in comparison to both building methods i.e. conventionally built and 3D build of the same design living room. Using a conventional method, the requirement of additional expenses makes the price raise to reach to about 811,330 Rupees while 550,000 Rupees was the estimated cost using 3D printing. So there is a cost difference to about 261,330 Rupees. Considering the governmental currency rate of 69.5135 Indian Rupees per unit dollar, there is a difference of \$ 3,760. Comparing to "Tabasco", Mexico construction (Mahdi RM 2021), its more than half the selling price is saved.

Chinese construction company HuaShangTengda constructed a 400 square meter mansion using 3D printing Tongzhou region near Beijing, China with in just 45 days. The mansion was an earth quake proof which can with stand up to 8 Richter scale. The walls are of 250mm thick and were printed using approximately 20 tons of C30-

grade concrete. This grade of concrete is usually used in paving roads and providing it with seismic resistance (William J)

### 3.4. Comparison Between Conventional and 3D Printing featured Constructions

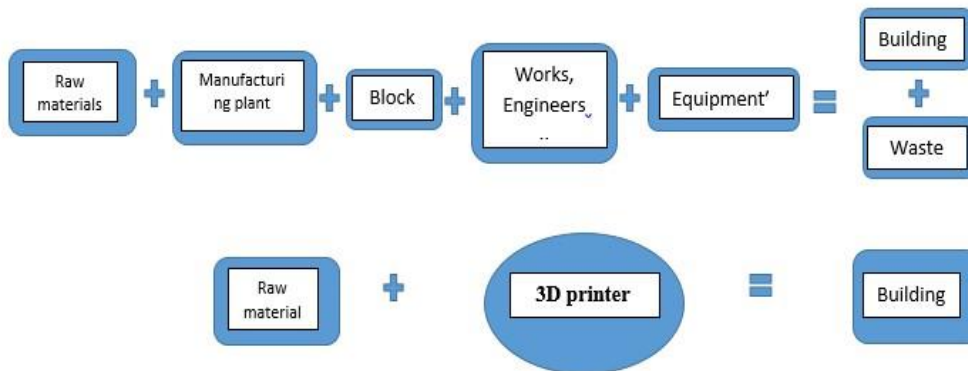
The use of 3DCP is believed to offer solutions to the construction of more affordable housing in the world, particularly for remote, isolated communities having limited construction infrastructure reduced construction time, labor savings, lower materials costs, possible use of local materials for construction, improved labor safety, increased design opportunities, less waste, scalability and reduced environmental impact (Xtreme et al 2021). In conventional method raw material require different packaging, storage space, transportation, and operating condition (Qaisar M et al 2021). Upon construction the need for foundation and hardening it laps for several days. Building of bricks and wall formation along with hardening it takes a long time. Even architectural models are not easily constructed since it takes time (Mahdi R M 2021). Additionally, some studies indicate that 3DCP wall patterns may afford similar benefits as conventional construction related to thermal insulation (Xtreme et al 2021). The conventional method involves human resources in different locations of the structure. Thus, they are time-consuming and expensive. The 3D printer on the other hand shows how the printer is both a tool and a manufacturer. The less involvement of the user in the printing process, the smoother the process is automated (Ahmed S 2019). Building waste many a time circumscribed concrete, bricks, metals, glass, plastics, wood, asphalt, and more. This waste is frequently disposed in landfills. It does not only pollute the land and air, but also the transportation required to remove such waste has a significant impact on the environment

as well upon building in destroyed sectors. As per the Environmental Protection Agency, there were as huge as over 170 million tons of debris generated in the construction and destruction of buildings alone in the U.S in the year 2003, of which

61 per cent were solely from the residential building (Abhisheke et al 2021). 3D printing can also be used to print home decors, furnishing products and other structures for architectural detailing [MajuR et al 2019].



**Figure 4.** Hua Shang Tengda mansion construction in Beijing (Source: William J)



**Figure 5.**Traditional method (above) Vs 3D concrete printing (below) method

#### 4. Conclusion

To sum up all the above, concrete 3D printing is increasing its demand in developing countries specially Africa. The 3D concrete printing technology is more advantageous compared to conventional

method of building. It is faster and more accurate in addition to complex geometric freedom. It is also economical and time saving building method. Concerning about cost the 3D printed house is mostly 30-50 % less of the same designed house built using conventional method. The cost reduction is

because it increases in labors demand. When it comes to waste materials, this technology creates only one third of the waste generated using conventional building methods. This would lead to a permanent housing solution in Eritrea and developing countries. From Economical point of view, Affordable house is the main problem in African countries as the population income is limited, but the rise of 3D concrete printing would minimize housing problems and create affordable houses easily. This will be an investment opportunity for investors in very part of the world. The country is still full of natural resources and a new method of printing could be discovered if a detailed research is conducted on the resources available so that

it can enhance additional cost reduction and increase in the investors revenue. All in all, this construction technology would create a stable nation and increase in citizen's advancement, while the nation increases in infrastructure level. At the end, from the authors point of view it is expected that construction companies should go for 3D printing procedure to construct their future structures and increase in their capital.

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## ROUTING FLEXIBILITY ANALYSIS OF DIDACTIC FLEXIBLE MANUFACTURING CELLS USING EVIDENCE NETWORKS

**Abstract:** Flexible manufacturing systems are becoming increasingly popular in modern industry, providing flexibility in producing different products and quick adaptability to changes in the production program. Didactic FMC (DFMC) are small manufacturing systems used for educational purposes, providing students with practical experience in production. DFMC systems are the basic element in learning new concepts of Industry 4.0. This paper explores the flexibility of routing components in DFMC systems using the Dempster-Shafer theory of belief functions and evidence networks developed based on this theory.

By using the Dempster-Shafer theory, we evaluate the flexibility of routing in the system for producing different products, i.e., the system's ability to adapt to changes in the production program according to the concepts of Industry 4.0. The analysis of routing flexibility allows for identifying critical points of the system and suggestions for improving system efficiency.

The results show that routing flexibility is a key factor for the efficiency of the DFMC system. The Dempster-Shafer theory provides a precise analysis of beliefs based on various input parameters, which contributes to the precision and reliability of the analysis of routing flexibility of DFMC system components. This paper contributes to the understanding of routing flexibility and provides guidelines for further research in this area.

**Keywords:** Flexible Manufacturing Systems (FMS), Flexible Manufacturing Cell (FMC), Didactic FMC - DFMC, Routing Flexibility, Dempster-Shafer Theory

### 1. Introduction

Flexibility is one of the key goals of every manufacturing system and as such represents a critical measure of its overall performance (Buzacott, J. A., & Mandelbaum, M., 1985). It is defined as: "Flexibility is defined as the ability of a manufacturing system to cope with changing circumstances or instability caused by the environment" (Gupta, Y., Goyal, S., 1989). Changes that lead to the need for flexibility of technological systems

can be internal (machine or material handling system breakdowns or some operational variability) or external (changes in the requirements of external customers, changes in the material of the parts being produced, etc.) (Buzacott, J. A., & Mandelbaum, M., 1985). According to the classification given in (Browne, J., Dubois, D. et al., 1984), FMS flexibility can be: Machine, Process, Product, Routing, Volume, Expansion, Operation, and Production flexibility.

The purpose of this paper is to introduce students to the flexibility of routing through an example of a didactic flexible manufacturing cell (DFMC) (Mirkov, G., 2022) by applying Artificial Intelligence (OpenAI, 2021) and modern mathematical tools such as Dempster-Shafer theory of belief functions (Shafer, G., 1976; Djapic, M., 2005) and Evidence Networks (Shenoy, P.P., 1992; Djapic, M., Lukic, Lj. etc., 2019) which are developed based on this theory.

In the educational process, the aim of routing in DFMC can be to increase the practical application of theoretical knowledge and skills that students acquire through lectures and exercises. Therefore, the selection of an appropriate group of parts for routing in FMC can be a crucial factor for the success of this goal. The application of Dempster-Shafer theory for analyzing the flexibility of routing in DFMCs can help optimize the process of selecting a group of parts for routing in FMC, considering the uncertainties and ambiguities that often arise in this process. Dempster-Shafer theory is based on the theory of belief, but unlike classical probability theory, Dempster-Shafer theory can take into account incomplete and contradictory knowledge.

Therefore, this paper will discuss the application of Dempster-Shafer theory in analyzing the flexibility of routing in DFMC, with a focus on selecting the best group of parts for routing in FMC in the educational process. Through this analysis, researchers will have the opportunity to assess the effectiveness of different routing strategies, and thus choose the best strategy to achieve the goal of routing in the educational process.

## **2. Dempster-Shafer Theory of Belief Functions**

Making conclusions (reasoning) about certain situation from the real world is often in difficult circumstances with insufficient

knowledge, no clearly defined criteria and mutual antagonism. Information about evidence can come from different resources: based on a person's experience, from signals recorded by appropriate sensors, from the contents (the context) of published papers and so on. Such evidence is rarely clearly delimited; it's often incomplete, ambiguous in its meaning and full of flaws.

Dempster-Shafer belief function theory provides powerful tools for mathematical presentation of the subjective (opposite of what probability theory is based on) uncertainty while it relies mainly on possibility of explicit definition of ignorance (Shafer, 1976). This theory is intuitively adapted formalism for reasoning below uncertainty limit. It, actually, represents the generalization of Bayesian theory of conditional probability. As such, it provides formally consistent method for interpretation and connection of evidence, which inside itself carries some degree of uncertainty, and in addition, provides getting meaningful answers to posed questions using only partial evidence. Complete records can be used only in necessary cases.

### **2.1. The Basic Concepts of Belief Functions**

Model of the belief function consists of variables, their values and the evidence, which supports the value of variables. Variables represent specific questions regarding the aspect of the problem under consideration. Given questions are answered using data originating from various sources, i.e., from context of published papers, from measurement data, from expert opinions, etc. Fully integrated support to the sought answer is called evidence.

Evidence can be represented by belief functions, which are defined as follows:

Definition.1. (Shafer, G., 1976) Let  $\Theta$  be a finite nonempty set called the frame of discernment, or simply the frame. Mapping

Bel:  $2\Theta \rightarrow [0,1]$  is called the (unnormalized) belief function if and only if a basic belief assignment (bba)  $m: 2\Theta \rightarrow [0,1]$  exists, such that:

$$\sum_{A \subset \Theta} m(A) = 1$$

$$Bel(A) = \sum_{B \subset A, B \neq \emptyset} m(B)$$

$$Bel(\emptyset) = 0$$

Expression  $m(A)$  can be viewed as the measure of belief which corresponds to subset  $A$  and takes values from this set.

Condition (1) means that one's entire belief, supported by evidence, can take the maximum value 1, and condition (3) refers to the fact that one's belief, corresponding to an empty set, must be equal to 0.

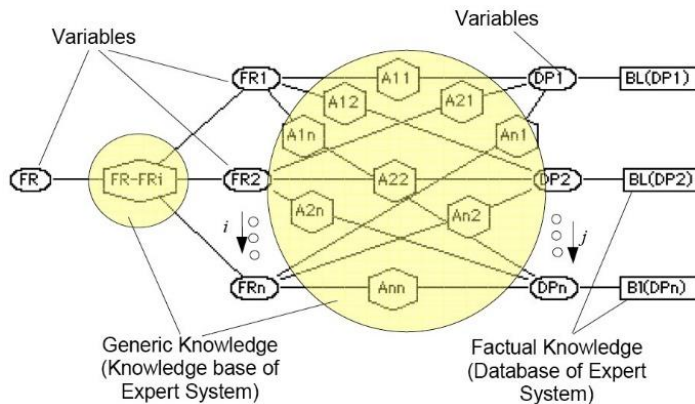
Value  $Bel(A)$  represents the overall belief corresponding to the set  $A$  and all of its subsets.

Each subset  $A$  such that  $m(A) > 0$  is called a focal element.

The empty belief function is the function which satisfies  $m(\Theta) = 1$ , and  $m(A) = 0$  for all subsets of  $A \neq \Theta$ . This function represents total ignorance about the problem under consideration.

### 2.2. What are the Evidential Systems? (3)

Valuation Based Systems - VBS is an abstract framework proposed by Shenoy (Shenoy, P.P., 1992; Djapic, M., Lukic, Lj. Etc. 2019) for representing and reasoning on the basis of uncertainty. It allows representation of uncertain knowledge in various domains, including Bayes' probability theory, Dempster-Shafer's theory of evidence which is based on belief functions and Zadeh-Dubais-Prad theory of possibility. Graphically presented VBS is called valuation network.



**Figure 1.** The concept of evidential networks (Đapčić, M., Lukuić, Lj. & Pavlović, M., 2019)

VBS consists of set of variables and set of valuations that are defined on the subsets of these variables. Set of all variables is denoted by  $U$  and represents a space covered with problem which is under consideration. Each variable represents a relevant aspect of a problem. For each variable  $X_i$  will be used  $\Theta X_i$  to denote the set of possible values of

variables called the frame of  $X_i$ . For a subset  $A$  ( $|A| > 1$ ) of  $U$ , set of valuations that are defined over  $\Theta A$  represents the relationship between variables in  $A$ . Frame  $\Theta A$  is a direct (Cartesian) product of all  $\Theta X_i$  for  $X_i$  in  $A$ . The elements  $\Theta A$  are called configurations of  $A$ .

Knowledge presented in this type of valuations is called generic or general knowledge (Fig. 1), which can be represented as a knowledge base in expert systems.

The VBS also defines valuations on individual variables, which represents so-called factual knowledge, and it constitutes database in expert systems (Figure 1). For a problem, general-generic knowledge defines an expert. During reasoning process that knowledge won't be modified. Factual knowledge will vary in accordance with condition of a problem currently being under consideration. The VBS treats on the same way these two kinds of knowledge.

The VBS systems suited for processing uncertain knowledge described by functions of belief function theory are called Evidential Reasoning Systems or Evidential Systems, and valuation networks are now called evidential networks (EN) (Figure 1).

The objective of reasoning based on the evidence is an assessment of a hypothesis, in case when the actual evidence is given (the facts). This can be accomplished by evaluating valuation networks in two steps (Đapić, M., Lukuić, Lj. & Pavlović, M., 2019): Combining all belief functions in evidential network, resulting in a so-called global belief function; Marginalization of global belief functions in the framework of each individual variable or subsets of variables produces marginalized values for each variable or subset of variables.

Easily way of understanding the reasoning process and its graphical interpretation is the condition on which depends whether and how fast these systems will be applied in solving everyday problems. As a software support to the VBS systems application, several software tools have been developed. For evidential systems the very known are: McEvidance, Pulcinella and DELIEF. McEvidance is an application that was developed for reasoning under conditions of

uncertainty (Figure 3). Using this system the user can create a graphical network of variables, their relationship and to bring in any records related to the variables. When all available input records that reflect current system status or process under analysis are being entered, evaluation of network can start.

During evaluation process first the global belief function is being generated by applying combining operation and then afterwards the marginalized values of all variables are being calculated.

### 3. Flexibility of Routing in DFMC

Flexibility is defined as the ability of a technological system to cope with variable circumstances (Buzacott, J. A., & Mandelbaum, M., 1985) or instability caused by the environment (Mascarenhas B., 1981). Flexibility is one of the key objectives of any technological system and a critical measure of overall production performance.

From the theoretical postulations of the characteristics of FMC according to Lim (1986) and Yilmaz and Davis (1984), flexibility is determined by eight categories of flexibility: Machine Flexibility, Process Flexibility, Product Flexibility, Routing Flexibility, Volume Flexibility, Process Sequence Flexibility, and Production Flexibility.

Routing flexibility can be defined as the ability of a technological system to cope with failures and continue producing a given set of parts. This ability exists if a particular type of part can be processed through several routes, or equivalently, if each operation can be performed on multiple machines. The main applicable circumstances arise when a system component, such as a machine tool, breaks down. This flexibility can be measured by the robustness of the FMS when there are failures, and production continues in changed circumstances. This

flexibility can be achieved by allowing automated and automatic redirection of parts to other machines, which also enables redundancy of machine tools; as well as duplicating the assignment of operations.

Monitoring systems or tracking networks can be a powerful tool in determining routing flexibility, i.e., determining the optimal grouping of parts for processing in a didactic flexible cell (DFMC). By varying different geometric shapes that can be found in the educational process, i.e., students' exercises, the characteristics of DFMC that we want to present to students can be emphasized.

In the example we are analyzing, we want to examine Routing Flexibility for two given conceptual solutions of DFMC.

Routing flexibility in FMC refers to the ability of the production process to change depending on production needs. This flexibility allows production processes to be optimized for different types of products, reduce waiting times, and increase overall productivity. Specifically, as previously mentioned, routing flexibility allows FMC to adapt to different production tasks and changes in production without the need for manual intervention. For example, if a machine breaks down or there is a production interruption, routing flexibility allows the production process to be redirected to other machines in the FMC to avoid loss of time and resources. Additionally, routing flexibility allows FMC to adapt to different production quantities and needs. Calculating routing flexibility for FMC usually involves analyzing different possible routes through the manufacturing system, taking into account various factors such as machine availability, production time, maintenance needs, and the like.

One way to calculate routing flexibility in FMC is to use production process optimization algorithms. These algorithms consider various optimization criteria such as production time, production costs, or

maximizing production capacity. Another way to calculate routing flexibility in FMC is to use simulation modeling. Simulation modeling allows for the analysis of different production scenarios, taking into account different conditions and parameters, in order to assess the performance and flexibility of the FMC.

In both cases, calculating routing flexibility in FMC is a complex process that depends on many factors and requires expertise and experience in manufacturing engineering and automation.

The available example being analyzed involves two concepts of DFMC. The common characteristic of both DFMCs relates to the following identical components: a robot with a peripheral axis, a CNC milling machine, programmable and gravitational feeders, and a type of control system (robot controller and machine control unit). The difference relates to the CNC lathe. The first DFMC has a standard (classical) type of turret head, and the designation DFMC1 is introduced for this flexible cell. The second flexible cell has a turret head with driven tools that allow the CNC lathe to perform smaller milling operations, which gives it the ability to process parts from group two according to the part categorization in Table 2 on a single type of machine; i.e., a CNC turning center. The designation DFMC2 is introduced for this type of flexible cell in further analysis.

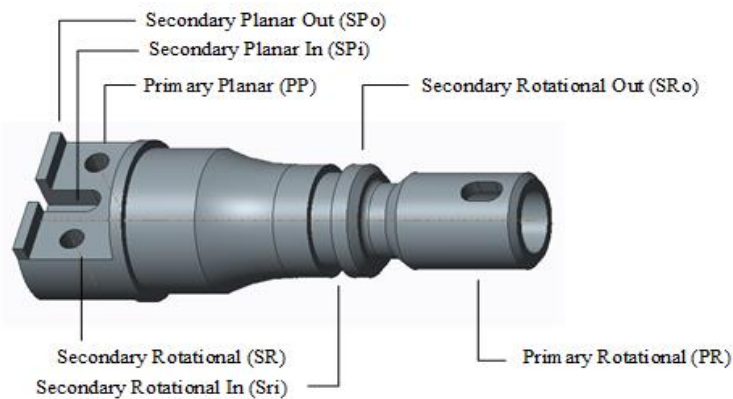
In the analysis of Routing Flexibility, evidence systems for the established part groupings have two clear goals. The first concerns the display of the ability of evidence networks to absorb knowledge that has been accumulated over the years in production engineering. The second goal relates to the expansion of previously generated evidence networks and their use as an auxiliary tool in the decision-making process. These goals will be achieved through an example that relates to the selection of part structures for processing a

hypothetical group. This type of part has already been used in other types of exercises (e.g., designing a technological process for CNC machines), so students have some experience.

As a result of the analysis, different classes of surfaces were identified on all parts (Figure 1). Types of processed surfaces include primary rotational (PR), secondary planar external (SPo), secondary planar internal (SPi), primary planar (PP),

secondary rotational (SR), etc.

Primary surfaces give parts their general shape. Secondary surfaces, such as planar internal and external surfaces and auxiliary holes, are processed from primary surfaces. The division of surfaces into primary and secondary was not made based on functional importance or processing complexity. Based on the classification of hypothetical surfaces, parts are divided into five categories, as shown in Table 1.



**Figure 2.** Different classes of surfaces

The classification of all parts into five categories was based on the combination of these surfaces, and is shown in Table 1. Accordingly, using the corresponding statistical analyses in Table 2, we form the percentage of the use of different processing machines or types of mechanical operations for processing each category of parts. These percentage ratios are also valid for the total number of operations for final processing. Thus, in the first category of parts, 100% of the work is represented by groove milling, while in the second category of parts, 75% is attributed to milling and 25% to drilling.

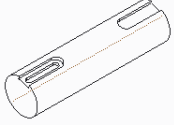
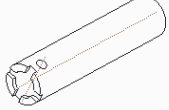
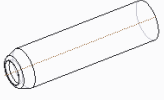
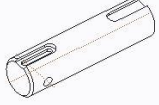
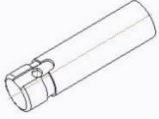
It is important to note that the level of reliability of the data in Table 2 cannot be taken as 100%. By default, in the following analysis, we will assume that the level of reliability in the accuracy of this data is 95%. This means that the results of the analysis

that was prepared (in the case considered by the lecturer) can be considered accurate with a probability of 0.95.

The rest of this paper shows how to apply the generated knowledge in conceptual design. The theory of belief functions together with proof systems or evidential networks allowed for the presentation of this knowledge in an appropriate form and later use as an aid in the decision-making process.

The group of lecturers analyzed their exercise program and decided to adapt it to students in such a way that the flexibility of routing in DFMC is better demonstrated by choosing an adequate group of parts. The percentage share of these parts with corresponding belief functions is shown in Table 3 for one of the variations presented in Table 5.

**Table 1.** Categorization of parts in school examples of exercises

	Categorization of parts in school examples of exercises	Example sketch
1.	Secondary Planar In (SPi)	
2.	Secondary Planar Out + Secondary Rotational (SPi+SR)	
3.	Secondary Rotational Out + Secondary Planar In (SRo+SPi)	
4.	Secondary Rotational Out + Secondary Planar In + Secondary Rotational (SRo+SPi+SR)	
5.	Secondary Rotational Out+ Secondary Rotational In + Secondary Planar In + Secondary Rotational (Sro+SRi+SPi+SR)	

**Table 2.** The percentage share from total assumed work for each operation of machining divided into categories of parts

Machining operations	Parts Category				
	SPi	SPi+SR	Sro+ SPi	SRo+Spi+SR	Sro+SRi+Spi+SR
Milling	100%	75%	30%	70%	55%
Turning			70%	15%	35%
Drilling		25%		15%	10%

**Table 3.** The number of parts in the series

The number of parts in the series			
Serial number	Type of work	Quantity	%
1	SPi	1	10
2	SPi+SR	1	10
3	SRo+ SPi	2	20
4	SRo+SPi+SR	2	20
5	Sro+SRi+SPi+SR	4	40

If we analyze the flexibility of routing for five different parts from Table 1, the percentage unit flexibility of routing for a specific processing strategy can be determined through artificial intelligence software (OpenAI., 2021). Based on the following facts:

- The flexible cell DFMC1, which has components: CNC lathe, CNC milling machine, robot with slider,
- Processing five different parts; the first has a milling operation, the second has a drilling and milling operation that is performed on a milling machine, the

- third has a double turning operation on DFMC1 or turning and milling on DFMC1, the fourth has milling and drilling on the milling machine DFMC1, and the fifth has turning, milling, and drilling on DFMC1, where milling and drilling are performed on the milling machine,
- Unit quantity of parts per group (first piece 1, second piece 1, third piece 1, fourth piece 1, and fifth piece 1), and
  - asking the artificial intelligence the question: "What is the percentage flexibility of routing for milling operations on FMC1?" The answer received is:
  - The percentage flexibility of routing for milling operations on FMC1 is given by the formula:
  - Percentage flexibility of routing = (Number of possible routings / Total number of operations) \* 100%

- Total number of operations: Total number of operations = Number of operations for the first part + Number of operations for the second part + Number of operations for the third part + Number of operations for the fourth part + Number of operations for the fifth part  
 Total number of operations = 1 + 2 + 2 + 2 + 3  
 Total number of operations = 10
- For routing milling operations, there are three possible paths for operations on FMC1 (CNC milling machine). These operations can be performed on the first part, second part, and fourth part. Therefore, the number of possible routings is 3.
- Percentage flexibility of routing for milling operations on DFMC1 = (3 / 10) \* 100% = 30% Therefore, the percentage flexibility of routing for milling operations on FMC1 is 30%.

Similar questions and answers obtained from the software are presented in Table 4.

**Table 4.** Percentage flexibility of routing for operations

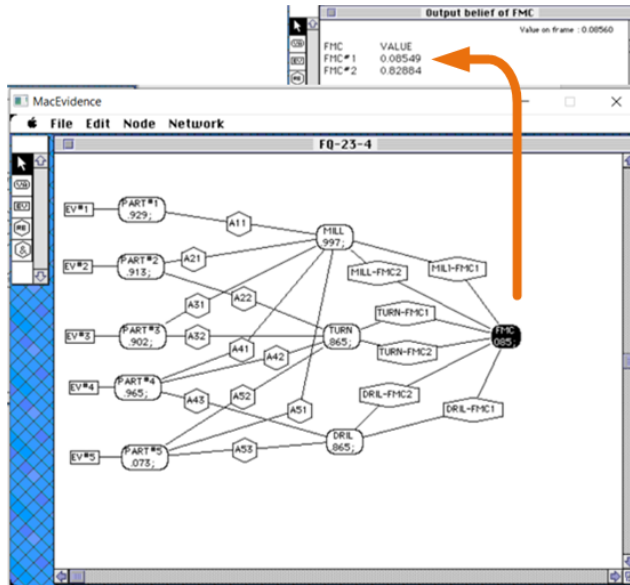
Percentage flexibility of routing for operations	Type DFMC	
	DFMC1 [%]	DFMC2 [%]
Percentage flexibility of routing for milling operations	30%	60%
Percentage flexibility of routing for drilling operations	20%	50%
Percentage flexibility of routing for turning operations	20%	67%

On the base of previous explained modeling knowledge with belief function of Dempster-Shafer theory is possible to create appropriate evidence network (Figure 3).

flexibility for DFMC1 and the highest routing flexibility for DFMC2 are evident. For the group of parts consisting of 10% of parts from the first group, 10% of parts from the second group, 20% of parts from the third group, 20% of parts from the fourth group, and 40% of parts from the fifth group, it can be concluded that it has average routing flexibility values compared to the analyzed groups of parts DFMC1 and DFMC2 (DFMC1=0.0857 and DFMC2=0.8273).

Table 5. shows data indicating a change in beliefs about routing flexibility depending on the percentage content of individual groups of parts. It is evident that all groups of parts processed on DFMC2 have incomparably greater routing flexibility compared to DFMC1. Thus, the group of parts consisting of 30% of parts from the first group, 30% of parts from the second group, and 40% of parts from the fourth group has the highest routing flexibility for flexible cell DFMC1, and the lowest routing flexibility for DFMC2. For the group of parts consisting only of parts from the first and fifth classes (DFMC1=0.0752 and DFMC2=0.8637), the lowest routing.





**Figure 3.** Evidence network with output belief

**Table 5.** Distribution of beliefs regarding routing flexibility

of group	Partial participation of the first, second, third, fourth and fifth categories in the group															Distribution of beliefs		
	I. SPi		II. SPi+SR		III. Sro+ SPi			IV. SRo+Spi+SR			V. Sro+SRI+Spi+SR			Bel (DFMC)				
1	0.1	0.9	0.0	0.1	0.9	0.0	0.2	0.8	0.0	0.2	0.8	0.0	0.4	0.6	0.0	0.0857	0.8273	0.087
2	0.1	0.9	0.0	0.2	0.8	0.0	0.2	0.8	0.0	0.2	0.8	0.0	0.3	0.7	0.0	0.0855	0.8283	0.086
3	0.2	0.8	0.0	0.2	0.8	0.0	0.2	0.8	0.0	0.2	0.8	0.0	0.2	0.8	0.0	0.0853	0.8299	0.084
4	0.2	0.8	0.0	0.3	0.7	0.0	0.2	0.8	0.0	0.2	0.8	0.0	0.1	0.9	0.0	0.0851	0.8309	0.084
5	0.3	0.7	0.0	0.3	0.7	0.0	0.2	0.8	0.0	0.2	0.8	0.0	0.0	0.0	0.0	0.0849	0.8319	0.083
6	0.3	0.7	0.0	0.4	0.6	0.0	0.2	0.8	0.0	0.1	0.9	0.0	0.0	0.0	0.0	0.0848	0.8322	0.083
7	0.4	0.6	0.0	0.1	0.9	0.0	0.1	0.9	0.0	0.1	0.9	0.0	3.0	0.0	0.0	0.0855	0.8288	0.085
8	0.3	0.7	0.0	0.3	0.7	0.0	0.0	0.0	0.0	0.4	0.6	0.0	0.0	0.0	0.0	0.0911	0.8130	0.096
9	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0752	0.8637	0.061
10	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0790	0.8514	0.069
11	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0752	0.8537	0.069
12	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0832	0.8354	0.082
13	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0752	0.8637	0.061

## 4. Conclusion

FMC (Flexible Manufacturing Cell) is a manufacturing system that consists of flexible machines and equipment organized in a manufacturing cell. This system allows production to quickly adapt to changes in order to avoid production downtime. Didactic FMC (DFMC) system is typically a smaller and simpler manufacturing system used for educational purposes to provide students with practical experience in production. In this sense, the analysis of the routing flexibility of the didactic FMC is conducted in the technological system design phase, but the objectives of this analysis are different than those of real manufacturing systems.

In DFMC, the objective of routing flexibility analysis is to evaluate the system's efficiency in producing different products, as well as the system's ability to adapt to changes in the production program. This analysis is usually conducted to improve the performance of the didactic FMC and enable students to learn the basic concepts of production and production processes.

On the other hand, in real manufacturing systems, the objective of routing flexibility analysis is to improve production efficiency and increase the competitiveness of the company in the market. This analysis is usually conducted to improve the manufacturing system's ability to adapt to changes in the production program and market demand, as well as to minimize

production costs.

In summary, although routing flexibility analysis is conducted in both types of FMCs, the objectives of the analysis and the way in which the results are applied are different.

In order to improve the quality of the teaching process, it is useful to find an adequate configuration of the group of parts intended for processing on the DFMC, which will adequately and clearly present a certain characteristic of the flexible system. In the presented example, one of the characteristics of FMCs, including DMFCs, is routing flexibility. Routing flexibility analysis as well as decision-making regarding routing flexibility can be successfully realized by applying the theory of belief functions - Dempster-Shafer theory and evidence nets developed on the basis of this theory.

In the exercise preparation phases, decisions are made about geometric, technological, kinematic, and flexible characteristics (routing flexibility) under conditions where there is no reliable knowledge about which parts, what configurations, and which technological processes will be used to process workpieces on CNC machines. In the formation of these decisions, artificial intelligence software and the theory of belief functions (Dempster-Shafer) play a crucial role. Proposed software solutions have successfully replaced expert knowledge used in the decision-making process, and the results obtained have justified the comprehensive benefits of this methodology

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## AI APPLICATION IN QUALITY ASSURANCE OF INDUSTRIAL LASER WELDING PROCESSES

**Abstract:** *The purpose of this paper is to explore conventional laser welding quality control methods and compare them with modern AI-based (Artificial Intelligence) testing solutions, highlighting the potential of AI in laser welding quality assurance. AI can effectively monitor various laser welding process signals and parameters to determine weld quality. Furthermore, AI image recognition can enhance weld error detection precision when monitoring laser welding with vision systems. In cases where conventional quality control methods, such as X-ray, are utilized, AI can be employed to process and interpret test results, reducing the time and effort required for a human operator. This paper presents and briefly discusses several successful AI application examples in laser welding quality assurance, as well as application possibilities, demonstrating the latest state-of-the-art non-destructive laser welding test solutions.*

**Keywords:** *Artificial Intelligence, Laser Welding, Quality Assurance, Non-Destructive Testing*

### 1. Introduction

Achieving a certain quality standard requires taking into consideration several factors – technical, technological, and economic[1]. Working conditions and equipment, production layout, as well as expenses of inspection, testing, and rework all affect the quality of the product. [2] The same criteria can be applied to the assessment of the quality of welded joints. However, when it comes to welding it is crucial to control and monitor the entire process, as errors can be frequent and consequences can turn out to be severe and costly [2].

The advent and improvement of artificial intelligence (AI) and its subfields, resulted in their rising impact on the manufacturing industry [3]. The advantages automated procedures hold over manual work increased

the popularity of AI applications in manufacturing processes, especially quality control [3]. The implementation of machine learning (ML) models in industrial quality has proven to be of great use as it contributes to savings in resources, time, and money. A few examples of applied ML models in quality inspection procedures are stated hereinafter[4].

Faults and defects in laser welding evaluated during quality control can be classified either as internal or external [2]. External defects can be detected by the naked eye or with magnifying glasses, as they appear on the surface of the material [2]. Internal defects can only be detected after the metallographic preparation of the samples [2]. These defects occur under the surface of the material. Some of the most common welding discontinuities are:

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- cracks,
- cavities,
- solid inclusions,
- lack of fusion and penetration,
- impering shape and dimension.

Welding parameters should be closely followed during process as they affect the quality of the weld [19]. For example, by analyzing and controlling parameters such as the laser power, the welding speed, and the size of the laser beam, the formation of welding discontinuities can be predicted [12]. Also, process parameters determine the geometry of the keyhole which affects the weld geometry and quality[5].

### **1.1 AI application in industrial quality**

AI-based methods are most commonly used for prediction, classifying a large amount of obtained data, and in optical inspection, when a high level of precision and accuracy is required for time-consuming and monotonous work.

An example of optical inspection based on a machine learning method is a blister defect detection for polymer lithium-ion batteries (PLB) performed by Ma et al. [6]. In this case, a widely used deep learning model, convolutional neural network (CNN), is employed to detect blisters in PLB sheets from images [4]. This can be regarded to as an image classification problem[6]. CNN uses a hierarchical structure to gradually extract advanced features from low-level features. It then uses these advanced features to do image classification and detect defects in PLB sheets from images [6].

Further use of machine learning methods is found in the identification of root causes of failures and quality deviations. Lokrantz et.al.[7] uses a Bayesian network, a form of a probabilistic graphical model, to represent dependence between manufacturing stages. This model uses expert knowledge and previously recorded data to perform

inferences regarding the root causes of quality deviations [7]. Such framework provides a chance for the knowledge to be stored for further use and distributed to other manufacturing sites [7].

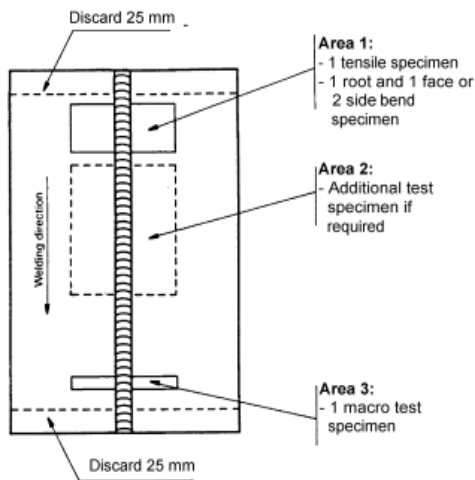
Another instance of employing machine learning tools is set by Sumesh et. al.[8]. They used two different classifier algorithms, J48 and Random Forest, to determine the quality of the weld based on the corresponding arc sound [7]. Input parameters for the classifier were sound signals recorded during experiments and later generated in Matlab software. The accuracy Random Forest showed was 88.69% and that of J48 was 70.78% [7]. Although the results turned out to be satisfactory there is still room for enhancing the performance of algorithms by bettering the conditions in which the sound arc is recorded, according to Sumesh et al. [7].

### **1.2 Conventional laser welding quality controls**

Laser technology has been present in the industry for more than 40 years, and it has contributed greatly to the improvement of welding efficiency and accuracy [9]. These developments enable greater manufacturing flexibility (control over design) and therefore increase the range of useful material properties that can be achieved [8]. However, laser welding requires rigorous control and constant process monitoring to achieve a high-quality standard [2]. Conventional methods used to evaluate the quality of a welded joint can be destructive or non-destructive [1].

Destructive tests are achieved through mechanical and structural tests and they provide quantitative indicators of the quality of the welded joint [2]. To determine the mechanical properties of welded joints, it is necessary to make test samples under the appropriate standard [1]. These samples are obtained by cutting a small part of the

welded piece that was intentionally left there, or by making special pieces (test plates) that are welded using the same procedure and welders as the planned construction [10]. Some mechanical tests include testing by tension, bending, measurement of hardness, etc [10].



**Figure 1.** Test plate

To determine the structure of the welded joint, structural (metallographic) tests are performed [10]. Samples used for these tests are prepared by grinding and polishing, after which the surface of the sample is etched [9]. The choice of the chemical reagent used for etching is based on the material of the tested object [10]. This procedure lets us see the macroscopic appearance of the welded joint as well as the microstructure in the thinned zones of the welded joint [10].

On the other hand, non-destructive evaluation involves the detection and assessment of deviations on both the surface and interior of the material [2]. Considering the fact that achieving a welded joint without any discontinuities is almost impossible, it is important to determine their shape and dimensions [1]. Discontinuities aren't considered errors if they are evaluated to be

within the permitted limits, prescribed in the quality requirements of the welded joint [1]. During these tests, the material is not damaged in any way. Some of the most common non-destructive tests are visual tests, testing with liquid penetrants, magnetic flux testing, ultrasound testing, and radiographic examination [10].

Both destructive and non-destructive methods usually require a lot of time and additional workstations, specialized equipment and materials, and trained staff, resulting in a high cost [11].

## 2. Smart laser welding quality assurance systems

An alternative to conventional quality assessment methods is found in the development and integration of process monitoring systems. These systems detect welding errors during the process and the negative impact of uncertain interfering factors can be effectively reduced and flawed parts can be separated [11].

When it comes to laser welding, process monitoring is conducted in three stages. In the first stage, during the pre-process, the weld seam is tracked [12]. After that, the melt pool, weld defects, spatter, etc. are monitored during the process. Lastly, the geometry of the weld and visible defects are examined post-process [12].

Using AI-based methods, weld features, defects, and the state of the weld can be predicted and adjusted [13]. Also, corrective measures are proposed through feedback to system control if needed, and the entire process becomes more efficient over time, as more data is collected. There are different methods used for process monitoring and quality assessment.

### 2.1 Signal monitoring sensor techniques

During process monitoring, the most commonly monitored signals are acoustic, optical, and thermal.

**Acoustic emission signal** is one way to monitor the laser welding process. The plasma ejected from the keyhole leads to pressure fluctuations which bring about the acoustic signal [13]. This signal can be measured without contact, by using a microphone or a resonant sensor [14].

Acoustic signatures, such as sound pressure deviation and band power, can be used to specify the weld penetration by applying a neural network algorithm and regression analysis methods [15]. The algorithms effectively separated full penetration from partial penetration. An automatic measure and control system designed by Lv et al. [16] proved that acoustic signals are also helpful in controlling arc length in real-time, based on the linear relationship between the arc sound and arc length. The linear fitting model was used to predict the surface height of the molten pool. Achieved prediction results were successful [16].

The main downside of this signal is its susceptibility to environmental noise. This interferes with the forthputting of acoustic signal monitoring[13]. However, this can be avoided by using noise reduction methods to reduce the background noise signals [17] or by using a plane microphone array system, composed of eight microphones [18].

**Optical signal** monitoring consists of optical radiation and optical vision monitoring [13]. The molten pool, spatters, and plasma emit strong optical radiation, and the optical radiation signal mainly comes from the laser beam and the welding area [19]. Based on a different wavelength, optical radiation signals can be divided into two categories – one is UV and VIS radiation, where the wavelength is 0.3 – 0.7  $\mu\text{m}$ , and the other is IR radiation with a wavelength range

between 1.1  $\mu\text{m}$  and 1.6  $\mu\text{m}$  [20, p.]. The equipment used to collect the optical radiation signals consists of, most commonly, spectrometers, photodiode sensors, high-speed cameras, CCD cameras, and CMOS cameras [13]. This monitoring method is widely used nowadays as it provides a large amount of reliable data. For example, [21] used the image processing method under different welding conditions to gain insight into the dynamic behaviors of the keyhole, and [22] measured the velocity and direction of the fluid flow inside the keyhole, by attaching a glass plate, very precisely. Results showed a connection between the fluid flow and laser power, feed rate, and welding gap [22]. Still, due to spatial restrictions, the signal camera sensor is limited in data collection[13]. To avoid this downside and to be able to extract enough features for proper evaluation of the quality of the weld seam, researchers opt for multiple camera sensors [13]. This way, the welding zone can be monitored from different angles and extensive information can be obtained [13].

**Thermal radiation signal** is especially strong in the keyhole, the molten pool, and the high-temperature metallic vapor, as the temperature and thermal radiation are very high in these parts of the welding zone [13]. Frequently used sensors for obtaining thermal signals are pyrometers and IR cameras [13]. While the pyrometer is cheaper and easier to assemble, the IR camera can reflect the temperature distribution of the welding zone more extensively [13]. IR images of the molten pool were used to estimate the width and depth of the weld seam[23], [24]. By analyzing the emitted thermal radiation, Weberpals et al. [25], examined the temperature distribution and geometrical structure of the welding zone. This approach could also be used to define the inclination of the keyhole [25].



## 2.2 Monitoring techniques

**Traditional monitoring methods** can be divided into two approaches, coaxial and paraxial [26]. The coaxial monitoring method monitors the welding zone by installing a spectroscope in the laser propagation path. [27]. Obtained optical and thermal signals are stable and undisturbed. The imperfection of this method is its lack of flexibility and complex installation of the monitoring sensor [13]. However, paraxial monitoring is characterized by easily adjusted monitoring distance and angle between the welding zone and the sensor [13]. These traditional methods commonly represent a basis for novel monitoring methods and multi-sensor fusion technology [13].

**Novel monitoring methods**, like X-ray imaging technique, inline coherent imaging (ICI), magneto-optical imaging (MOI), etc. have achieved good results in obtaining some welding features, which are normally difficult to get during the process [13]. These features, like the depth of a keyhole for example, are very helpful when evaluating welding quality since they are closely connected to it [13].

**X-ray videography** can obtain temporally and spatially defined information about the keyhole geometry during the welding process[5]. Furthermore, this method can also be used to identify the inner defects of the weld seam with high spatial and temporal resolution [13]. By using an X-ray diffraction system, the microstructure and mechanical properties of the weld seam can be investigated [28], and residual stress distribution in the weld seam measured [29].

**Optical coherence tomography (OCT)** is another novel technique. OCT is a 3D measuring technology for automated laser welding[13]. It can serve as a basis for an inline monitoring device used to extract the tomographical geometrical measurement

data during the process of weld seam forming [30].

**The MOI technique** is based on the magnetic induction principle and the Faraday rotation effect [31]. An experiment showed that the microstructure of the weld joint can be investigated using the MOI method, and without the metallographic preparation process [32].

Automated monitoring of laser welding processes is often achieved using *weld watchers*. Analyzing the measured light emission, created from the interaction between the laser and the material, weld watchers can recognize errors in welding based on previously recorded error-free weldings[33] [32].

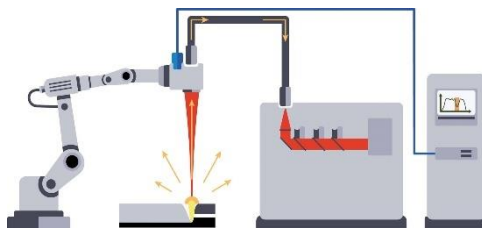


Figure 2. Weld watcher

Using smart evaluation methods, weld watchers can signal warning thresholds to the system control completely automatically [32].

**Multi-sensor fusion technology** combines various signal sensors and benefits from the advantages of each one [12]. It can, therefore, monitor the welding process effectively and comprehensively [13]. The main sensor of this technology is usually the vision sensor, as it provides extensive information about the welding zone [13]. The combination of sensors varies based on the desired outcome. For example, the X-ray system can be combined with the high-speed camera [34], the sound sensor with the vision sensor [35], etc.

### 3. Successful examples and possibilities of AI application in laser welding quality assurance

AI can be applied in many ways to ensure the quality of the welded seams, significantly reducing test costs, especially compared to destructive test methods. Possibilities are numerous, but some of the most significant would-be AI monitoring of various process parameters to determine weld quality, monitoring optical signals during welding and applying AI image recognition, and AI result processing and interpretation for some of the conventional control methods (such as X-Ray). A few successful application examples shall be presented and shortly discussed.

**Image recognition** can be applied in many ways in quality control of welded joints. Welding errors can be detected while observing the melt pool contour, (melt-on and the resolidification line) [11]. Various defects can be identified in this way, especially lack of fusion. In order to have a proper setup researchers have used a CMOS camera with an additional light source, and a robust algorithm for image analysis. Image recognition approach can be utilized to detect laser optical backlash during welding, a heat camera can be used to monitor thermal distribution patterns, or different light sources can be applied in order to have a visual inspection of the welded seam in form of a machine vision [6], [11], [19], [23].

**Monitoring process parameters** in order to determine weld quality can be a very promising approach. Non-visual process parameters could be monitored during the welding process. For example, AI can be trained to monitor temperature, voltage, electric current, sound, pressure, and many other parameters during welding and determine the outcome of the welding operation based on various combinations of

parameter values [8], [11], [13], [35]. When possible, the most economical approach is to use existing process parameters measurement values, without investment in microphones or other measurement devices. An example of this approach is the utilization of an adaptive neuro-fuzzy inference system (ANFIS) and multi-gene genetic programming (MGGP) to predict the laser weld quality, such as surface roughness, weld strength and more [36].

**AI result processing and interpretation** is a useful method to eliminate long manual work, make the process cost-efficient, and get the testing results faster. Eddy current testing, ultrasonic testing, X-Ray, or CT (computer tomography) scanning can provide as an output a very complex result. For a human, it can be quite tricky to analyze, understand and interpret those results, and the process can take a long time. If a CT scan of a laser welded seam is analyzed for pores, on the output scan an operator should look for pores, measure them and make a report. Many scanning systems have a built-in AI feature for porosity analysis, but if porosity-induced fatigue damage should be calculated numerous calculations should be performed. Researchers have tried to predict porosity-induced fatigue damage of laser welded joints, where the AI algorithm could be a very beneficial tool to increase prediction accuracy and reduce testing time [37], [38].

### 4. Conclusion

This paper provides a rough overview of the AI application in industrial quality, with a focus on laser welding quality assurance. Basics of the laser welding process were given, followed by conventional laser welding control methods. Conventional testing methods can be quite costly and time-consuming, especially destructive testing methods. State-of-the-art technologies

provide better solutions. AI prediction models or process monitoring solutions can be applied to provide real-time test results in a high-speed production environment with very low investments, and very low testing costs.

Through various examples of AI application in laser welding quality assurance, it is shown that there is a great potential to improve conventional quality control systems, shorten the test duration, reduce the test cost, improve defect detection precision, and much more. AI can be successfully

applied to monitor various laser welding process signals or parameters to determine the weld quality, in cases where laser welding is monitored with some vision systems AI image recognition can be applied to enhance the weld error detection precision, or if a conventional quality control method is applied (such as X-ray), AI can be utilized to process and interpret test results as it might be a time-consuming process for a human operator.

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## STUDY ON OPEN CONTACT SYSTEMS WITH FLAT PARALLEL ELECTRODES FOR AERIAL ROBOTS CHARGING PLATFORMS

**Abstract:** *The authors of this paper proposed the design of a charging platform for aerial robots (ARs), the advantages of which are the simplicity of implementation, non-requirement of precision landing ARs on the platform and the possibility of servicing several robots simultaneously. The platform comprises a row of flat parallel open electrodes lying in the same plane and separated by thin dielectric spacers. One half of platform electrodes are connected with positive pole of the charging power source and another half – with negative one, and their polarities are interlaced. The AR has several on-board electrodes in its support stanchions, and their contact points are located at the vertices of a regular polygon. Geometric analysis of the on-board electrodes' positions on the platform has been carried out. Practical recommendations have been given for configuring electrodes that can lead to 100% probability of correct contacting. Simulations with the help of the special software were carried out and the probability of correct contacting after landing for different number of contact points under uncertainty of their coordinates was estimated.*

**Keywords:** *Aerial Robot; Unmanned Aerial Vehicle; Landing; Charging Platform; Open Contact System.*

### 1. Introduction

The term “Aerial Robot” (AR) is used commonly in the field of robotics. It's been known for two decades, and it means a small pilotless flying machine with high degree of intelligence (Michelson, 1998). The better known term is “Unmanned Aerial Vehicle” (UAV) which has long been used in aviation. An AR can be considered as an UAV “capable of sustained flight with no direct human control and able to perform a specific task” (Feron and Johnson, 2008). In other words, ARs is a big class of mobile robots based on UAVs for special tasks that can be

performed using their intelligence and autonomy.

There are many types of UAVs based on different flight principles (Liewet al., 2017). This paper deals primarily with the Rotary-Wing type of aerial vehicles (helicopters, multicopters) and other aircrafts (convertiplanes and other hybrids) capable of vertical take-off and landing (VTOL). VTOL UAVs are the closest to common notion of “robots” because of their capability of hovering, which has huge advantages, in comparison with Fixed-Wing aircrafts, for general versatility. Perhaps the most popular implementation of AR is the quadcopter due

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to its successful combination of wealth of opportunities and ease of implementation (Ghazbi et al., 2016).

ARs are designed for various useful functions: aerial photography, monitoring, construction operations, agricultural works, delivery of small packages and so on. One of the most pressing tasks in aerial robotics is on-ground automatic service and maintenance of ARs. This is especially important for the operation of not one single AR, but their groups. Today many well-known companies, as well as new startups specializing in Unmanned Aerial Systems (UAS) (Austin, 2010), are developing various service stations for ARs (Aerobotics, 2022), (H3 Dynamics, 2022), (Noon.21st Century, 2022), (Skycharge, 2022), (WiBotic, 2022).

UAS comprises of one or more UAVs (ARs), along with the technical equipment necessary to operate them and other components (Fetisov, 2021). Full composition of UAS may be different depending on its purposes. UAS provides an infrastructure for working environment of ARs. Important components of UAS are service stations. These are specific objects of UAS infrastructure, mainly intended for refueling or recharging UAVs.

Commonly ARs' power units are fully electrical and on-board power supplies are accumulator batteries of Lithium Ion or Lithium Polymer types. Such batteries provide time duration about 30-40 min for helicopters or multicopters. This time is often not enough to carry out various tasks. The AR therefore must replenish somehow its on-board energy supply after discharging.

Different means are known for recharging on-board batteries of UAVs and thus providing long duration of AR's mission. Among them, for example, is transmission of energy to the flying UAV by laser beam (Cui et al., 2017). There are solutions for replenishing energy of on-board power

supplies by means of solar panels (Morton et al., 2015). Many various projects use electromagnetic field based wireless power transfer (Luet et al., 2018), (Nguyen et al., 2020), (Chittoor et al., 2021). But the most effective and the easiest way to implement recharging is periodical landing ARs onto a charging platform with special contact terminals fed by a ground-based DC power source.

A large number of technical solutions based on direct contact between on-board and surface electrodes are known. Many systems use various quick connectors with male plugs and sockets. Some of them have lock devices for reliability of contacting (Lee et al., 2016). One part of such connectors often have funnel-shaped centering housing with inside electrode for easy insertion of a corresponding protruding part with another electrode (Antonini et al., 2019).

Service stations may contain not only charging systems but also special automatic mechanisms for fast battery swapping. Such mechanism removes the discharged battery from the supported AR and replaces it with a freshly charged battery (Toksoz et al., 2011), (Swieringa et al., 2010). In this case, the AR will be held up at the station for the minimum time and the battery removed will be charged after AR's departure. In paper (Kemper et al., 2011) the comparison of simple charging stations with contact terminals of different types and the charging station with swapping of batteries is made. The authors proposed methodology for estimating the economic feasibility of automatic recharging/swapping stations for different applications.

Electrical connection between ground and on-board parts of charging circuit in many cases is worth using platforms with open contact systems (Kemper et al., 2011), (Al-Obaidi et al., 2020), (Fetisov et al., 2014). In this approach commutation of ground and on-board electrodes appears right after landing when AR's undercarriage open electrodes



touch and simply lay on ground platform open electrodes (pads, strips). Such solution, unlike the conception of charging stations with fixed plug-in connectors, provides arrangement of charging process even in conditions of inaccurate AR landing. There are no complex operations for connecting and disconnecting plugs after landing and before take-off. And, besides, one platform allows charging for a group of ARs simultaneously.

Typically, open surface electrodes lie in the same plane, but in some projects they are intentionally spaced at different altitudes, as in (Stoyanov, 2014), to facilitate the positioning of the vehicle on the platform and ensure the correct electrical connection between surface and on-board electrodes.

Redundancy of electrodes is used to enable independent positioning of the AR on the platform, with an excess of number of surface or on-board electrodes, or both of them. The number of electrodes exceeding the number of charging source poles, i.e. two, should be considered excess. Typically, the greater the redundancy, the greater the freedom to position the AR. And if there is no redundancy or its degree is small, then various additional positioning devices have to be used to ensure that the docking of the AR on the platform is correct (Galimov et al., 2020).

In this paper the authors present results of studying one type of platforms with open contact pads, namely so-called platforms with flat parallel electrodes (Fetisov and Akhmerov, 2019). Their main advantage is simplicity of implementation, and reliability is quite high if special requirements for geometric parameters of electrodes are met.

This article does not deal with short-range navigation and precision landing of the vehicle on the ground service platform. These tasks are usually performed by on-board and (or) land-based video cameras. Data fusion integrating video information

and signals from other sensors (inertial sensors, GPS receiver, barometer) is often used. These issues are relatively well covered in the technical literature (Saripalli et al., 2003), (Conte and Doherty, 2009), (Kendoul et al., 2009), (Kendoul, 2012), (Kong et al., 2013).

This work focuses mainly on the charging platform design and geometric analysis of the mutual positions of the AR's on-board electrodes and electrodes of the platform.

## 2. Charging stations based on landing platforms with flat parallel electrodes

The general idea of the proposed charging station (Fetisov et al., 2013) (Figure 1) uses redundancy of platform electrodes. It consists of a row of flat parallel electrodes implemented as metal stripes lying in the same plane and separated from each other by narrow insulating spacers. One half of platform electrodes are connected with positive pole of the charging power source and another half – with negative one, and their polarities are interlaced. Let's the AR has 4 on-board landing electrodes positioned at the end of the AR's legs. Due to special geometrical features of the platform and on-board electrodes different polarities of the on-board electrodes would be obtained under any position of the AR on the station. That is at least one on-board electrode would be of different polarity than others (condition of heteropolarity). The special on-board distributing diode circuit provides right connection of the on-board battery charging controller to the platform power source under any random combination of on-board electrodes' polarities (Figure 1, a). The charging controller is connected to the accumulator battery GB1.

If the width of the platform electrode is  $a$ , the width of the insulating spacer is  $\delta$ , and the length of the side of a square which vertices correspond to the contact points of

on-board electrodes is  $d$ , then the geometrical condition providing 100% probability of heteropolarity of on-board electrodes is the equality  $d=a+\delta$ . Due to the small size of  $\delta$  we shall count  $d=a$  (Figure 1, b).

Circuits of balancing battery cells and circuits of disconnection of on-board electronics during charging time are not shown in figure 1, a. Due to the special form of insulating spacers and ends of on-board landing electrodes short circuit between neighboring platform electrodes via a landing electrode is practically impossible.

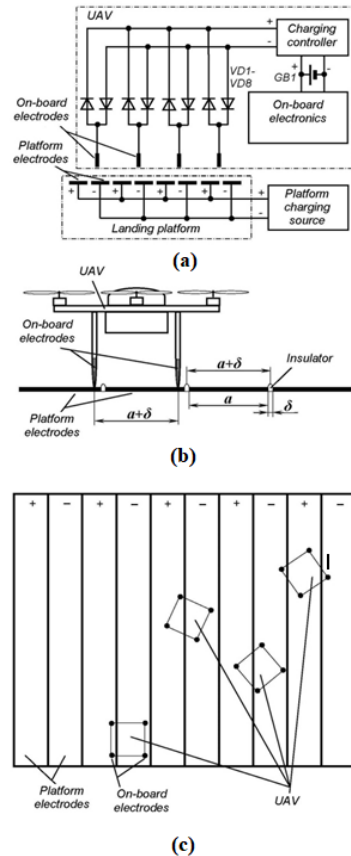
The described charging station may be used for service of a few ARs simultaneously (Figure 2).

### 3. Design of electrodes

For right positioning on-board electrodes on the ground platform and excluding situations when the on-board electrode lays on two adjacent platform electrodes simultaneously or gets stuck on the insulator's edge ends of on-board electrodes must be rather sharp (Figure 1, b). The contact area therefore is small. This fact makes it necessary to limit charging current and leads us to find a solution to improve reliability of contacting.

Improved contacting can be achieved in a number of ways:

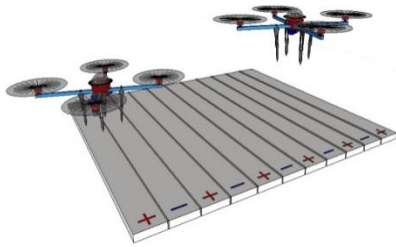
- use of protective metal coatings,
- increasing the number of on-board electrodes,
- increasing the force of pressing on-board and ground electrodes together by the use of magnetic or electromagnetic elements (Mulgaonkar, 2012),
- providing conditions for all on-board electrodes to be pressed uniformly and qualitatively against strips of the platform.



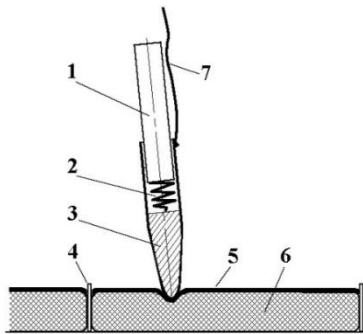
**Figure 1.** Charging station with flat parallel electrodes: a – station structure; b – UAV positioning on the platform flat electrodes; c – random locations of on-board electrode contact points on the landing platform.

The latter can easily be achieved by spring-loading on-board electrodes. But it's not the only option. For example, figure 3 illustrates the technical solution in which an increase in the contact area is achieved by landing the AR on strips in the form of soft metal mats.

It is obvious that in case of landing on a soft strip its deformation thereof will contribute to "wrapping" the lower part of the tip with the deformed surface of the strip and to multiplying the contact area of the electrodes.



**Figure 2.** A charging station based on a platform with flat parallel electrodes can serve multiple ARs simultaneously.



**Figure 3.** The technical solution with spring-loaded electrodes and soft on-ground strips: 1 – rod of UAV landing gear (support stanchion), 2 – metal spring, 3 – metal tip (on-board landing electrode), 4 – dielectric separator, 5 – metallized coating, 6 – soft elastic material, 7 – current-carrying wire.

## 4. Geometric analysis of on-board electrodes possible positions

In the above example (Figure1), a UAV has four on-board landing electrodes. This case is typical of quadcopters, where it is convenient to place electrodes-stanchions under the motor-bearing beams of the device frame. In other cases, the number of on-board landing electrodes may also be chosen according to the number of bearing beams. For example, it is better to have three on-board landing electrodes for tricopter and six for hexacopter. And it is naturally to place contact points of them in the vertices of

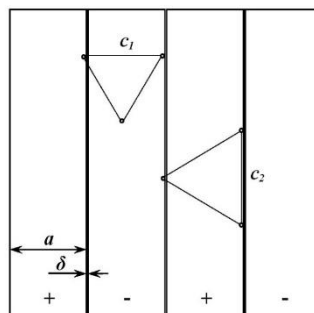
regular polygons. Further we will examine in more detail some of the options for the location of the contact points. Only those variants of location are considered acceptable for which the probability of the ends of all electrodes falling onto strips of only one polarity is zero. That is, the situation of unipolarity for all contact points should be excluded.

### 4.1. Location of contact points at the vertices of a triangle

Of all geometric variants for triangles, only the position of the contact points on the vertices of a regular (equilateral) triangle is permissible. Figure 4 shows two near-critical but tolerable positions of contact points for this case. Still consider  $\delta$  negligible in comparison to  $a$ .

For the first variant shown in figure4 (length of side  $c_1 = a$ ), it is clear that, if the triangle is rotated, it is possible to make such a landing when all three touching points are on the same strip. For the second variant (the width of the strip  $a$  equals the height of the triangle:  $h = c_2 \cos 30^\circ$ ) such situation is excluded. At any rotations, one point of contact will lie on the adjacent strip relative to the other two. Therefore, it is better to select

$$c_2 = a / \cos 30^\circ \approx 1.155 \cdot a.$$



**Figure 4.** Near critical positions of the contact points at the vertices of regular triangles

A further lengthening of the side of the triangle is not permissible, as it is possible for two vertices on the base of the triangle to be on the same strip and for the opposite vertex to be on the strip «through one» (i.e. the polarity of all three vertices will be the same). For these reasons, touching points cannot be placed at the vertices of an unequal triangle.

Positioning the contact points of on-board electrodes at the vertices of the triangle has one clear advantage over all other possible variants (such as vertices of square, hexagon, octagon and so on): uniform pressurization of all on-board electrodes to the planes of the ground electrodes is guaranteed at all times, even if there are different irregularities, distortions and differences in the planes of the ground electrodes. For multicopters with four or more on-board electrodes, all electrodes have to be pressed uniformly by special measures (Figure3).

**4.2. Location of contact points at the vertices of a square**

This option has already been considered above. To meet the heteropolarity condition of on-board electrodes, it is necessary to maintain equality  $d=a$ , where  $d$  is the distance between adjacent contact points (the length of the side of a square). Positioning the contact points at the vertices of a rectangle is not acceptable, as all four of the on-board electrodes may be on strips with the same polarity.

Four landing electrodes can be found not only in quadcopters, but also in vehicles with higher number of rotors. For example, figure5 shows hexacopter and octocopter whose support stanchions are not made under each motor-bearing beam. At the ends of these stanchions, electrodes can be formed whose contact points fall into the vertices of the square.



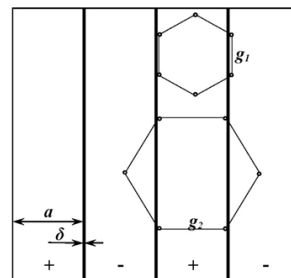
**Figure 5.** Hexacopter and octocopter with four support stanchions

However, increasing the number of on-board electrodes can provide high charging currents. And from this point of view, the configuration of the on-board electrode system in which they are located under each beam of a multicopter at the vertices of regular polygons has some advantage. In addition, as will be shown below, configurations with high number of on-board electrodes provide a higher probability of successful landing that ensures the heteropolarity of on-board electrodes.

Then next consider the location of the contact points at the vertices of a regular hexagon (configuration for a hexacopter).

**4.3. Location of contact points at the vertices of a regular hexagon**

Similar to figure4, figure6 shows two near-critical but tolerable positions of contact points for this case. It is not difficult to see that the length of the side of the hexagon must be at least  $g_1$  (to prevent all vertices from falling into the same strip) and at most  $g_2$  (to prevent the opposite triads of the vertices from being through a strip from each other).



**Figure 6.** Near critical positions of the contact points at the vertices of regular hexagons

Simple geometric calculations yielded the following inequalities for the side of the hexagon  $g$ :

$$a/(2\cos 30^\circ) = 0.577a < g < a.$$

#### 4.4. Location of contact points at the vertices of a regular octagon

As in the previous case, consider two critical lengths of the polygon side ( $f_1$  and  $f_2$  shown in Figure 7). This length of the side of the octagon must be at least  $f_1$  (to prevent all vertices from falling into the same strip) and at most  $f_2$  (to prevent the opposite tetrads of the vertices from being through a strip from each other).

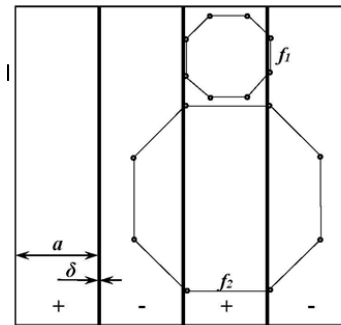
From simple geometric calculations we get the next double inequality for the side of the octagon  $f$ :

$$a \cdot \tan 22.5^\circ = 0.414a < f < a.$$

#### 4.5. Geometric analysis summary results

The results of the geometrical analysis that has been performed in 3.1–3.4 we placed in the summarizing table (Table 1). The optimal side lengths for regular polygons ( $c$ ,  $d$ ,  $g$ ,  $f$  for triangles, squares, hexagons and octagons respectively) with contact points at

their vertices are expressed by the strip width  $a$ . In addition, similar expressions are given for the circumcircle radius  $R$  for each polygon. This parameter is suitable for the simulation program described below. There is a known formula linking  $R$  to the length  $x$  of the side of a generalized regular polygon:  $R = x / (2 \sin(180^\circ/n))$ , where  $n$  is the number of sides of a regular polygon.



**Figure 7.** Near critical positions of the contact points at the vertices of regular octagons.

Column 4 of Table 1 contains expected optimums of the polygon side length and the circumcircle radius  $R$  at the fixed value of the strip width  $a = 200$  mm. This value will also be used later in simulations.

**Table 1.** Theoretically calculated optimal ratios\* between the geometry of the electrodes and the strip width  $a$

Number of on-board electrodes (Number of regular polygon sides)	Regular polygon side length symbol	The optimal length of the polygon side and the circumcircle radius $R$ expressed by the strip width $a$	Expected optimums of polygon side lengths, mm and the circumcircle radius $R$ , mm at $a = 200$ mm
3	$c$	$c = 1.155a$ $R = 0.667a$	$c = 231$ $R = 133.4$
4	$d$	$d = a$ $R = 0.707a$	$d = 200$ $R = 141.4$
6	$g$	$0.577a < g < a$ $0.577a < R < a$	$115.4 < g < 200$ $115.4 < R < 200$
8	$f$	$0.414a < f < a$ $0.541a < R < 1.307a$	$82.8 < f < 200$ $108.2 < R < 261.4$

\* Optimal geometrical conditions correspond to 100% probability of heteropolarity of on-board electrodes

## 5. Simulation Software

It is of practical interest how the probability of correct electrical connection of the on-board and ground parts of the charging system depends on the number of contact points, the size length of the corresponding regular polygon, and the uncertainty of the contact points' positions.

Estimating the probability of the correct position of the apparatus on the platform in an analytical form is rather problematic, so such estimation was made using the special software simulator, called CoptersLanding. The program allows to simulate random positions of the air robot on the platform, to analyze the polarity of contact points of the on-board electrodes and to calculate the percentage of successful and unsuccessful landings.

In Options Area of the program (Figure 8, on the right), the user can set the number of strips, length and width of strips, the number of on-board electrodes (contact points), the circumcircle radius for the regular polygon whose vertices coincide with contact points, and the uncertainty of the coordinates of the contact points (maximum random deviation of coordinates from given values). The user can set the single run or multiple runs of simulation.

The Results Area window of the program displays the result of the simulation (Figure 9, on the left). For all runs of simulation the polarity of each contact point is shown and the result of the landing - successful (I) or unsuccessful (O, in case of the same polarity for all contact points).

The final result is represented by the number of simulation runs and the percentage of

correct landings (Figure 9, the upper-left corner), which, if the number of runs is large enough, can be considered with some degree of approximation as a probability of successful landing.

The central part of the software window shows the view of the landing platform with strips of electrodes and images of all random landings represented as positions of contact points.

Only those landings for which all contact points of the UAV are placed on the platform without crossing its borders are evaluated.

The program allows to emulate simultaneously the AR random position on the platform and random deviations of coordinates of all contact points.

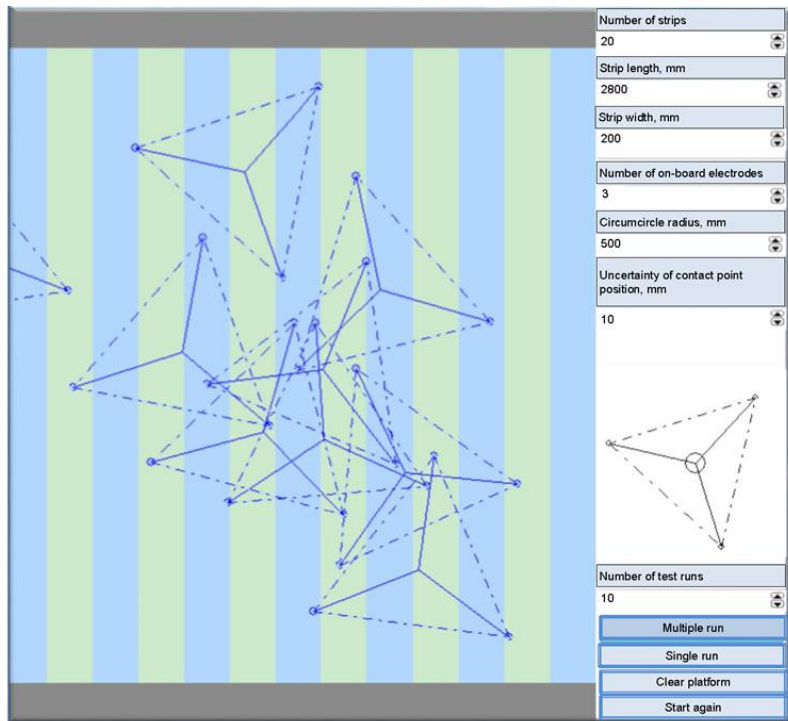
With a large number of statistical tests (in all simulations it was given at 10000), it is possible to get a reasonably reliable estimate of the probability of successful landings).

In all the evaluated cases of landings, the following geometrical parameters of the platform were given constant:

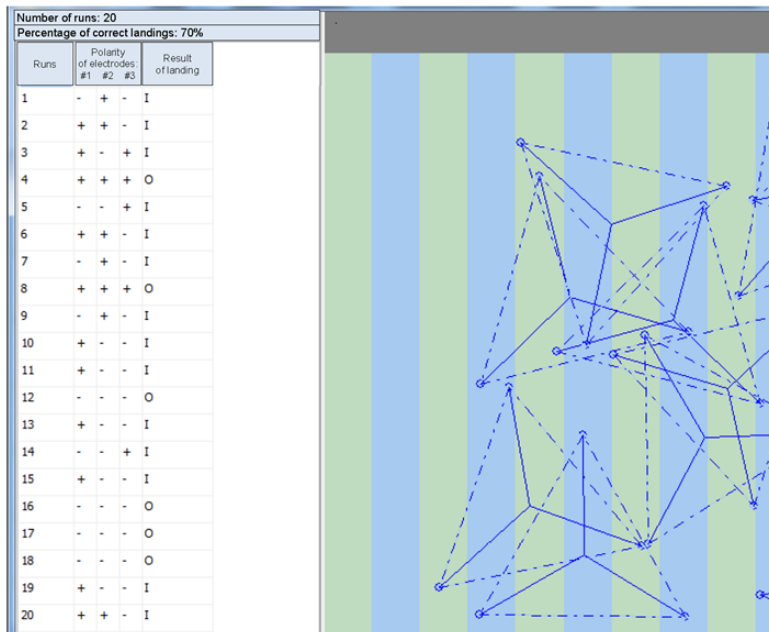
- number of strips: 20;
- strip length: 3000 mm;
- strip width: 200 mm.

The following parameters were varied:

- number of on-board electrodes: 3, 4, 6, 8;
- radius of the circumcircle: 50–400 mm;
- uncertainty of the contact points coordinates (limit values of random deviations with uniform probability distribution law): 0, 3, 5, 7, 10 mm.



**Figure 8.** CoptersLanding Options Area (on the right).



**Figure 9.** CoptersLanding Results Area (on the left).

6. Simulation results

Random landing simulation results for the case of the absolutely exact location of contact points at the vertices of regular polygons (the uncertainty of coordinates of

contact points  $\gamma=0$ ) are represented in the graphs of Figure 10.

The theoretical predictions shown in Table 1 have been fully confirmed by simulation results.

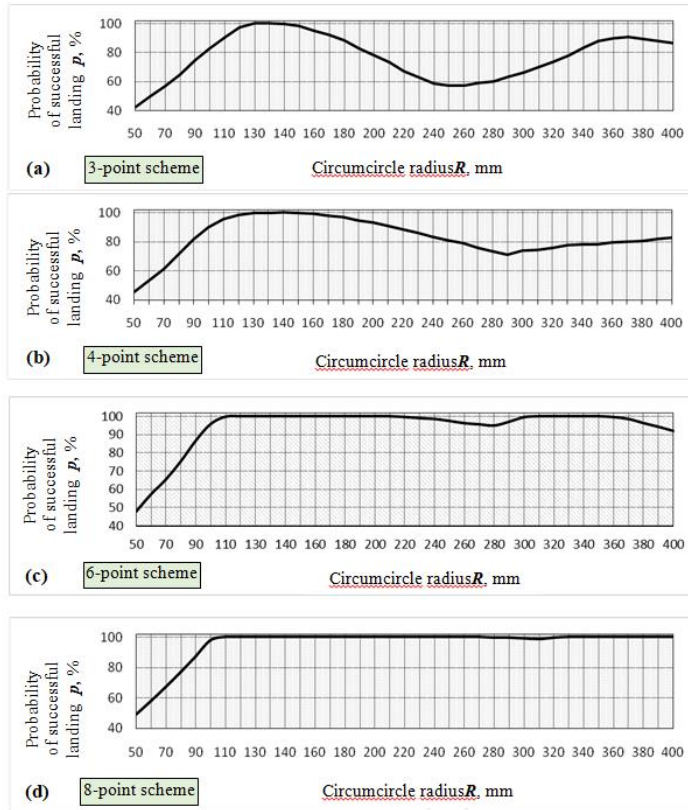


Figure 10. Probability of successful landing vs. circumcircle radius for different contact schemes: (a) 3-point scheme, (b) 4-point scheme, (c) 6-point scheme and (d) 8-point scheme

For all tested variants of the contact points' location (3, 4, 6, 8 points) there are optimal ranges of the AR's geometric parameters (radius of the circumcircle  $R$ ), at which the landing will always be successful in the sense of the correct commutation of electrodes. Furthermore, as can be seen from Figure 10(a – c), the optimality zone

expands as the number of contact points increases.

Somewhat unexpected was the presence of a zone of minimal probability of successful landing following the maximum zone (it is visible, with varying degrees, on each of the graphs of Figure 10(a – c)). Then again, the probability increases, though not always to 100%.



It would be difficult to predict theoretically the behaviour of the curve in this area. Therefore, a simulated computational experiment to assess the probability of a successful landing is practically the only reliable means.

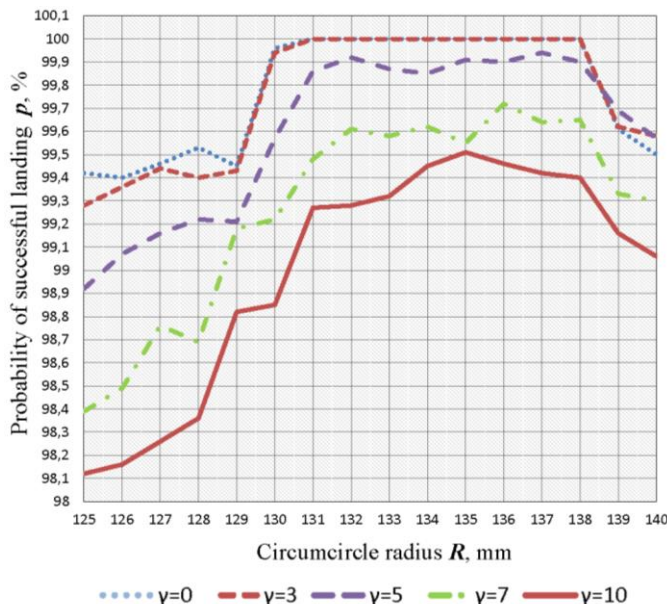
A special series of simulations was implemented to estimate how the uncertainty of the contact points' coordinates  $\gamma$  affects the probability of successful landing  $p$ . Limit values of 0, 3, 5, 7, 10 mm were given successively for  $\gamma$ . These are typical values for real conditions, when the uncertainty of coordinates may be due to factors such as technological errors in the installation of the on-board electrodes or the inflexibility of the supports. The ranges of  $R$  within and in close proximity to the above-mentioned optimum zones were the most interesting to study. The behavior of the dependencies  $p = f(R)$  for the values  $\gamma = 0, 3, 5, 7, 10$  mm was studied in detail. The results for 3-, 4- and 6-point

contact schemes are presented in Figure 11-13.

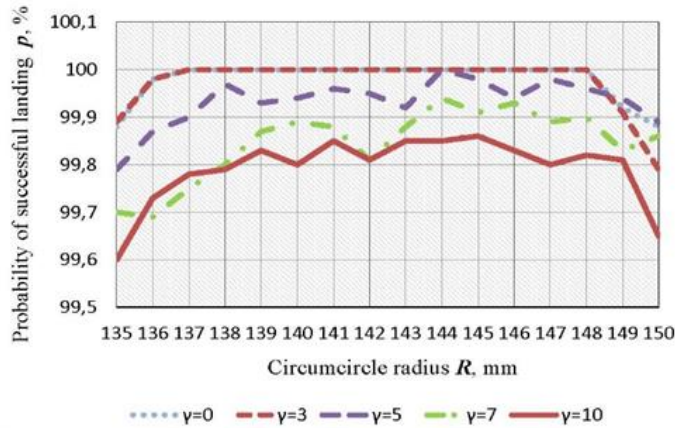
The graphs show that for 3- and 4-point contact schemes where the optimal zone of  $R$  is relatively narrow, it is almost impossible to achieve a 100% successful landing at  $\gamma = 5$  mm and more.

For 6- and 8-point schemes (the graphs for 8-point scheme are not shown here, because they are similar to the graphs for 6-point scheme shown), starting with certain  $R$  values (in Figure 13, the values of  $R \approx 126$  mm), the uncertainty  $\gamma$  ceases to have any effect on the probability of successful landing.

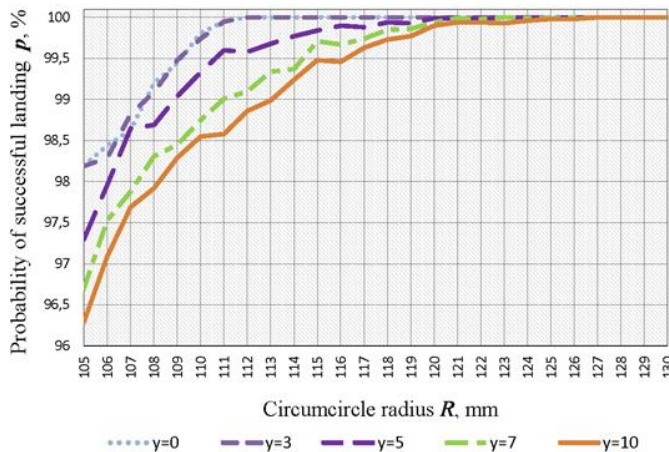
The range of values of  $R$  where  $p = 100\%$  at any values of  $\gamma < 10$  mm continues to the right up to values about 260 mm for the 6-point contact scheme, and never ends at all for the 8-point contact scheme.



**Figure 11.** Probability of successful landing vs. circumcircle radius for 3-point contact scheme at different uncertainties of contact points' coordinates  $\gamma$



**Figure 12.** Probability of successful landing vs. circumcircle radius for 4-point contact scheme at different uncertainties of contact points' coordinates  $\gamma$



**Figure 13.** Probability of successful landing vs. circumcircle radius for 6-point contact scheme at different uncertainties of contact points' coordinates  $\gamma$

## 7. CONCLUSION

The developed simulation program made it possible to estimate the probability of successful landing of an aerial robot having regular arrangement of on-board electrodes (their contact points are located at the vertices of a regular polygon) on the charging platform that has flat parallel electrodes of interlaced polarity. Landing is considered successful if the condition of

heteropolarity for on-board electrodes is met, i.e. when in contact with strips, at least one on-board electrode shall have a polarity different from others.

The proposed methodology and tool can help to choose the right relationship between the geometrical parameters of the landing platform and the aerial robot.

In order to maximize the probability of a correct landing, it is necessary to observe the

special geometric relationship between the width of the ground electrode  $a$  and the distance between contact points of adjacent on-board electrodes (side length of a regular polygon), namely, according to Table 1:

- for 3-point contact scheme the distance between adjacent contact points must be  $1.155a$ ;
- for 4-point contact scheme the distance must be  $a$ ;
- for 6-point contact scheme the distance must be between  $0.577a$  and  $a$ ;
- for 8-point contact scheme the distance must be between  $0.414a$  and  $a$ .

Increasing the number of contact points extends the range of tolerable distances between adjacent of them when the probability of a correct landing is 100 %.

The latter conclusion is particularly important for conditions where contact points' coordinates are unstable. If, for example, random deviations of the contact points' coordinates are 5-10% of circumcircle radius  $R$ , it is impossible to reach 100% chance of a successful landing for 3-point and 4-point contact schemes (Figures 11, 12), but this is possible for 6-point and 8-point schemes, and the range of tolerable distances between adjacent contact points is rather wide.

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## **AUTOMATIC TOOL PATH GENERATION IN CONTOUR MILLING USING GENETIC ALGORITHM**

***Abstract:** The purpose of this paper is to present new approach in automatic tool path generation in contour milling based on genetic algorithm and bitmap representation of work piece and additional resources. It deals with the problem of tool path generation and optimization in contour milling which is the most common case in metalworking industry. The starting point is assumption that the geometry of initial working piece, machined part and clamping fixtures is represented as bitmaps, then the mathematical model is presented and genetic algorithm is used to generate and optimize tool path. Proposed approach greatly reduced the costs of part production through improved machining efficiency, realized through independent software solution implemented in object-oriented language Delphi and can be used as starting point for fully autonomous NC code generation.*

***Keywords:** Genetic algorithm, optimization, milling tool path, bitmap representation*

### **1. Introduction**

The problem of tool path generation and optimization in chip removal machining processes has attracted the attention of a large number of researchers for several past decades. Machining in general and milling in particular is one of the main production processes used to manufacture durable goods. The cost optimization of production processes remains one of the major focus points of machine builders world-wide. (Khatiwada, Nepali, Raj and Bhattarai, 2020). The conventional ways of selecting the tool path or programming the NC code used data from machining handbooks and the knowledge of programmer for optimal processing (Bharath and Natraj, 2018). However, the conventional or traditional NC programming when compared to the modern CNC machining has many disadvantages for instance increasing time and cost production

and, decreasing accuracy and quality of the work piece. In the literature, there is a growing trend of development and application of models for the automatic generation and optimization of toolpaths. The most common and most researched approach is the application of artificial intelligence and metaheuristics algorithms in tool path optimization and milling processing parameter's selection, as well as the application of various geometry recognition techniques starting from a 3D model or from a 2D representation of the part. is reflected in the model setting and the modeling of goals and constraints.

Bharath and Natraj (2018) stated that determining the optimal machine tool path has been proven to lead to high productivity and minimal production costs. Furthermore, they provide statistical data related to the methods used by various authors in researches, with the conclusion that Genetic

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Algorithms (GA) and Particle Swarm Optimization (PSO) method are largely used to optimize machining efficiency and when compared with other methods, the GA has been successfully applied for many optimization problems with various parameters related to tool path and effective in improving the robustness of feature selection over a range of problems.

Kumar and Khatak (2018) define the tool path as a sequence of positions within the surface to be machined and divide the surface into a grid with a finite number of squares, where each square represents one element of the tool path and the square is viewed as one point. The goal of optimization is minimization of processing time, minimization of the time required for tool change and positioning in high-speed motion, and minimization of the effect of jerk on the machined surface. The optimization is performed by applying the GA. Makhanov (1999) presents a mathematical model of a variable grid of points as a basis for path optimization in five-axis milling and provides an algorithm that generates a tool path consisting of different segments that are adapted to the type of tool movement and increases the processing accuracy. Jacso, Matiasi and Szalay (2019), presented the model of tool path generation in contour milling, which is not based on the discretization of the surface being processed, but on equations from analytical geometry and vector calculus, which assumes that the angle of engagement of the tool is always constant. The generated tool path follows the shape of the contour, that is, it enables the processing of any shape of the contour, but the model does not foresee path optimization.

The model that integrates toolpath generation and optimization is provided in the research of Barclay, Dhokia, Nassehi (2015) The model is based on the discretization or pixelization of the surface, which is processed by levels, that is, the tool

path is generated and optimized for the value of the axial depth of cut. The authors state that the problem of path generation in milling can be viewed as a TSP problem (Traveling Salesman Problem) that can be efficiently solved by applying GA. Like Kumar and Khatak (2018) the surface to be processed is modelled with a mesh with a finite number of squares, where each square represents a tool positioning point, i.e. a city through which a traveling salesman must pass, establishing an analogy with the TSP problem. They define the number of squares in the grid as finite, limited only by the resolution of the CNC machine. Car, Veza and Mikac (2004) and Essink, Nassehi, and Newman (2014) have an almost identical approach to problem modeling, with the only difference being in the structure of the GA (genetic operators, representation of genes and chromosomes, etc.). Oysu and Bingul (2009) presented an approach for milling tool path generation based on optimization of sequences of predetermined contours. This approach gives good results if there is a clear logic for the previous selection of contours,

From the previous brief literature review, it can be concluded that the presented models of automatic tool path generation and optimization are based to a lesser extent on a purely geometric approach or to a greater extent on model discretization and the application of metaheuristic methods for solving the problem of tool path generation and optimization. The lacks of the presented models are almost identical - they are applicable mainly to rough milling processes, they depend on the shape of the contour being processed and on the degree of discretization of the surface.

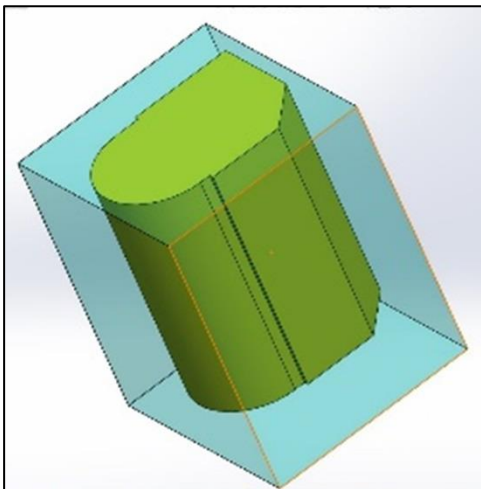
The goal of the research presented in this paper is to define and demonstrate through experimental results the concept of automatic generation and optimization of the tool path in contour 3-axis milling which is independent of the shape of the contour and



applicable for both rough and finish milling as a starting point for fully autonomous NC code generation.

## 2. The problem definition and formulation

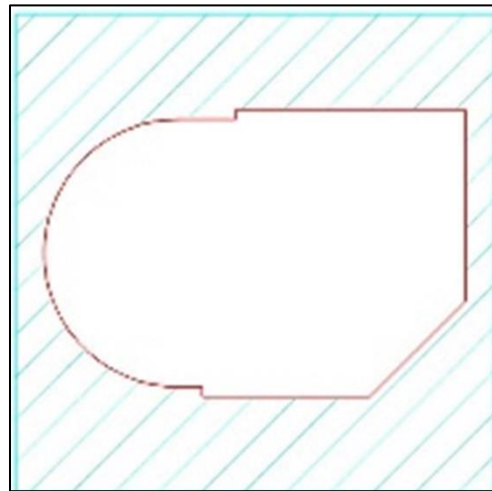
The basis for the automatic generation and optimization of the tool path is the technical documentation (technical drawing, 3D model of the part being processed, etc.) and also the initial shape of the raw material from which the part is made. The information contained in the technical documentation must be recognized in a form suitable for tool path generation. Figure 1 show a typical industrially inspired part in 3D model representation.



**Figure 1.** 3D model of work piece

Figure 2 shows a plane view of the same part, where the hatched surface represents the material that must be removed in order to obtain the shape marked in red, i.e. the final contour of the part. The shape and dimensions of the initial workpiece (marked blu in Figure 1) is predetermined and as such, represents one of the input data in the model.

In order to determine the path of the tool, it is necessary to find a measure of the discretization of the surface being processed (Barclay, Dhokia, and Nassehi 2015) i.e. to determine the size of the set of points and the position of the points that represent the positioning of the center of the tool, having in mind that the tool must be positioned at each point of that set, but also that its movement leads to processing the contour to the final size, that is, to enable the final processing. In order for the tool path to be generated, it is necessary first to determine the tool used to perform the processing and to determine the milling parameters-speeds, feeds and cutting depth. The process of automatic tool path



**Figure 2.** Planar representation of the work piece contour

generation in contour milling can be divided in three steps:

- determination of tools and milling parameters (speed's and feed's)
- discretization of the surface being processed
- tool path generation

## 2.1. Tools and milling parameters

The task of optimizing the contour milling machining is defined at the following way: select the milling parameters speed and feed that meet the quality limits surfaces and optimization criteria (Tanović, Petrakov 2007). The traditional methods for milling parameters calculation are widely known and are well described in the literature. Although the mentioned methods are applicable in everyday practice, nowadays, especially in the conditions of individual and small-batch production, data from the tool manufacturer's catalogue are most often used to determine the tool and milling parameters for the selected cutter. These catalogues are available in electronic form, so determining the tool and parameters using this data is very (ae) easy and fast. Based on the geometry of the surface and the required quality of processing, a tool of the appropriate diameter is chosen in such a way that all segments of the contour can be processed with that tool, but very often, due to the shape of the contour segments, several different tools must be selected. For the purposes research presented in this paper, it is considered that the milling process of the work piece is performed with one tool, because the principle of path generation for each subsequent tool is the same. The manufacturer of the tool according to the type of engagement (Figure 3) and according to the recommended values of the axial ( $a_p$ ) and radial ( $a_e$ ) depth of cut gives the recommended values of the milling parameters.

The radial ( $a_e$ ) and axial depth of cut ( $a_p$ ) are always given as a function of the diameter and material of the tool, the cutting speed  $V_c$  (m/min) is given depending on the material of the work piece, and the step per tooth  $f_z$  (mm/tooth) is given depending on the diameter of the tool, the type of engagement and radial and axial cutting depths. For the purpose of this paper, the speeds and feeds

will be considered as a constant value, while the radial cutting depth can exceed the value determined by the catalogue data, which depends on the contact surface of the tool and the work piece, which will be discussed later. The axial cutting depth is also constant value, but it depends on the depth of the contour, i.e. the height of the work piece, and in case the length of the cutting part of the tool corresponding to the selected sizes is smaller than the height of the work piece, the processing is performed in several passes according to the height of the work piece. Therefore, the number of revolutions of the main spindle, the speed of the auxiliary movement and the axial depth of cut are considered as constant value and with radial depth of cut along with diameter of the tool represent set of input data for the model presented in this paper.

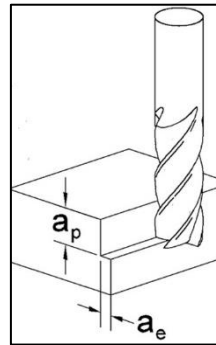


Figure 3. Tool engagement

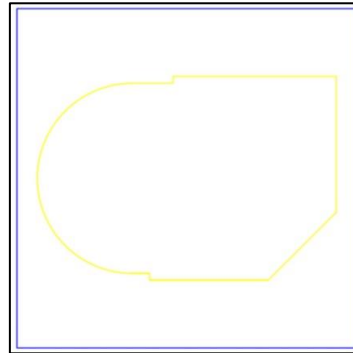
## 2.2 A bitmap based discretization model of the machined surface

In contour milling, the tool path represents an ordered set of points where the tool is positioned, moving in the direction of the auxiliary motion velocity vector. If  $n$  is the number of points in that set, then theoretically there are  $n!$  potential toolpaths. If restrictions are taken into account, then that number decreases but is still very large. Discretization can be modelled as pixelization-mapping of the surface being

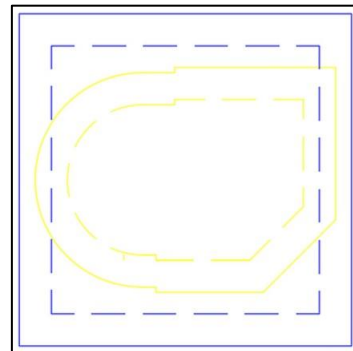
processed with a large number of squares (Kumar and Khatak, 2018) basically cover the surface being processed very well, but then their number, that is, the resolution of the grid of squares goes up to 0.01 mm is the usual resolution of today's CNC machines. Such a data set is very large for processing by metaheuristic methods, especially GA, which can lead to the fact that it is not possible to find a solution that converges to the optimal one in an acceptable time (Barclay, Dhokia and Nassehi, 2015). Other approach is surface discretization by placing up an equidistant grid of points on the surface to be processed, but this method gives good results only in cases of rough contour milling (Nassehi, Essink, and Barclay, 2015).

However, if the surface to be processed is represented as a coloured bitmap image, these drawbacks can be avoided. Figure 4 shows initial bitmap image of working piece where the initial work piece contour is coloured blue and the finished part is coloured yellow. In order to discretize a milling, feature the following algorithm must be carried out on initial bitmap image.

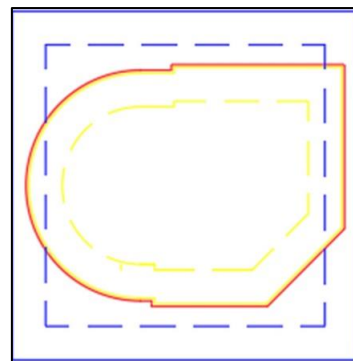
- 1) Offset all contours by tool radius to determine the boundaries of the tool positions (Figure 5)
- 2) The contour of the finished part from the previous step offset by the value of allowance for fine milling (Figure 6)
- 3) Colour the finished part and all additional resources in yellow, the allowance for fine processing in red and the rest of the space inside the initial work piece contour in blue (Figure 7)
- 4) Pseudo code of point map algorithm for discretization of machined surface is shown below:  
 for  $i=1$ , bitmapwidth step  $a_e$   
 for  $j=1$ , bitmapheight step  $a_e$   
 if  $\text{PixelColor}(i,j)=\text{blue}$  then  $P(i,j) \in M$   
 next  $j$ , next  $i$



**Figure 4.** Initial stage of discretization



**Figure 5.** Offsetting feature boundary



**Figure 6.** Offsetting for the fine milling

The colour of each pixel that is at a distance equal to the radial depth of cut  $a_e$  from neighbouring pixels is checked, and if it is coloured blue then it belongs to the set of points  $M$  through which the centre of the tool must pass in order to obtain the

machined surface (Figure 8). In this way, all illegal moves of the tool are eliminated because a collision cannot occur between the tool and the work piece or between the tool and the clamping fixture.

Example:

bitmap width:  $X=2000$  px

bitmap height:  $Y=2000$  px

bitmap resolution:  $R=1000$  DPI (px/inch) i.e.  $39.37$  px/mm

The dimensions of the initial workpiece are:

width:  $2000/39.37=50.8$  mm

height:  $2000/39.37=50.8$  mm

tool diameter:  $d=12$

radial cutting depth:  $a_e=1.2$  mm

resolution of the grid points for rough machining:  $1,2 \times 39,37=42,44$  px/mm.

The grid of points for rough machining is defined as points map  $M=[m_{ij}]$  and for above example has 762 points. For rough machining it is more than enough. For fine machining the same algorithm is processed, but with one difference. Every pixel is a point in point map for fine machining (pixels colored in red in Figure 7), and if the allowance for fine machining is 0,2 mm which is common value taken from everyday practice then the number of points in point map for fine machining is 672 points but with resolution of 0,02 mm/px ( $1/39,37$  px/mm) which is enough for fine machining.

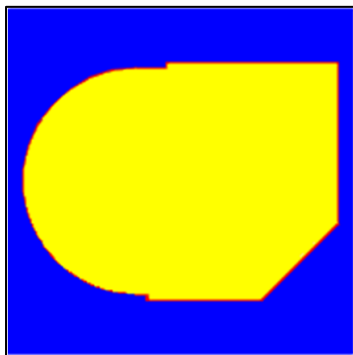


Figure 7. Step 3 of point map algorithm

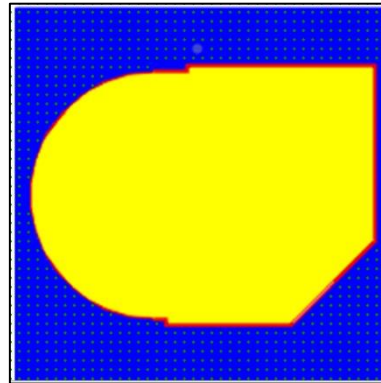


Figure 8. Imposed map of points

The necessary bitmap image (Figure 7) for executing the point map algorithm is very easy to obtain from any CAD software. Radial depth of cut  $a_e$  or *stepover* is the percentage of the tool diameter engaged in material (Figure 9).

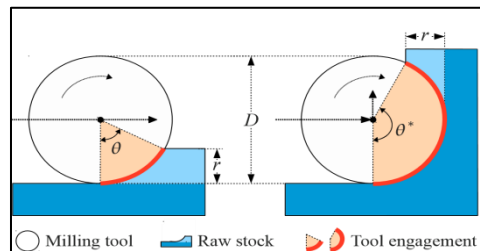


Figure 9. Radial depth of cut and TEA

The stepover determines the material removal rate (MRR) and reflects the cutting forces, but only for straight line motions. A parameter which better reflects the cutting force, regardless of the toolpath shape, is the *tool engagement angle-TEA* (Dimitrache, Borangiu and Dogar, 2010) as the amount of sweep subtended by each cutting edge as it engages and leaves the stock. For straight line motions, there is a direct, nonlinear relationship between tool engagement angle and stepover (Tanović and Petrakov, 2007). The engagement angle reaches its maximum ( $360^\circ$ ) when plunging the tool vertically into the material. The next maximum value,

180°, is encountered during a slotting operation; this condition may lead to high thermal stress on the tool, since the chips cannot be evacuated properly. Tool engagement is also known to increase at internal corners in toolpath. The engagement angle also has direct influence on the chip shape, therefore keeping TEA constant ensures consistent chip size and shape throughout the milling process (Dimitrache, Borangiu and Dogar, 2010). A large value of the TEA would result in a large amount of material removed, which certainly increases productivity, but then the cutting resistance is high and the wear of the tool is intense. As there are advantages and disadvantages of a larger or smaller milling angle, in the model considered in this paper, the milling angle  $\theta_{max}$  represents the input value in terms of the target value. Therefore, it is necessary to know TEA at every moment, that is, at every point of the tool path, and by comparing that value with the target, make a decision whether that segment is acceptable or not. In their research Wang, Jang and Stori (2005) presented in detail the process of calculation TEA by determining the overlap of the pixels of the section of the circumference of the tool and the current geometry of the work piece. This way, which is common in literature, involves the discretization of the tool and surface being processed into bit matrices of 0 and 1 and is highly dependent on resolution, which can be very time-consuming and even lead to the impossibility of real-time execution. In the next paragraph, a very simple method for calculating TEA will be presented, which is based on the simulation of the movement of the tool and bitmap representation of work piece.

### 2.3 Simulation algorithm for tool engagement angle calculation

By moving the center of the tool through the points of the points map  $M = [m_{ij}]$ , the chip is removed. As shown in Figure 10, the

contact between the tool and the surface being processed is determined by the length of the circular arc between the first and last point of contact.

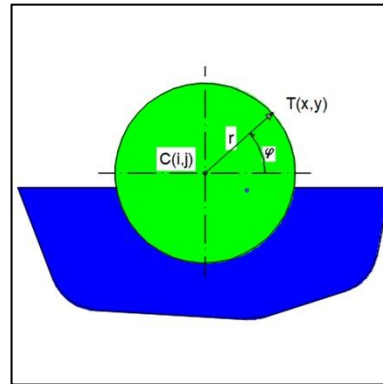


Figure 10. Calculation of TEA

Every point T on tool boundary can be represent by  $x = r \cdot \cos\varphi$  and  $y = r \cdot \sin\varphi$ . If  $r=r+1$  then all points outside the tool boundary will be checked but not on tool boundary, which is important because we need to number all blue pixels immediately behind the tool boundary, because the pixels are blue only in the points where the tool has not yet been. The pseudo code is shown below:

```

for every [mij] do
n=1
r=r+1
while φ ≤ 360° do
x = r · cosφ; y = r · sinφ
if PixelColor(x,y)=blue then n=n+1
φ = φ + 0,1
end
end
θM = n/0,02  $\frac{mm}{px}$ 
If θM ≤ θ point C is acceptable
else point C is illegal;

```

By simulating the movement of the tool as shown, it is very easy to calculate the TEA, and what is even more important, the

condition of the work piece is known in any moment i.e. where the tool has passed (white colour) and where it has not (blue colour).

### 2.4 Mathematical formulation of the proposed model

A 3 axes CNC machine moves in both  $x$  and  $y$  directions simultaneously and Euclidean distance function is to be used to calculate the distance between points. In this way a distance matrix matrix  $D=[d_{ij}]$  is created.

Let  $i$  and  $j$  be two arbitrary points from set  $M$ .

#### Input variables

- geometry described by a bitmap image
- the set of points described by the point map  $M=[m_{ij}]$ ,
- the distance matrix  $D=[d_{ij}]$  between the points of the set  $M$
- radial cutting depth  $a_e$  in mm
- maximum TEA  $\theta_{max}$  in degrees
- tool diameter  $d$  in mm
- speed of main spindle  $S$ (mm/rev)

$$\forall j \in \{0 \dots n\} \sum_{i=0}^n Z_{ij} \cdot \psi_{ij} = 0$$

- feed rate  $F_{th}$  (mm/min)
- rapid feed rate  $F_{bh}$  (mm/min)

#### Control variables of the mathematical model

$$X_{ij} = \begin{cases} 1 & \text{if point } i \text{ is immediately by } j \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

$$Y_{ijk} = \begin{cases} 1 & \text{if tool travels from } i \text{ to } k \text{ in same dir.} \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

$$Z_{ij} = \begin{cases} 1 & \text{if } j \text{ is machined} \\ 0 & \text{otherwise} \end{cases} \quad (3)$$

$$\Theta_{ij} \text{ TEA when moving from } i \text{ to } j \quad (4)$$

#### Constraints of mathematical model

1) Constraint that ensure that every point from set  $M$  is visited by the tool at least once

$$\forall j \in \{0 \dots N\} \sum_{i=0}^N X_{ij} > 0 \quad (5)$$

2) Constraint that ensure that tool leaves each point after visting for another

$$\forall j \in \{0 \dots n\} \sum_{i=0}^n X_{ij} = \sum_{k=0}^n X_{jk} \quad (6)$$

3) Constraint that ensure that every point is followed by a different point and path moves on

$$\forall j \in \{0 \dots n\} X_{ii} = 0 \quad (7)$$

4) From each subset of points the tool must be positioned at least once in another point that is not part of the of that subset of points  $\forall Q \subset \{0 \dots n\}: Q \neq \emptyset$

$$\sum_{\{i, j \in N\}: i \in Q, j \in N \setminus Q} X_{ij} + \sum_{\{i, j \in N\}: i \in Q, j \in N \setminus Q} X_{ji} \geq 2 \quad (8)$$

5) Constraint to ensure that the tool engagement angle  $\Theta_{ij}$  must be smaller or equal than the maximum allowed engagement angle  $\Theta_{max}$

$$\forall j \in \{0 \dots n\} \sum_{i=0}^n X_{ij} \cdot \theta_{ij} \leq \theta_{max} \quad (9)$$

6) Constraint that ensure that during the chip removal process, the movement of the tool is allowed only towards neighbour points.

$$\forall j \in \{0 \dots n\} \sum_{i=0}^n Z_{ij} \cdot \psi_{ij} = 0 \quad (9)$$

### The objective function

The objective function of the mathematical model represents the criteria of optimisation. In the observed model the goal is to achieve high productivity, thus minimization of processing time, with minimization of the jerk effect with as uniform tool angle of engagement as possible.

Minimization of the processing time, can be written as:

$$F_{c1} = \min \sum_{i=1}^n \sum_{j=1}^n \left( \frac{d_{ij}}{F_{rh}} + \frac{r_{ij}}{F_{bh}} \right) \cdot X_{ij} \quad (10)$$

where  $d_{ij}$  are the distance between the points of the path in which the tool moves in a feed rate and  $r_{ij}$  the distance between the points of the path in which the tool moves in a rapid rate.

The minimization of the number of changes in the direction of movement of tool, taking into account the control variable defined by expression (2) can be written as:

$$F_{c2} = \min \sum_{i=1}^{n-2} \sum_{j=2}^{n-1} \sum_{k=3}^n \frac{1}{Y_{ijk}} \quad (11)$$

The third goal of optimization is the smallest possible deviation of the TEA from the target value and can be defined as:

$$F_{c3} = \min \sum_{i=1}^n \sum_{j=1}^n |\theta_{ij} - \theta_c| \cdot X_{ij} \quad (12)$$

that is, as a minimization of the deviation of the TEA value at each point of the path in relation to the target value.

The problem of milling path optimization is clearly multi objective optimization problem. For the purpose of this research the method of weight coefficients will be applied.

Determining the weight coefficients can be a problem (Singiresu S.R., 2009) because the vector of weight coefficients controls the optimal solution. Mathematically, the optimal solution obtained with equal weighting coefficients should lead to the smallest conflict between the optimization goals, but in practice it is often not a satisfactory solution, so when determining the weighting coefficients, it is always necessary to have information in the order of priority of the goals. For the purposes of this paper, the greatest weight will be given to achieving maximum productivity so objective function is defined by following expression

$$F_c = 0,5 \cdot F_{c1} + 0,25 \cdot F_{c2} + 0,25 \cdot F_{c3} \quad (13)$$

### **3. Proposed algorithm fo milling path generation and optimization**

An acceptable milling tool path represents permutations of points while respecting the constraints defined in the mathematical model which is basically an integer programming model. Genetic algorithms, as one of the modern, metaheuristic methods, are very suitable for solving this type of problem because in most cases they can find the global optimum with a very high probability (Singiresu S.R., 2009). It should be noted that the efficiency of the genetic algorithm depends on the applied genetic crossover and mutation operators (Umbarkar & Sheth, 2015). There are many literature sources related to this method, i.e. the GA's mechanism is widely known. Furthermore, only short definitions of GA-related terms and explaining the definitions in the observed model's context are given.

#### **3.1. Definition of GA related terms in the context of observed model**

**A gene** in the observed model is the primary

carrier of informations. The point is denoted as  $M$  and every point that should be visited by the tool at least once contain the following informations:

- position defined by coordinates
- condition (machined or no)
- speed at which the tool moves towards the point ( $F_{rh}$  or  $F_{bh}$ )
- ordinal number of point in the path

**An individual or chromosome** is represented by a combinations of genes and it is acceptable solution. In the observed model. this will be acettable tool path.

**The population** is a set of individuals, and in the observed model, it will be a set of all acceptable tool paths.

**The parents** are two acettable tool paths that combine to create new tool path.

**Fitness** is a function that tells us how good each tool path is. In the observed model, the path length is the fitness and it is defined by expression (13) in the mathematical model.

**Crossover** is the genetic operator defined as combining two individuals, i.e. tool paths to create new tool path.

**The mutation** is the genetic operator defined as the process in which one individual or one tool path participates, and the goal is to generate a new tool path. A mutation changes the value of one or more genes on a chromosome. The process of implementation of genetic operator's crossover and mutation in the observed model will be explained later.

### 3.2. Chromosome representation and decoding

In the construction of a genetic algorithm, the first step is to define an appropriate genetic representation or an appropriate coding method. An acceptable representation is the most critical factor influencing all other phases of the GA (Singiresu S.R., 2009). It primarily depends on the model

being observed so that the chromosome coding solution with a vector of real components will be given.

As mentioned earlier in this paper the geometry of working piece is already recognized. The coordinates of every point is known so the distance matrix  $D=[d_{ij}]$  can be easily determined. In the observed model, the tool can pass through any point of the map of points several times, with the fact that it only passes once to remove chips, and it can pass through the same point again only for the purpose of approaching the cutting zone. Thus, the gene in the chromosome is marked with a natural number and represents the ordinal number of the point of the point map through which the tool passes. The tool can move from one point to another either at feed rate or rapid rate depending on whether the chip is removing or tool positioning is performed. Therefore, it is necessary to know the speed with which the tool moves from the point  $i$  and arrives at the point  $j$ . The next segment that describes the trajectory of the cutter is the engagement angle  $\theta_{ij}$  which can be  $\theta_{ij} = 0$  if the tool is moving at rapid rate or  $\theta_{ij} > 0$  if the tool is moving at feed rate. In addition to knowing the x and y coordinates of each path point, it is also necessary to know the z coordinate, i.e. the plane in which the center of the tool moves and the condition of the point i.e. if is previously machined o no. An example of fully decoded chromosome is given in Table 1.

The decoded chromosome enables the creation of a CL (Cutter Load) file, that is, a file that represents the basis for generating NC programs and is generated by all today's CAM systems. For example, 3-5 record in the previous table shows that the tool moved from point 3(22, 6, 50) to point 5 (26, 6, 0) at rapid rate without removing chips by positioning in the plane  $z=50$  (26, 6, 50) and rapid move to  $z=50$  (26, 6, 0). In this way, the entire path of the cutter from point



1 to point 6 can be read, with the order of movement of the tool being 1-3-8-5-4-2-10-7-9-8-3-5-6.

**Table 1.** Decoded chromosome

	1	3	8	5	4	2	10	7	9	8	3	5	6
F (mm/min)	$F_{bh}$	$F_{rh}$	$F_{rh}$	$F_{rh}$	$F_{rh}$	$F_{rh}$	$F_{rh}$	$F_{rh}$	$F_{rh}$	$F_{bh}$	$F_{bh}$	$F_{rh}$	$F_{rh}$
$\theta_{ij}$ (°)	0	40	42	25	30	35	39	41	42	0	0	0	30
x (mm)	20	22	24	26	28	30	32	32	34	24	22	26	26
y (mm)	6	6	6	6	6	6	6	6	6	6	6	6	10
z (mm)	50	0	0	0	0	0	0	0	0	50	50	0	0
Machined	true	false	false	false	false	false	false	false	false	true	true	false	false

### 3.3. Initial population

Using the distance matrix  $D=[d_{ij}]$ , it is necessary to form another set of points which is very important for generating the initial population. That set K is the set of the closest points of each point of the point map, which contains all the k closest points to the point where the center of the tool is located. In the observed model, there can be up to 24 closest points to each point of the point map, and the x and y coordinates of the members of that set tell to which point the tool can move from any current point of the path. By forming the set K, a part of unacceptable or illegal paths is eliminated, i.e. the constraint defined by expression (9) is implemented. When all points of set K is visited by the tool then next random point of tool path is chosen. At the initial moment, only the points located in the first and last row and the first and last column of the map of points have the condition  $machined=true$  and that point are peripheral points status of peripheral points, all other points have the status  $machined=false$ , i.e. the status of unprocessed points. It is clear that the first point of any milling path must be one of the points with status  $machined=true$ . Furthermore, the algorithm for forming the

initial population is given below:

**Step 1:** Randomly select the initial point from the set of points M with  $machined=true$

**Step 2:** For a randomly selected point from step 1, load the previously determined set of nearest points K to the randomly selected point.

**Step 3:** Randomly choose one point from the set K in the label j that has the status of an unprocessed point i.e.  $machined=false$

**Step 4:** Calculate the milling angle  $\theta_{ij}$  when moving from i to j.

**Step 5:** If  $\theta_{ij} \leq \theta_{max}$ , point j becomes a tool path point. If  $\theta_{ij} \geq \theta_{max}$  then go to step 10.

**Step 6:** Assign status  $machined=true$  at point j.

**Step 7:** Calculate the vector product of vectors and  $\vec{ix}\vec{j}$  if the vector product is different from zero, increase the control variable  $t=t+1$ , if it is equal to zero, the control variable t keeps its previous value.

**Step 8:** Calculate  $|\theta_{ij} - \theta_c|$ . Control variable  $d=d+|\theta_{ij} - \theta_c|$ .

**Step 9:** Check the statuses of the neighboring points of point j. If the statuses are  $machined=true$ , then point j becomes a

peripheral point, ie. the status of point  $j$  machined=true

**Step 10:** Repeat steps 3-9 for each point from the set  $K$ .

**Step 11:** Repeat steps 1-10 for each point in the set  $M$  until all points from the set  $M$  have status machined=true

**Step 12:** Repeat steps 1-11 for each individual from the initial population

By forming the initial population whose size is the input parameter of the genetic algorithm, the initial set of possible tool paths is formed. By choosing the parents, that is, two tool paths, and applying the genetic operators of crossover and mutation, and calculating goodness for each individual, that is, for each tool path, a path that converges to the optimal path is reached.

### 3.4. Fitness calculation

Fitness is a function that defines how good is the created tool path. This implements the goal function given by expression (13) in the mathematical model. The fitness calculation is done with each tool path in the population. The algorithm for fitness calculation is simple and in fact it is the calculation of the variables ProcessingTime, DirectionChange and Deviation.

The ProcessingTime variable is determined as the time it takes the tool to cover the distance between each two adjacent points from the previously formed tool path, taking into account whether the tool moves between the points at a rapid rate or a feed rate. The ProcessingTime is calculated for each path from the population.

The variable DirectionChange is determined as the number of changes in the control variable  $t$  (defined in step 7 of the algorithm for creating the initial population) in the tool path. The number of changes in the control variable  $t$  is calculated for each tool path in the population.

The Deviation variable is determined as the sum of the differences between the TEA and the target value of the TEA. The sum of the differences is defined by the control variable  $d$  (step 8 of the algorithm for creating the initial population). The deviation variable is calculated for each tool path in the population.

When these variables are determined, the fitness of the tool path, is calculated. The calculation method is given by the following pseudo code:

```
Set the TopPath variable to 0
for I=1 do Population size in steps of 1
Assign the  $i$ th toolpath to the variable C1
C1=Path(I)
Assign the toolpath to the variable C2 with the index TopPath C2=Path(TopPath)
If
0.5*ProcessingTime(C1)+0.25*DirectionChange(C1)+0.25*Deviation(C1)<
((0.5*ProcessingTime(C1)+0.25*DirectionChange(C2))+0.25*Deviation(C2))+0.25*Deviation(C2)
Assign the value of the  $i$ -th index to the variable TopPath, that is, save the value of the best fitness in the variable TopPath.
Go to the next passage
```

### 3.5. The parents

The parents represent two toolpaths that combine to create new toolpaths. The selection of parents or paths is done by comparing their fitness. It is clear that the parent should be the path that has the shortest length (the greatest fitness), and when this is determined by comparing with the fitness of other paths, then the logical variable *parent* is assigned the value of truth, ie that path is chosen in the set of paths for crossover. The comparison is repeated until the number of iterations defined by the size of the set of parents, which represents the input size of the genetic algorithm, is fulfilled.

### 3.6. Crossover operator

The crossover is a process in which two individuals are combined to obtain new individuals, ie the selection process selects parents and the newly created individuals are children. The genetic material of a child is a combination of the genetic material of both parents. With the fact that in the problem of path optimization for milling processing, the same points can be included more than once in the same path, so specific crossover operators are used to implement crossing, so specific crossover operators are used to implement the crossing. The reviews of the most common crossover operators used in GA are given in (Umbarkar, Sheth 2015) and in (Padmavathi, Yadlapalli 2017). The Order-base Crossover (OX) operator, was chosen for the realization of crossover operation in this paper. It constructs an offspring by choosing a substring of one parent and preserving the relative order of the elements of the other parent. For example, the following two parent strings: (1 2 3 4 5 6 7 8) and (2 4 6 8 7 5 3 1), and suppose that a first cut point between the second and the third bit and a second one between the fifth and the sixth bit is selected. Hence, (1 2 - 3 4 5 - 6 7 8) and (2 4 - 6 8 7 - 5 3 1). The offspring are created in the following way. Firstly, the string segments between the cut point are copied into the offspring, which give (\* \* 3 4 5 \* \* \*) and (\* \* 6 8 7 \* \* \*). Next, starting from the second cut point of one parent, the rest of the elements are copied in the order in which they appear in the other parent, also starting from the second cut point and omitting the elements that are already present. When the end of the parent string is reached, we continue from its first position. In those example, this gives the following children: (8 7 - 3 4 5 - 1 2 6) and (4 5 - 6 8 7 - 1 2 3).

### 3.7. Mutation operator

Mutation is a process in which one individual or one tool path participates, and the goal is to generate a new tool path. A mutation changes the value of one or more genes in a chromosome. As the gene in the optimization model is a point with coordinates that describe it, which cannot be discarded, and the chromosome represents the path of the tool, there is a specificity of the mutation process in the observed model. Namely, in the classic TSP model, at the point where the mutation is performed, 0 turns into 1, and vice versa. The goodness value must be calculated for the newly created individuals. Thus, a new population is formed, with the same number of individuals as at the beginning. However, in the model for determining the tool path in the the contour milling, it is not possible to remove the gene, because the gene is a point, and the path must include all points at least once. For this, the mutation is done by the process of inversion, that is, by replacing the places of two points in the path with a correspondingly low probability, which represents the input data of the GA. After changing the points in the path, the acceptability of the newly created path is checked, that is, the angle of engagement is checked. Points are chosen randomly until points satisfying the previous condition are found.

#### Pseudo code of proposed GA

Input parameters for GA shown in this paper are: Set of point M, TEA target value, diameter of the tool, the population size, the number of parents, mutation rate and the number of generations.

#### Start

Enter the input parameters  
Create Points map, Distant matrix and  
Matrix of neighbors K of each point

Create Initial population  
 Calculate the fitness of individuals of the first generation  
 Generation = 1  
 Repeat  
     Selection of parents  
     Children = 0  
     Repeat  
         Pick of two parents for a crossover (Parent1, Parent2)  
         Crossover OX (Parent1, Parent2)  
         Mutation  
         Children = Children + 1  
     Until Children = population size-total number of parents  
     Generation = Generation + 1  
     Calculate the fitness of individuals for the current generation  
 Until generation = total number of generations  
**End.**

#### 4. Presentation of the independent software solution, experimental results and discussion

The application in which the previously presented solution is implemented is written in the object-oriented programming language Delphi. Bitmap representation of the image is created base on industrially inspired part in Autocad. Figure 11. shows the initial form of the application. The application consists of several parts:

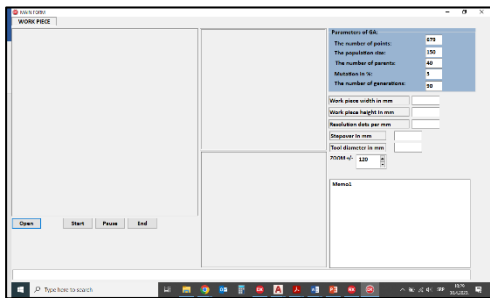


Figure 11. The initial form of the application

In the left is a window where bitmap image is displayed, in upper right corner is the part for entering the genetic algorithm's input parameters, and in the middle there are panels that monitor GA executions, in which the graphic representation of the current tool path is simultaneously displayed. After loading the application, user must choose bitmap by pressing the Open button. By pressing the Start button execution of GA begins with creation of points map, as shown in Figure 12.

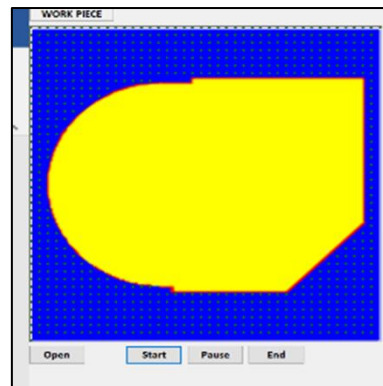


Figure 12. Creation of point map

The middle panel showing current data and graphical display during GA execution and the lower right part of the input screen represents the space in which, during and after the genetic algorithm's execution, the GA execution results are displayed. After the proces of generating and optimizing the tool path) the data necessary for NC code creation are written in a sort of CL (Cutter Load) file prepared for the processing in the appropriate post processors of CNC machines.

##### 4.1. Experimental testing of proposed GA

Unlike many examples that can be found in the literature, where the results of GA execution are shown by varying the degree of mutation, population size, number of

parents, etc., in this research, the proposed GA was previously tested by varying the previously mentioned parameters in order to find the optimal parameters. The tests were done with a constant value of TEA=40 degrees. Then GA was tested by varying TEA and radial depth of cut (stepover) according to Table 2 (Dimitrache, Borangiu and Dogar, 2010).

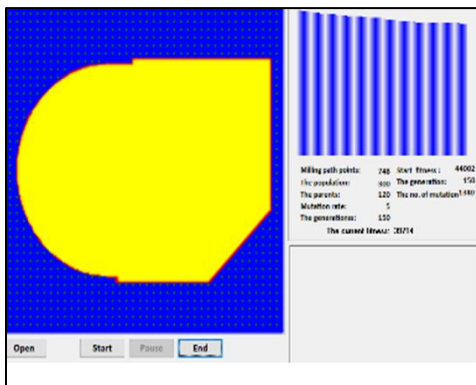
**Table 2.** Relation between  $a_c$  and TEA

$a_c$	10%	25%	50%	75%	85%	95%
TEA	37°	60°	90°	120°	135°	155°

During the extensive testing of GA, it has been shown to give the best results for:

- population size=300
- the number of parents=120
- mutation=5 %
- the number of generations=150

Fitness value was 39714 (Figure 13). With these parameters GA was tested for TEA value given in Table 2.



**Figure 13.** Results of GA testing

The results of GA testing for different TEA values are given in Table 3. It is clear that fitness or the path of the tool that converges to the optimal one, is highly dependent on TEA, because in the formula for calculating the fitness, the highest weight coefficient is given to the objective related to the length of the path.

**Table 3.** Relation between TEA and fitness of the proposed GA

Fitness	39714	20584	16249	11435	10024
TEA	40°	60°	90°	120°	150°

From the results shown in Table 3 it is clear that it is necessary to find the optimal ratio of the diameter of the tool, the tool angle of engagement (TEA) and the radial depth of the cut to have a tool path which converges to optimal one. The results of the previous experiment were needed to carry out the experiment in the real production conditions using the coordinates of the points obtained by executing the proposed GA.

#### 4.2. Experimental testing of proposed GA in real production conditions

The conditions of the experiment are given in Table 4.

**Table 4.** Conditions of the experiment

CNC machine	CNC milling machine IBARMIA ZVX 2000
Control unit	HEIDENHAIN TNC407
The machine working space	2500x500x600 mm
Tool	Carbide millin cutter: HK16822161 Ø16x63x125 mm, 30° TiAlN
Initial work piece dimension	50x50x70 mm
The dimension of finished work piece	40x30x59,9 mm
Materijal	1.4301
Speed of the main spindle	S=1600 o/min
Feed rate	$F_{rh}=100$ mm/min
Rapid rate	$F_{bh}=4000$ mm/min
Radial depth of cut	$a=2$ mm
TEA max value	$\theta_{max}=40^\circ$
The clamping of the piece	Shown on Figure 14
The operation	Contour milling



Figure 14. Clamping of work piece



Figure 15. Finished part

By executing the NC program where the path of the tool was obtained by executing a previously defined algorithm implemented through several programming codes of the Delphi language, the machined contour was obtained, which is shown in Figure 15. It should be noted that the central hole was not the subject of this experiment, but was done due to the test of the drilling tool. By measuring the overall dimensions of the processed piece, it was determined that all dimensions except the width of the piece of 30 mm are within the tolerances of the free measurements, and that the measures of 30 mm deviates by +0.2 from the tolerance of

the free measures, which may be a consequence of inadequately entered correction of the cutter diameter. Figure 16 shows (circled in red) the deviation from the contour defined by the drawing in the transition area (the contour is shown in Figure 13) from a straight line to a curvilinear contour, which is a consequence of the irregular arrangement of points in the map of points in this zone, so that the algorithm for placing the map points should be revised and eventually corrected.



Figure 16. Deviations from measures and shapes

The surface roughness of the machined surface was not measured because it was not part of the experiment. The purpose of the experiment is to determine deviations in the dimensions and shape of the finished piece during processing with the NC program, basically generated by the application of the algorithm described in point 2 of this paper. The total machining time of the piece was 6 min and 15 s. It was concluded that it is necessary to perform another experiment with a corrected algorithm for setting the point map and measuring the surface roughness, comparing the measured values with those required on the drawing of the piece, in order to obtain more complete results of the application of the proposed tool path generation model in contour milling.

## 5. Conclusion

For the classical method of creating NC programs, qualified operators, complex and often expensive software CAM packages are needed, the time of creating the program is relatively long, and there is no guarantee that the time of creating the part will be the least, that is, that the production costs will be reduced to a minimum, because the effectiveness NC programs largely depend on the knowledge or experience of the programmer or operator. One of the alternative approaches, presented in this paper, is the complete autonomy of the NC code generation process during contour milling based on the existing or recognized work piece geometry.

The paper provides a detailed description of the algorithm for mapping the surface to be processed, which, based on experimental results, must undergo minor correction in the part when the length of the contour segment

is less than the recommended radial depth of cut. Also, the cutting zone and the method of calculating the parameters are defined, before all angles of engagement in the cutting zone, and a detailed description of the genetic algorithm used to solve the optimization problem is given. Complete automation of the process is possible as a subject of further research, but it requires very complex computer programming, especially in the part related to the transformation of the coordinates of the optimized path into NC code, taking into account the variety of control units that can be found on modern CNC machines. Also, further research is needed in order to evaluate presented GA with other crossover and mutation operators to improve the speed of execution. The proposed GA was tested only for rough machining and having in mind that the presented algorithm for fine contour milling is the same, the further research will refer to testing and possible corrections for fine contour milling,

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## **QUALITY CONTROL IN THE MANUFACTURING INDUSTRY BASED ON THE APPLICATION OF COMPUTER VISION**

***Summary:** Application of technologies based on information communication systems, internet networks, embedded systems, data storage in the cloud, computer vision, machine learning within manufacturing industry leads to a number of advantages in the quality control process. The goal of the work is the development of the system for quality control within production industry with the application of computer vision and algorithms for comparison and analysis. The secondary goal of the work refers to the storage of data on product quality and the control of production machines based on the analyzed data. The result of the application of the mentioned system is reflected in the identification of non-compliant products, which will lead to a reduction of the company's losses.*

***Keywords:** Industry 4.0., Quality 4.0., Cloud, OpenCV, Computer Vision, CNN, SSIM, IOT*

### **1. Introduction**

Product quality control within the manufacturing industry is one of the most important indicators of success companies. The very development of technology and its use within the industry leads to a greater number of detection methods non-conformities and quality control. As the area of the manufacturing industry itself differs from company to company, as well as the non-conformity that can be presented in several ways, several methods of quality control can be applied. One of the ways of quality control is computer vision, which has a huge advantage over manual ways of quality control in terms of the adaptability of the system to a specific purpose, the application of deep learning in the process of making a decision on non-conformity, algorithmic systems (Rožanec et al., 2022, Louw et al. , 2019, Yang et al., 2020).

This technology also has limitations, so it can be used to detect text, color, dimensions, and scratches. The accuracy of the obtained data depends on several factors, the most important of which relates to the algorithm itself used to detect inconsistencies, external factors such as lighting, vibrations, equipment quality, while the speed of the system is directly related to the hardware. The advantage of applying computer vision compared to manual methods of quality control are certainly based on speed, timely information in real time, smaller losses, reduced costs of finishing products or semi-products, reduced production of scrap products, which directly affects company profits (Yang et al., 2020). In addition to the large number of systems based on the application of computer vision for quality control, this area is still under-researched, it is necessary to strive for the development of less complex systems that

will require less software and hardware power and that will achieve results at the same speed. Accordingly, there is a need for the development of this system that will contribute to the efficiency and speed of product non-conformity detection. The main goal of the system developed and presented in this work is the development of a quality control system based on computer vision, where the focus is on external non-conformities of products within the manufacturing industry, where the amount of funds needed for its implementation should be taken into account. The advantages of using this system can be seen in the training of the system where convolutional neural networks were used, the use of which significantly accelerated the training, which makes the system much more adaptable to needs.

In the continuation of the work, a review of the literature will be presented, which will include the current technology that has been applied in the field of product quality with the use of computer vision. Application of Industry 4.0. as well as the very technologies it includes for solving problems in the quality control process.

## 2. Literature review

### 2.1. Quality control in manufacturing industry

Quality control within the framework production industry can be seen as a process that consists of two sub-processes that make up the identification of quality and quality comparison (Powell et al., 2021;). The quality identification process can be seen as the process of determining the current quality of the product by various measurement methods, the comparison process involves comparing the identified quality with the results that need to be achieved (Powell et al., 2021;). Quality of the product is closely related to the user of

the product or service, which is actually a determinant of the level of required and achieved product quality (Rodrigues et al., 2020; Powell et al., 2021;). Seen from the side of the customer or user of the product on alone Product quality is affected by a number of factors of the same and which are often defined standard or user requirements (Carvalho et al., 2021; Rodrigues et al., 2020 ;). Also, the time of use of a product can define the necessary quality when it is used in industry or when it is used for general use. Quality can be expressed in a number of ways, the basic way of expressing quality is numerically, that is, when talking about some numerical values, it can also be expressed in nominal scales, descriptively, yes or no.

### 2.2. Computer vision

Computer vision as the basis of the system presented in this work is based on the acquisition, processing and creation of data. The technological pillar of computer vision is based on the use of a camera that is applied for the data acquisition process (Stavropoulos et al., 2020;), and it can be applied industrial dedicated cameras as well as general purpose cameras. When it comes to data processing itself, it can be performed in several ways, the most common used by industrial computers while they are all more commonly used general purpose computers viewed from the aspect of finance (Stavropoulos et al., 2020;). The basis computer vision consists of algorithms applied for object tracking, dimensional control, object selection, object recognition, etc. (Stavropoulos et al., 2020;). The complexity of the algorithm directly affects the speed of the system, which is of high importance in some application cases. In order to increase the speed, they are often used and neural networks (Almazán-Lázaro et al., 2022;). In order to achieve satisfactory system performance, which is reflected in accuracy, speed, and the necessary financial

resources, it is necessary to strive to reduce complexity of the algorithm and at the same time maintain or increase its accuracy (Almazán-Lázaro et al., 2022;). In order to achieve satisfactory system performance, which is reflected in accuracy, speed, and the necessary financial resources, it is necessary to strive to reduce the complexity of the algorithm and at the same time maintain or increase its accuracy (Almazán-Lázaro et al., 2022;). Also, the very functionality of the computer vision system can be affected by external factors such as lighting, image resolution, vibrations, distance, etc., in order to increase accuracy of these systems, it is necessary to strive to reduce the influence of the mentioned factors. Today, computer vision finds application in many industrial fields, and its contributions in the application of control quality can be observed through the reduction of scrap, reduction of the number of finished products, controlled production, implementation on industrial robots where it increases the precision of the robot's gait as well as the download position, recognition of different situation, product palletization, control of industrial lines, reduction of the required number of employees in quality control positions (Vukicevic et al., 2019).

### 2.3. Industry 4.0.

Application of Industry 4.0. in the quality control process, it enables the implementation of modern technologies that directly affect the quality control process itself (Culot et al., 2020). The main goal of the application of Industry 4.0. is based on easier and faster execution industrial processes, obtaining more accurate data, reducing the possibility of errors, all with a combination of the application of already implemented technology and new ones (Bigliardi et al., 2020; Horváth et al., 2019). One of the indicators of success applications of industry 4.0. is also reflected in process

control, adaptability system, availability (Albers et al., 2016). The application of internet networks, sensor systems that can independently communicate and collect data is called IIOT (Industrial Internet of things), also this technology includes a database as well as control industrial machines (Bal et al., 2019; Muller 2019; Tupa et al., 2017, Singh et al., 2019). Seen from the side of software that is applied within Industry 4.0. and depending on herself there are a number of industrial areas software systems, tools that lead to cost reduction, faster work, increase efficiency and effectiveness as well as loss reduction (Mijailović et al., 2020). From the hardware perspective of Industry 4.0. implies the application of microcontroller platforms, programmable logic controller, which together implemented in the quality control process and within one machine represent embedded systems (Pasika et al., 2020; Izaddoost et al., 2020; Kullig et al., 2020). Big data provides the ability to store large amounts of data that can be analyzed further to help predict future system failure. With the use of industrial cameras, it is possible to obtain quality data, which further, with the use of deep learning, can lead to a reduction in the possibility of errors. (Maurizio et al, 2021).

### 3. Case study

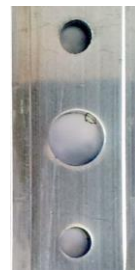
Within this chapter it will be presented a system that was developed for visual quality control in the production industry of small and medium-sized companies with the use of opencv library, computer vision, cloud system, CNN (Convolutional neural network). Since quality control is performed manually in most small and medium-sized companies, the goal of this paper is the development of an adaptable system for application in the field of visual quality control. Current quality control process: an employee from the quality department supervises the production as well as the products themselves, controlling the

essential characteristics of the product for its functionality. Which means that an employee periodically monitors a production machine and the semi-finished products it produces, as he needs a certain amount of time to check all machines. According to the above, if after the departure of the employee who will perform the quality control process on a certain machine, it produces a non-compliant product, it will continue to do so until he reaches the same machine again. The presented problem can be solved with the application of computer vision if it is a surface one non-compliance. The working principle of the presented system is as follows: based on data acquisition, their processing is performed, after which the system's reaction and data storage take place. Acquisition process data processing is done with the help of system hardware using a camera, data processing in the specific case of photos is done with the use of opencv libraries, TensorFlow library, CNN (convolutional neural network) and non-conformity detection algorithms, the system's reaction is the process of stopping further production if the defined number of non-conformities is exceeded products, data storage is done in real time on the cloud system.

### 3.1. System software

The work process of the presented system can be observed in the following way, when starting the system, it is necessary to initially train the system, that is, to define the non-conformity detection classes. The user of the system performs the training by placing images of non-compliant products in the database from where the system will use these images as reference images, that is, images with which it will compare new images downloaded from the production machine. After training, the system can be put into operation, training must be performed every time the product is

changed. Based on training and neural networks as well as a comparison algorithm, the system recognizes non-compliance, prints the result of non-compliance in percentages and stores the data on the cloud. Within the aforementioned system, the SSIM (Structural Similarity Index) algorithm was used, which compares pixel by pixel the reference image and the image currently collected by this system, calculates the squared error that is created and caused by different pixels. On the very result of algorithm and the accuracy of the system can be affected more factor, the position of the camera must always be in the same location in relation to the product, lighting can affect the quality itself photos and thus the result algorithm, if it is necessary to add the source of illumination must be addressed attention to the product itself, must not come to glare or shadows, vibration is essential prevent them from affecting the movement cameras. In Figure 2, you can see an example of an image of a compliant product that was used to test the operation of the algorithm, all tests of the algorithm were performed within the premises university, laboratory center for quality.



**Figure 2.** Example of a compliant product  
Source: Author

It can be seen in Figure 2 example of a compliant product that does not have a non-conformity. After placing one or more reference images, the user of the system, as well as placing the hardware at the physical location where the acquisition will be

performed, can start the system. The system can also be used to check products for non-compliance or if already collected images are used. In Figure 3, you can see the non-conforming semi-product that was used in the comparison process.

As can be seen in Figure 3. the product has damage caused during the production process. When comparing picture 3 with picture 2, the result of the algorithm is 0.9258, i.e 92.5% similarity. Figure 4 shows the result of the algorithm.



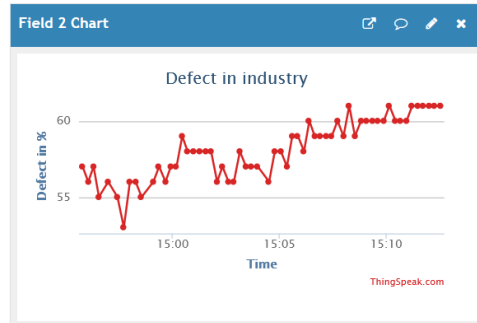
**Figure 3.** Non-compliant product  
Source: Author

```
SSIM compare 1 image A new and image B: 0.9258742417832705
SSIM for compare 2 image A new and image A: 1.0
```

**Figure 4.** Comparison result  
Source: Author

As can be seen from the results of the algorithm, the similarity of image 2 and image 3 is 92.5%, i.e. 7.5% are non-compliant pixels in the specific case of non-compliance. After the collected and processed data is stored on the cloud system in thingspeak cloud was used within this system, an example of stored data collected by this system can be seen in Figure 5.

We can additionally process and display data stored in the cloud in several ways, the advantage of cloud data is its availability.



**Figure 5.** Data stored in the cloud  
Source: Author

## 4. Discussion

After analyzing the work of the sector for quality in small and medium-sized companies in Serbia, it was concluded that the quality control process is still carried out manually today mainly due to the amount of funds needed to implement modern solutions. When it comes to the funds that will be invested in the system, it is necessary to reduce the error of the system by reducing the price, to adjust system performance available hardware, enable simple user interaction. An advantage this system can be viewed from the aspect of adaptability in terms of changing the image acquisition location itself, even though it is embedded-implemented in an already existing system or machine, it can be moved to another location. On the other hand, the disadvantages of the system are its sensitivity to external factors that directly affect the quality system operation. The implemented system is implemented on one production machine, which means that it is necessary on every machine implement the same system where they would get a wide network of data and control over the entire production of a company, which is actually another goal. By reducing the occurrence of non-compliant products or even their complete elimination, the company's profit is directly affected, as well as the efficiency

and speed of production response to market demand, quality increases production.

## 5. Conclusion

The initial goal of this study which refers to the development of the control system product quality within production industry was successfully implemented, the results of the system are presented. The presented system is a universal solution that can be applied both on the production machines themselves and can be set up within the quality center for quality control of several different products. Depending on the location of the system application, it is necessary to pay attention to the external factors that may affect accuracy the result of the system. Collected and presented data is stored on cloud system in real time, as far as possible allows viewing of data in each moment. If viewed from the aspect networking of the entire production of one companies where on every production if one such system were implemented in each machine, they would have an overview of the current state of production, where they would have a defined number of non-compliant products, good products and products that are going to be finished. Also, by networking the machines, we can obtain data on the total efficiency for each of the machines in production. Quality control

represents one of the most important processes in every production company which is from of essential importance for the development of the company as well as the ultimate profit of the company, hence the goal for the development of the quality control system, the secondary goal starts from the fact that there are currently not enough experts in the field of quality control, also the application of such systems reduces the need for experts and increases the availability data. The limitations of this study are related to external factors that can affect the accuracy of the system, one of the main factors is related to the position of the product that the camera will photograph, the product must always be photographed in the same position so that the data is as accurate as possible. Given that the system is based on the application of the ssim algorithm, which is in conjunction with CNN, and functions in the manner presented in this study, it represents a unique solution based on the goals of this study. Future directions of research will be based on the implementation of several different algorithms in the process of detecting non-compliant products, which will further reduce the possibility of system errors, as well as reducing the influence of external factors on the operation of the system.

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## DETECTION AND RECOGNITION OF ROAD SIGNS USING YOLOV5

**Abstract:** *In the field of deep learning, a convolutional neural network is a class of artificial neural networks that became dominant in various computer vision tasks, which is widely used to solve complex problems in various areas, including driver assistance systems in the auto- motive field. Convolutional neural networks overcome the limitations of others conventional machine learning approaches since they are designed to automatically and adaptively learn the spatial characteristics of features in an image. In this paper, we are going to evaluate the inference and accuracy of YOLOv5s, for effective traffic sign detection in various environments.*

**Keywords:** ADAS; CNN; traffic sign detection; YOLO

### 1. Introduction

Road signs are as old as the roads, traffic signs are a crucial part of our road infrastructure, they provide essential information to road users without these useful signs, we would encounter a higher rate of accidents.

In the race to develop autonomous vehicles, without the information of what is around these vehicles and their precise location, such a car cannot operate without risk. It is for this reason that the detection of traffic signs plays an essential role in autonomous vehicle systems, which are required to recognize and understand these traffic signs to ensure they follow road regulations.

In recent years, significant progress has been made in the field of computer vision thanks to the development of deep learning techniques such as convolutional neural networks (CNN) that have emerged from the study of the human and animal brain. In recent years, most of the state- of-the-art object-detection algorithms have used convolutional neural networks (CNNs) and

have achieved fruitful results in target detection tasks, such as EfficientDet [1] and YOLO algorithm.

YOLO [2] is an acronym for the term "You Only Look Once". It is an algorithm that identifies and detects the different objects in a real-time image. This model divides the image into several cells, if the center of an object is in a certain cell, the latter is responsible for detecting that object.

YOLOv5 [3] is the last version of the YOLO family, which is a model that consists of a single CNN which makes it very fast compared to other detection methods like R-CNN and Faster R-CNN [4].

One of the main advantages of YOLOv5 for traffic sign recognition is its speed and efficiency. YOLOv5 is based on a "darknet" architecture that is designed to be fast and efficient, making it ideal for real-time applications such as traffic sign recognition. This allows YOLOv5 to process images and videos quickly, even on low-power devices, making it a good choice for use in autonomous vehicles and other on-the-go applications. This paper contains:

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1. Briefing You Only Look Once (YOLO) architecture.
2. Identify the most effective training parameters on YOLOv5s and evaluating it's performance.

## 2. Litterature

### 2.1. Single-stage and two-stage algorithms

Modern object detection models can be divided into two categories: two-stage detectors and single-stage detectors. Two-step detection models like R-CNN use two networks to carry out the task of proposing the regions and the task of classification, while one-stage models perform both of these tasks by a single network. The proposal of the regions is carried out by what is called RPN (Region Proposal Network).

RPN is used to find areas where search for the objects in order to reduce the computation time, this is done by generating bounding box proposals each with the probability that an object exists in this region. After generating a list of locations possible objects, a convolutional feature extraction is performed on each candidate region. In the second step, the content of each framing box is classified, to decide which ones to keep and which to eliminate. In general, two-stage architectures achieve better accuracy, but they are slower than one-stage architectures. The biggest drawback of two-stage architectures is that they do not excel at performing real-time detection and require multiple GPUs to train the model[5], thus, the YOLO model has been proposed to address these limitations.

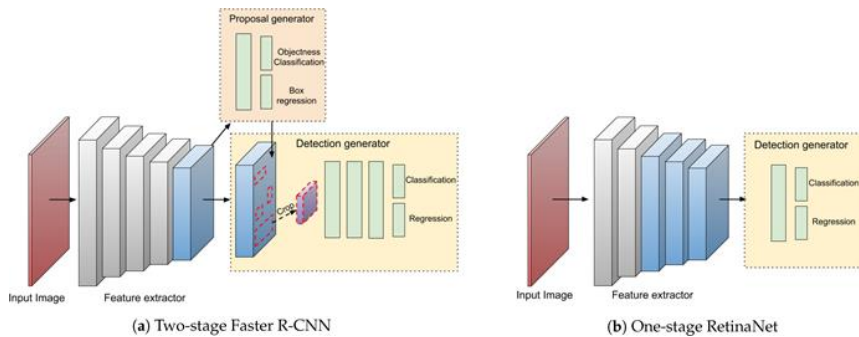


Figure 1. Example of single-stage algorithm and a two-stage algorithm

### 2.2. Introduction of YOLO

YOLO is an acronym for the term "You Only Look Once". This is an algorithm that identifies and detects the different objects in a real-time picture. This model divides the image into several cells, if the center of an object is in a certain cell, the latter is responsible for the detection of this object and it consists of a single CNN which makes it very fast compared to other detection methods like R-CNN and Faster R-CNN. In all object detection architectures, the first step is in extracting features from the input

image through a convolutional network, the depth and type of convolutional backbone used in these architectures affects the speed, accuracy, and memory usage of the model. Recent object detection models have a "Backbone" which is a convolutional neural network used to extract feature keys of an input image, the depth and the type of the convolutional "Backbone" used in the model affect the speed, accuracy, and memory usage of the model. The second component is the "Neck" which creates feature pyramids, these pyramids help models successfully generalize objects. It helps in

the identification of the same object in different scales and sizes, and performs an aggregation on the characteristics and transmits it to the third component called "Head". The "Head" part of the model is mainly used for the last stage of detection. It applies the bounding boxes to the objects and calculates final output vectors with predictions of the classes. YOLO's model can be applied in many fields which depends on fast object detection, and although the prediction speed of the model was very high, the performance was still not comparable to Faster-RCNN when it was introduced for the first time.

YOLOv2 and YOLO 9000 have been released in 2016, YOLOv2 achieved a mAP of 76.8% mAP at 67 FPS and 78.6% at 67 FPS. YOLO 9000 [6] uses the architecture of YOLO v2 but it is able to detect more than 9000 classes. However, the mAP value of YOLO 9000 is only 19.7%. The previous YOLO architecture had many problems. She made a lot of location errors and had a bad "recall". So, the objective of the new article was to improve these defects of YOLO, while maintaining the speed of architecture. YOLOv2 uses a convolutional neural network called DarkNet as feature extractor. As a result of these improvements, YOLOv2 offers a good accuracy and detection speed. At 67 FPS, YOLOv2 can give a 76.8% mAP, at 40 FPS the detector gives an accuracy of 78.6% mAP, a better accuracy than other state-of-the-art models such as Faster RCNN and SSD while running much faster than these models. The 3rd version of YOLO, called YOLOv3 was released in 2018 by the same authors of YOLO and YOLOv2. There are major differences between The architecture of YOLOv2 YOLOv3 and older versions in terms of speed and accuracy. YOLOv2 and YOLOv3 are worlds apart in terms of accuracy, speed, and architecture. YOLOv2 uses Darknet-19 as a feature extractor base, while YOLOv3 now uses Darknet-53. Darknet-53 is a

"Backbone" directed by YOLO creators Joseph Redmon and Ali Farhadi. According to their articles, Darknet-53 is 1.5 times faster than ResNet101. This accuracy means no compromise between accuracy and speed for Darknet backbones, because Darknet-53 is still as accurate as ResNet-152 but twice as fast. In addition, you can easily switch between speed and precision by simply changing the size of the model, without the need for re-train the whole model. YOLOv3 also increased mAP for small objects by 13.3%, which is a huge improvement over YOLOv2.

### 2.3. YOLOv5

YOLOv5 uses CSPNet (Cross Stage Partial Network) as a Backbone, which showed significant improvements in the time of processing using deeper networks. The problem with previous networks is that they required very heavy inference calculations. Cross Stage Partial Network (CSPNet) was created with the aim of solving this problem, by allowing networks more flexibility by including feature maps at the beginning and end of each network step. This avoids having duplicate gradients in the network, because the information is similar between the beginning and the end of each step.

In YOLOv5, PANet (Path Aggregation Network) plays the role of the Neck of the model, it consists of a series of layers to combine and aggregate the image features to pass them to the prediction layers.

The Head of YOLOv5 remains the same as the YOLOv3 [7] and YOLOv4 [8] versions. YOLOv5 has several varieties of pre-trained models. The difference between them is a trade-off between model size and inference time, The YOLOv5s version is small in size but not the most accurate, while the YOLOv5x version is the biggest in size but it is the best of the YOLOv5 family in terms of accuracy.

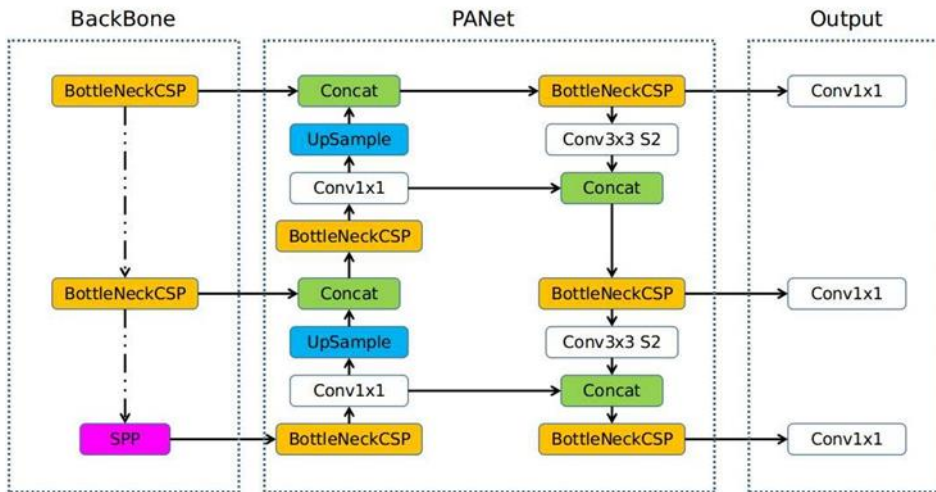
**2.4. Related work**

Current research in the field of computer vision involves building a better image detection system for comprehensive machine learning use. Each new decade have seen the introduction of new traffic signs. The first stage observes traffic signs determining the proper placement of traffic signs in relation to the size and location of each sign. The second stage of the project is the process of displaying an image and understanding the different signs based on colors and shapes associated with them. Traffic sign detection is commonly used in ADAS. Neural Network Classifiers like CNN use classifiers to categorize data in general, issues with object recognition persist in certain models with unfair highlights. Using the word CNN is more appropriate when referring to the subject.

In the last years, many researchers have worked on the detection and recognition of traffic signs using different object detection models.

Mulyanto, A. [9] used YOLOv4 to perform the detection on a dataset of traffic signs from Indonesia, since the research that was done the model showed a main average accuracy of (mAP@0.5) of 74.91% for 26 classes of traffic signs. However, the weak point of their model was the recognition of images of panels that are strongly identical, small differences between some Panel categories seem to pose challenges for deep learning and show the limitations of YOLOv4. Despite this, the model satisfies the requirements of ADAS (Advanced driver assistance system) to provide reliable information to drivers related to the presence of traffic signs on the road.

Overview of YOLOv5



**Figure 2.** Architecture of YOLOv5

C. Dewi [10] proposes a study which analyzes and compares CNN models and extractors features, in particular the two object detection models; YOLOv3 and YOLOv4. This comparison, uses images that

contains 60 traffic signs in different conditions and environments. Their work also presents an approach that combines synthetic images with real images in order to improve the diversity of datasets

and check the effectiveness of dataset synthetics. They concluded that YOLOv4 is more accurate than YOLOv3 using a dataset that combines original images with synthetic images, obtaining an accuracy of 84.9% for YOLOv3 and 89.33% for YOLOv4. This study also shows that training a model with a combination original images and generated images, improves performance when compared to the mere use of the original images.

Zhang et al.[11] modified the number of convolutional layers in the network based on YOLOv2, proposed an improved single-stage traffic sign detector and using Chinese Traffic Sign Dataset Training in an effort to make it more adapted to Chinese Street View, a novel Perceptual Generative Adversarial Networks Developed to detect small flow signs, which improves detection performance and generate super-resolution maps for small signs.

### 3. Approach

#### 3.1. Dataset

A dataset is a group of annotated images. Annotation means specifying the position and the class of the object. Each dataset contains a specific number of classes. Mapillary [12] is a crowdsourced and open-source sharing service for images, Mapillary offers different capture modes, including on foot, on a bicycle or on a car. With data from 190 countries, Mapillary Traffic Sign Dataset is one of the largest traffic sign datasets with great variability in conditions, weather, time of the day and camera sensors and viewpoints, which is publicly available for use in machine learning, to detect and recognize traffic signs.

The Mapillary traffic sign dataset of fully annotated images consists of 52,000 images that reach a total size of 41.5 GB, distributed over more than 300 different classes. Because of ram and storage limitations, it

was necessary to choose a few classes among these 300 classes to work on them. The following classes were retained with a total of 5772 instances:

- regulatory-keep-right-g1: 1242 instances.
- regulatory-no-entry-g1: 2048 instances.
- regulatory-yield-g1: 2775 instances.
- warning-pedestrians-crossing-g4: 1124 instances.
- regulatory-stop-g1: 1386 instances.

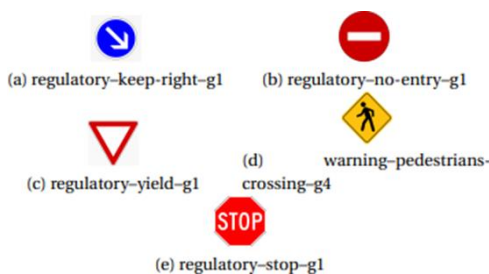


Figure 3. Retained classes for training

#### 3.2. Training the model

The models are trained on 5772 instances from the Mapillary road traffic signs dataset in five classes: keep right, no entry, yield, warning pedestrians crossing and stop. The model is trained for 200 epochs, with batch sizes ranging from 32 up to 80 using Google-Colab's Tesla T4 GPU, and 16GB of VRAM. Google Colab is a hosted service of Jupyter notebook that requires no configuration and allows access without charge to computing resources, including GPUs. Google Colab is a complete tool for training and testing quickly machine learning models without having a hardware limitation.

Before the training process, it is necessary to divide it into three parts: training, testing, and validation.

The training data will be used to train the model during the machine learning process. The validation data will be used to tune the

hyperparameters to achieve the best possible configuration. The model is trained on the training set and simultaneously evaluated on the validation set after each epoch to optimize the model performance.

The test data will be used to verify the performance of the trained model, in order to avoid errors or anomalies, and to achieve performance characteristics such as accuracy and recall.

There are no strict rules on partitioning, but if there are multiple hyperparameters to tune, the machine learning model requires a larger validation set than in less complex cases, typically putting 70% of the data in the training set, 20% in the validation set, and 10% in test set. To start the training, it is necessary to specify the dataset, the batch size (batch-size), image size (image-size), and either weights pre-trained or randomly generated weights. Before changing any parameter, it is recommended to train the model first with the default parameters to establish a performance base on which to improve.

Epoch: At each epoch, an entire data set is transmitted to the neural network once. As the number of epoch increases, the weights of the neural network are modified more times and the model goes from underfitting to an equilibrium point and then to overtraining.

Ultralytics suggests starting with 200 epochs. If this produces a overfitting we reduce the epochs. If overfitting does not occur after 200 epochs, one trains the model longer, i.e. 300, 600, 1200 epochs, etc.

Batch-size: Since an epoch is too large to transmit it to the neural network at a time, it must be divided into several batches (batch) smaller. The batch size or batch-size is the number of samples (in our case, the pictures) in each batch. In the case of YOLOv5, it is better to use the largest batchsize allowed by our hardware, since a small value of batch-size produces poor batch standard statistics and should be avoided.

Image size: The larger the image size, the results are generally better, but the model takes longer to train, the default image size value for YOLOv5s is 640, in most cases of good results can be obtained without modification on the default value of image-size, so the value 640 is retained for our training.

The training batch size has a big impact on GPU memory required for training a neural network, the larger the batch size, the more images are transmitted through the neural network at once, this will directly cause the required GPU memory to increase. We start with a large batch size value of 128, this causes the training process to stop prematurely since the required GPU memory is greater than the one available, we reduce the lot size value and we run the training again and repeat this process until we find the highest value possible with our GPU memory for the batch size, the value we end up with for the batch-size after this process is 80.

## 4. Numeric evaluation

### 4.1. Evaluation metrics

Precision, which measures the accuracy of our predictions. that is, the percentage of predictions that are correct.

$$Precision = \frac{TP}{TP + FP}$$

Recall is the percentage of true positives, among the total number of real objects. For example, if a model correctly detects 90 people in an image or there are 100 people, the recall is 90%.

$$Recall = \frac{TP}{TP + FN}$$

- TP (True Positive) : the case where the prediction is positive, and the

actual value is actually positive. Example: The model detects the presence of a traffic sign, and the sign actually exists in the image.

- FP (False Positive) : cases where the prediction is positive, but the actual value is negative. Example: The model detects the presence of a traffic sign, but the sign does not actually exist in the image.
- TN (True Negative) : cases where the prediction is negative, and the actual value is actually negative. Example: The model does not detect any traffic signs, and indeed no signs exist in the image.
- FN (False Negative) : cases where the prediction is negative, but the actual value is positive. Example: The model does not detect any traffic signs, but the image does indeed contain a sign.

The mAP value (mean average precision) is a popular evaluation metric used for object detection, many object detection algorithms, such as SSD, Faster R-CNN and YOLO, use the mAP value to evaluate their models for research publication.

To calculate the mAP value, we use the intersection on union for that we need:

- The actual bounding boxes, i.e. the bounding boxes that specify where our object is in the image labeled by hand in the test set.
- The bounding boxes predicted by our model.

The calculation of the intersection on the union can be determined via the following formula:

$$IoU = \text{Areaofoverlap} / \text{Areaofunion}$$

## 4.2. Results

Once a model has been trained, it is necessary to be able to evaluate its

performance. The model changes its weights through the training set, it does this by reducing the result of the cost function for the training set.

An good way to verify the effectiveness of the model is to observe the curve of the loss function during training, if the predictions deviate too much from the actual results, the loss function would take a very large number.

The loss function is a method for evaluating how much an algorithm models the training data, using an optimization function, the loss function learns to reduce the prediction error over time.

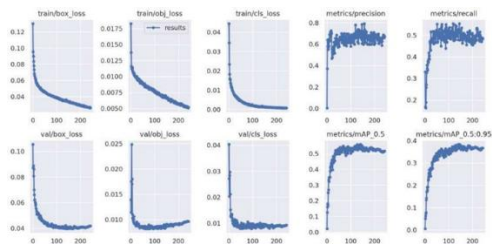


Figure 4. Loss curves for 200 epochs

According to the evolution curve of the loss function that we obtained, the model converges, we also observe a slight overfitting, because the cost function on the training set is smaller than on the validation set, so it is not possible to continue training to improve performance after that point; the most optimal results observed were during the 76th epoch.



Figure 5. Correctly classified image

There are three parameters used to evaluate the YOLOv5 model from the training results, namely the Precision, Recall and mean Average Precision (mAP).

	mAP@.5	P	R
All	63.8%	77.6%	58.6%
regulatory-keep-right-g1	68.1%	78.2%	58.3%
regulatory-no-entry-g1	52.9%	63.2%	51.5%
regulatory-yield-g1	69.8%	85.5%	65.8%
warning-pedestrians-crossing-g4	60.7%	72.7%	57.9%
regulatory-stop-g1	67.6%	88.3%	59.4%

**Figure 6.** Results table for a batch-size of 80

According to Fig. 5., the experimental result shows that the system returns 78.2%, 63.2%, 85.5%, 72.7%, 88.3% precision rate for 1st, 2nd, 3rd, 4th, and 5th sign, respectively, this gives us a mean precision of 77.6%. This table describes the performance of the proposed approach on Mapillary

	mAP@.5	P	R
All	63.7%	80.5%	54.1%
regulatory-keep-right-g1	68.8%	85.9%	56.3%
regulatory-no-entry-g1	52.9%	73.2%	44%
regulatory-yield-g1	68.1%	92.4%	60%
warning-pedestrians-crossing-g4	61.4%	75.9%	52.5%
regulatory-stop-g1	67.3%	74.9%	57.5%

**Figure 7.** Results table for a batch-size of 64 traffic sign recognition using standard evaluation metrics.

These tables display that the five classes are recognized with a mean Average Precision(mAP) of 63,7%. For the five categories YOLOv5 achieved a precision of above 80% using a batch-size of 64. However when using a batch-size of 80 the precision value is less than 80%, this is because the amount of training data and time to train the model and some images may be identical. This shows that even if the documentation recommends using the highest possible batch-size value for better performance, the model may benefit from using a smaller value such as 64 in our case, however using an even smaller value ie: 32; did not produce better results.

When comparing these results with a paper that implemented YOLOv4- based CSP-

DarkNet53 deep learning model using the Indonesia Traffic Signs (ITS) dataset, that obtained a performance with the main average Precision (mAP@0.5) of 74.91% for six categories but a precision of 74%.



**Figure 8.** Incorrectly classified image

Object detectors such as YOLOv5 are easy to be deceived by objects similar to road signs. One of the main issues is that the ability of the object detector is limited in certain cases, for example a reflection of the traffic sign, or an object that is similar in shape which is just a local pattern of the whole image, but ignores the other information like background.

## 5. Conclusion

One of the main advantages of YOLOv5 is its ability to detect objects in real-time. This is particularly important in the context of traffic sign recognition, where the ability to quickly and accurately identify traffic signs is crucial for ensuring the safety of drivers and pedestrians.

Another strength of YOLOv5 is its ability to accurately detect and classify a wide range of objects, including traffic signs. This is achieved through the use of convolutional neural networks (CNNs), which are able to learn complex patterns in visual data. Another key advantage of YOLOv5 for traffic sign recognition is its ability to handle



a wide range of conditions and scenarios. YOLOv5 is trained on a large dataset of images and videos that includes a wide variety of conditions, including different lighting conditions, weather, and backgrounds. This allows YOLOv5 to generalize well and handle a wide range of scenarios, making it robust and reliable for traffic sign recognition.

In addition, YOLOv5 is able to make high-quality predictions with a high level of accuracy. YOLOv5 uses a single neural network to make predictions, which allows it to make predictions that are more accurate and more consistent than other models that use multiple networks. This makes YOLOv5 a good choice for applications where accuracy is critical, such as traffic sign recognition.

In terms of limitations, one potential issue with using YOLOv5 for traffic sign

recognition is its reliance on large amounts of labeled training data. This can be a challenge in some contexts, where there may be limited availability of annotated traffic sign images.

Additionally, YOLOv5 may not always be able to accurately detect and classify traffic signs in challenging conditions, such as low lighting or the presence of clutter. Further research and development is needed to improve the robustness of YOLOv5 in these scenarios.

Overall, YOLOv5 has great potential for use in traffic sign recognition, due to its ability to detect objects in real-time and its strong performance on a wide range of tasks. However, further research and development is needed to address potential limitations and improve its performance in challenging conditions.

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## **IDENTIFICATION OF PRODUCT NON-CONFORMITIES USING COMPUTER VISION ALGORITHMS**

*Summary: The implementation of computer vision in the process of identifying non-conforming products, as well as the application of technologies based on Internet networks, deep learning, large databases within the manufacturing industry leads to the emergence of quality 4.0. Today, the application of computer vision as well as non-conformity detection algorithms in the manufacturing industry can be seen as technological pillars of quality 4.0, which is in direct connection with the company's operations. The main goal of the work is the development of a system for identifying non-compliant products within the manufacturing industry, where the focus is on the application of technologies based on computer vision. The secondary goal of the work refers to the reduction of the necessary funds for the implementation of the system on production machines, the development of a universal, flexible system, where the timely identification of non-compliant products will reduce the company's losses.*

**Keywords:** Industry 4.0., Quality 4.0. Cloud, Computer vision, OpenCV, Hough transform, Real time

### **1. Introduction**

Timely identification of the number of non-compliant products within the production industry, where the focus is on each production machine as well as the product itself, leads to a number of advantages on the way to successful business. Currently, a number of ways to identify non-compliant products can be found on the market. Of course, depending on the production of a specific product, the method of identifying non-conformity, i.e. the application of a certain technology, also depends. Viewed from the aspect of surface non-conformity of the product, identification can be done using technology based on computer vision (Yu et al., 2019). The advantage of applying this technology compared to others is the adaptability of the system, independence,

accuracy, response time considering that they represent real time systems, as well as the price of such systems (Ligarski 2012). The implementation of computer vision in the process of identifying product non-conformities implies the use of algorithms that will analyze and detect images, as well as a number of libraries that are necessary both for calculations and for linking algorithms, the most significant being the use of the OpenCV library (Chai et al., 2021). The basic processes of computer vision are data acquisition and data processing, problems that may occur in the data acquisition process relate to external factors that may affect the quality of the collected data, while problems in data processing may relate to the complexity of the applied algorithms as well as the time that is required for the processing process

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itself. Considering that this technology can be applied for the detection of surface inconsistency, and according to the algorithms used, it can be divided into systems developed for the detection of contours, objects, color, text, dimensions. Certainly, the application of computer vision in the process of identification of non-compliant products brings a number of advantages compared to traditional methods that were based on the training of employees or experts in the field of quality and who performed the identification process visually. The main goal of this study stems from the need to develop a quality control system that will work independently without the assistance of an employee. Although there are a large number of researchers who have done case studies in the field of quality control using computer vision technology, there is still a need for further development of such systems that will focus on contour detection in the shortest possible time interval and with minimal hardware requirements. Secondary objectives relate to the storage of data collected by this case study, data analysis. The advantages of the application of this case study compared to the traditional methods of identification of product non-conformity are reflected in the timely operation of the system, the reduction of the production of non-conforming products, the availability of data, and the reduction of production errors. The contributions of this study derive from the advantages of implementing algorithms that are related to the time required for contour detection in the specific case of circle detection, system training that requires a few minutes, and its adaptability.

Within this paper, a review of the literature will be presented, in which terms related to product non-conformity itself, identification and classification, and non-conformity management methods will be defined. The technologies applied within this study as well as the system developed by this study

for the purposes of identifying product non-conformities, which arise from the needs that are a consequence of real problems in the manufacturing industry.

## **2. Literature review**

### **2.1. Non-compliance**

A non-compliant product is any product that deviates from the quality defined by the standard, that is, from the requirements of the customer or user of the product or service. Observed from the aspect of non-conformity of the product that can occur during its production itself, it can be concluded that a larger number of non-conformities or deviations from quality requirements can be detected on one product at some point. The increased production of non-compliant products directly affects the company's profit, primarily through increased losses, among the biggest losses are certainly the raw materials needed for the production of products, additional time spent by employees, additional energy (Liepiņa et al., 2014;). In order for the company not to get into a situation that could endanger its business, it is necessary to adhere to the quality of the product defined by the standard, which further leads to the need for quality control, i.e. continuous checks to see if there are non-compliant products in production (Powell et al., 2021; ). It certainly does not mean that even if a product's non-conformity is observed, it cannot be used further, in some cases it is possible to refine it, and that is if it is a minor non-conformity, while in the case of a major non-conformity, the product is declared scrap and as such cannot continue the further process ( Hoyle 2009). Of course, if it is possible to finish the product, it is further sent to the finishing process, but this can significantly affect the price of its production (Hoyle 2009).

## **2.2. Identifying non-conforming products in the industry**

The identification of non-conforming products within the manufacturing industry can be seen as a process of determining deviations from the product quality requirements of a company, and it can happen on the production machine itself, the production line, or on the packaging of the product as a final process during the life cycle of the production of a product (Donauer et al., 2015; Powell et al., 2021;). Although the process was successfully implemented and the product nonconformity was identified, the identification of the cause that led to the nonconformity is also of great importance, preventing the cause that led to the nonconformity directly affects the further flow of production (Ligarski 2012; Powell et al., 2021 ;). Deviations can be in the form of surface inconsistencies or inconsistencies that can appear in the structure of the material, which leads to different methods of identifying inconsistencies and to different technologies that can be used in the process of identifying inconsistencies (Koucha et al., 2021;). Successful and timely identification of non-compliant products directly affects the reduction of scrap, savings in production time, and losses that occur due to product processing (Koucha et al., 2021;).

## **2.3. Methods of identification of product non-conformity**

The basic methods of identification of inconsistencies refer to surface inconsistencies and internal inconsistencies, which are based on the structure of the material. External defects are those located on the surface of the product, most often caused by machine failure or carelessness of employees, and refer to minor damage such as scratches, paint, text, etc. While internal defects are mainly based on the discovery of trapped air during metal casting, which can

later result in cracking of the product. The methods of detecting internal non-conformities that are most often applied today are radiation methods, ultrasound methods (Yang et al., 2020). Using ultrasonic methods based on the propagation of the ultrasonic wave, it is possible to conclude in which region the inconsistencies are found, as well as the order of their magnitude (Ha et al., 2021). The beam-based method uses a beam that is passed through the material and thus the location of the defect as well as the size can be obtained (Cacace et al., 2021). While the methods of detecting surface non-conformities in small and medium-sized companies are mostly based on manual control, that is, they depend on the employee and on the basis of his knowledge and experience as well as his ability to visually recognize the defect. When it is necessary to control product dimensions or centricity, there are manual tools that can be applied that depend on the employee. The application of modern technologies such as machine vision applied for visual control brings with it a number of advantages, shorter data processing time, timeliness, accuracy (Yu et al., 2019). Of course, machine vision depends on the quality of the equipment, the algorithm used to select and recognize non-conformities, but on the other hand, after installing the system, it is independent, that is, it does not depend on the employee and his knowledge and experience, it provides data in real time (Oqaidi et al., 2021, Sivkov et al., 2020, Steenkamp et al., 2017, Chai et al., 2021). Certainly with the application of computer vision and within Industry 4.0. technologies such as deep learning and artificial intelligence are also applied for faster and more efficient non-conformity selection as well as event prediction based on system experience, cloud data storage systems, IIOT (industrial internet of things) is applied for machine control based on defined non-conformity, industrial robots as well as

industrial production lines, (Cronin et al., 2021, Julian oks et al., 2021, Khan et al., 2020, Shavetov et al., 2019, Oqaidi et al., 2021, Sivkov et al., 2020, Steenkamp et al., 2017, Chai et al., 2021).

#### **2.4. Classification of non-conformities**

As the level of non-conformity of the product can differ by several different factors, it can be divided into minor non-conformities, major non-conformities and critical non-conformities (Monteiro et al., 2019; Powell et al., 2021;). Minor non-conformities are noticeable, but the product as such can be found on the market at lower prices with an indication that it deviates from the standard (Gamme et al., 2019;). Greater product non-conformity requires product rework after which the product can be forwarded to the market (Chiu et al., 2018;). Critical non-conformance represents deviations from the requirements that affect the functionality of the product, which automatically means that it cannot be used as such (Hoyle 2009). Product non-conformity can occur for several reasons, the most common of which is due to the failure of the production machine, deviation of the quality of the material from which the product is made, carelessness of employees (Chiu et al., 2018;). Product non-conformity can be expressed in several ways, the basic way is external and internal non-conformity (Chiu et al., 2018; Monteiro et al., 2019;). External non-conformity is a deviation that is visible, it is most often damage on the surface of the product or semi-finished product in the form of scratches, deviation of shape, dimensions, text, color (Monteiro et al., 2019;). While the internal non-conformity refers to the structure of the material, if it is metal casting or plastic injection, there may be air trapped in the product itself (Gamme et al., 2019;). In order to prevent the production of non-compliant products, it is necessary to react in time, that is, if an employee notices the

production of non-compliant products that occurred as a result of a machine failure, it is necessary to stop the further flow of production. It is necessary to classify non-conforming products according to the degree of non-conformity and, based on the data, proceed further in accordance with the company's policy (Gamme et al., 2019;). After the non-conformity identification process, it is necessary to mark the non-conforming products based on the classification, which refers to products that can be processed, can be sold as such, but with a note, products that are sent to scrap (Monteiro et al., 2019; Powell et al. ., 2021;). Successful classification of non-conforming products can prevent the appearance of non-conforming products on the market, which significantly affects the company's business. Marking of non-compliant products after classification should be a defined process and easy to learn for employees, so that based on a successful classification, the products will be passed on to the production flow in accordance with the performed classification.

#### **2.5. Management of non-conformities**

Successful management of non-conforming products is the basis of a company's successful production. In order to successfully manage non-compliant products, it is necessary to define product control intervals, ways of marking non-compliant products, and procedures for disposing of non-compliant products. Control intervals are directly related to the type of production, whether it is serial mass or individual, as well as by top management (Hoyle 2009). After the detection of a non-conforming product, and depending on the level of non-conformity, it is necessary to mark the product in an adequate way if it is a question of critical non-conformity, after which the product is declared as scrap and as such is further sent for destruction, in the

case of major or minor non-conformity, if it is possible, it is necessary to refine the product mark the product and pass it on for further processing (Hoyle 2009; Powell et al., 2021;). The marking of non-conforming products is one of the important processes, since on the basis of the marked products, the procedure is followed, the marking differs from company to company, mostly companies practice to have an internal way of marking (Hoyle 2009).

### **2.6. Application of computer vision in the quality control process**

Computer vision can provide a wider range of data in terms of quality control, positioning of robots in space, control of production lines as well as the products themselves, object recognition, barcode scanning (Louw et al., 2019). The quality control process can be observed in several ways, depending on the production itself, i.e. what needs to be controlled, mainly the color of the product, the text or stamp on the product that is stamped, dimensional control, quality control of the object's surface, i.e. whether there are visible damages on the surface such as scratches or in the process of forming the sheet whether it contains all the necessary openings. Also when it comes to monotonous tasks such as comparing two objects or sorting both on the industrial machine itself and on the production line, computer vision is imposed as a good technology for the mentioned application. Certainly, when it comes to precise profile measurements, which require a lot of time, the process can be accelerated with the application of computer vision. Monitoring of products throughout the entire technological process of production or within a certain technological process.

### **2.7. Industry 4.0.**

By applying Industry 4.0 technologies. in the process of identifying product non-conformities, significant advantages can be achieved compared to manual identification (Bigliardi et al., 2020; Horváth et al., 2019). All this affects the speed of production, product quality, timeliness of data, availability of data, accuracy (Culot et al., 2020). The most important technologies of industry 4.0 that are applied in the process of non-conformity identification are: computer vision, IIOT (Industrial Internet of things), deep learning, neural networks, databases, internet networks, microcontroller platforms, programmable logic controller, cloud, embedded systems, sensor systems, distributed systems (Albers et al., 2016, Bal et al., 2019; Müller 2019; Tupa et al., 2017, Mijailović et al., 2020).

### **2.8. Cloud**

The storage of real-time data collected from the industry in a database that can be accessed independently of the platform or operating system is called the cloud. These systems represent one of the most important tools for the successful implementation of Industry 4.0. (Lane et al., 2016). The application of cloud systems in relation to traditional databases has a number of advantages, the most significant of which are access in real time, it lowers the necessary funds related to the maintenance of the database and the hardware part (Kolesnyk et al., 2021; Mijailović et al., 2018). In the case of the application of some other databases that require hardware systems for storing large amounts of data, they would be within the manufacturing industry (Lane et al., 2016; Murugaiyan et al., 2020), which actually represents a number of disadvantages of such a system. While in the case of cloud system application, all data is located in one place that is always available,

with the fact that the lack of such systems can represent an internet connection (Lane et al., 2016).

### 3. Case study

This paper presents a system developed for the identification of non-conforming products or semi-products, based on the application of computer vision. In the process of identifying non-compliant products, the system, in addition to data acquisition, performs the process of detecting contours based on circles. As it is often the case that in industry, during the production process, the product contains openings for screw connections or technological openings that are further important for the product assembly process, hence the need for the development of such a system. Also the application of this system that is imposed is the product assembly process where the identification of screws can be done, it can also be applied for product selection. Based on the use of the Hough transformation, it detects circles on the semi-finished product, preventing further operation of the machine if the lack of one or more circles is identified. The system was developed to work in real time, where data is stored on the cloud, providing the possibility of accessing data in real time. Certainly, the advantages of using this system are reflected in speed, flexibility, reduction of the number of non-compliant products, precision.

#### 3.1. System software

When it comes to starting the system for the first time, it is necessary to place the hardware on the corresponding production machine, after checking the system can be started. After the first start of the system, it can work independently, which makes the application of this technology an advantage over traditional ways of identifying non-compliant products. When the system is

started, images are acquired using computer vision and the OpenCV library, then the collected data are processed using Hough's transformation, and the output of the system is data related to the number of identified circles as well as the number of compliant or non-compliant products. It is also possible to define conditions related to the number of identified circles, after obtaining the specified data they are stored on the cloud in the specific case ThingSpeak was used. The mentioned process is executed in real time, where the total time of the algorithm is 0.35 seconds for one image, which is certainly faster than the system requirements, that is, from the production machine and its process of producing one product. Certainly one of the important features of this system is adaptability, it can be moved from one production machine to another and continue working without interruption. Algorithm performance tests were performed within the premises of the university, laboratory of the quality center. In Figure 1, you can see an example of a semi-finished product that has circles on it that refer to twisted screws.



**Figure 1.** Example of a semi-finished product with both screws

Source: Author

As can be seen in Figure 1, the semi-finished product contains 2 screws that were detected using the developed system. Figure 2 shows the result of the algorithm.

```
The first contour is the screw: 39 px.  
The second contour is the screw: 39 px.
```

**Figure 2.** Result of the semi-finished algorithm with both screws

Source: Author



Based on the results of the system algorithm, which are shown in Figure 2, it can be seen that the product is compliant. In Figure 3, you can see the non-compliant semi-product.



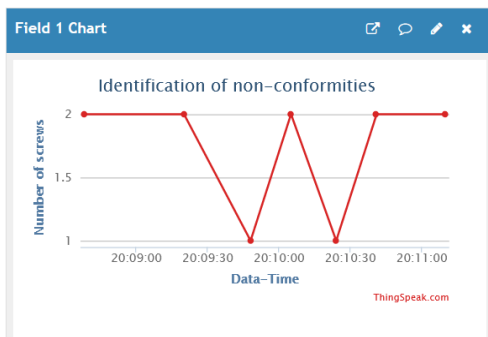
**Figure 3.** Non-compliant semi-finished product  
Source: Author

Based on Figure 3, it can be concluded that one screw is missing from the semi-finished product, which can also be seen based on the results of the algorithm shown in Figure 4.

The first contour is the hole for the screw: 35 px.  
The second contour is the screw: 39 px.

**Figure 4.** Inconsistent product of algorithm results  
Source: Author

As can be seen in Figure 4, the product is non-conforming, it does not have one of the two screws. The presented data is stored on the cloud system within this system thingspeak cloud was used, an example of the stored data collected by this system can be seen in Figure 5.



**Figure 5.** Data stored in the cloud  
Source: Author

We can additionally process and display data stored in the cloud in several ways, the advantage of cloud data is its availability.

## 4. Discussion

The focus of the system developed in this work is on the process of identifying product non-conformities with the use of modern technologies that involve the application of computer vision. After the implementation of the system in the production industry, it brings a number of benefits compared to the traditional ways of identifying non-compliant products. Some of the advantages are reflected in the speed, accuracy, flexibility, independence of the developed system. Traditional ways of identifying non-conformities involve the interaction of an employee, i.e. the engagement of employees from the product quality sector, where there are a number of limitations and in terms of the time necessary to identify non-conformities if it is a serial production or several production machines, the time needed to form a report or the reaction that would stop the further flow of production if there is an increased number of product non-conformities. While in the case of the application of the system developed in this work, we receive the data in real time, the reaction of the system is also in real time, we can create reports, the data is stored in the cloud and can be accessed from all platforms and operating systems and further processed. The shortcoming of this system can be seen from the aspect that it was developed for use on one production machine, while a quality expert can observe several different machines as well as different types of non-conformities. Certainly, the use of this system and timely reaction affects the further flow of production and the reduction of non-compliant products.

## 5. Conclusion

The system developed by this case study represents a solution that should reduce the production of non-conforming products created in production, most often caused by a machine failure or error, thus satisfying the initial goal of the study. The increased number of non-compliant products directly affects customer satisfaction as well as costs, which certainly represents another goal for the development of this system. Timely reaction of the system is essential in terms of stopping the further flow of production of non-conforming products, which directly affects the production time.

The results of the study, which were stored on the cloud, were presented. The system has

limitations related to the application itself, the developed system is used to identify contours that represent circles, which means that it cannot be used for contours of other shapes. Certainly the developed system satisfies the initial goal where the focus was on the detection of contours representing circles. This study presents a unique solution for the application of software used for identification, which is based on the implementation of the Hough transform and the training of the system, which involves defining the basic parameters related to the number of contours and their size. Further directions of this study will go towards the development of a system that will be able to detect a larger number of different contours on one product.

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## SIMULATION OF LIQUEFACTION OF NITROGEN RICH GASEOUS EMISSIONS FROM THE OXYGEN PRODUCTION PLANT

**Abstract:** Liquid  $N_2$  attained extensive applications in the fields of refrigeration, medical, constructional and chemical industries. Oxygen production plant in Orotta Hospital, Eritrea assessed with  $156.6 \text{ Sm}^3/\text{hr}$  of waste  $N_2$  gases that contains 96.4 % (vol) of  $N_2$ . Thus this work focused on the liquefaction of such waste gases employing Precooled Linde-Hampson and Kapitza's cycles in aspen HYSYS®. Specific energy requirements assessed initially for open and closed loop models and noted higher rates in all open loop cycles examined. Highest Pressure and the Lowest Temperature adjudge the extent of  $N_2$  liquefaction. Optimal liquefaction of Pure  $N_2$  at 150 atm of CDP and  $-115.2^\circ\text{C}$  of LCT in PLHC system yielded a liquid of  $156.6 \text{ Sm}^3/\text{hr}$  at the expense of 4195.4 kJ/L of energy while the waste  $N_2$  gases liquefies at 400 atm of CDP and  $-107.2^\circ\text{C}$  of LCT with 68.1 % of excess energy consumption. Pure  $N_2$  liquefaction in KC at 40 atm and  $-171.2^\circ\text{C}$  resulted in 0.148 liquid fraction at the energy cost of 3719 kJ/L whereas the optimal liquid fraction of 0.1488 and  $\text{COP}_{\text{act}}$  of 0.8404 were derived from the liquefaction of waste  $N_2$  gases at a CDP of 40 atm and LCT of  $-162.5^\circ\text{C}$ . However, Kapitza's system has proven to be more attractive than PLHC in terms of energy savings although both models produce similar products.

**Keywords:** Liquefaction, Waste  $N_2$  Gases, Liquid Nitrogen, Linde-Hampson cycle, Kapitza's cycle, HYSYS® Simulation.

### 1. Introduction

Liquefaction of gases has been practiced for several years and become a key branch of cryogenics for wide applications including commercial liquid gas production for easy storage, handling, transportation and potent applications in cryogenic engineering that meant to design and maintain systems or components at lower temperature. Gases can be liquefied either by cooling or by applying

high pressures or by combined effect of both. Liquefied gases have prominent role in industrial applications. Liquid forms of nitrogen, ammonia and  $\text{SO}_2$  can be used as refrigerants, liquid  $\text{CO}_2$  finds application in soda fountains, liquid chlorine has importance in bleaching and disinfectant purposes, liquid air served as best source of  $\text{O}_2$  in rockets and jet-propelled planes, liquid helium has driven the development of space research and liquid hydrogen acquired

attention for the significant applications in nuclear weapons development and rocket propulsion [Narayanan. K.V 2011]. However, permanent gases such as N<sub>2</sub>, H<sub>2</sub>, Ar or O<sub>2</sub> usually possess very small intermolecular forces of attraction and cannot be liquefied easily due to their lower critical temperature (T<sub>c</sub>) while the gases for which the intermolecular forces are larger such as NH<sub>3</sub>, SO<sub>2</sub> and H<sub>2</sub>O have high value of T<sub>c</sub> and can be easily liquefied.

Nitrogen(N<sub>2</sub>) is a diatomic chemical element available plentifully in atmospheric air and exist in the gaseous state at ambient conditions whereas liquid nitrogen is a cryogenic liquid obtained by the liquefaction process at a very low temperature of -196°C. Liquid nitrogen is odorless, colourless, non-reactive and non-flammable liquid majorly produced by air separation techniques such as cryogenic distillation and pressure swing adsorption (PSA). Liquid nitrogen has been applied as a coolant in food preservation, transportation and desserts making. In medicine it is used as a refrigerant in cryobanks to preserve biological cellular materials such as reproductive cells that include sperm & egg, semen, blood and other tissue samples. Furthermore, liquid nitrogen is employed in dermatology for freezing and preventing the growth of precancers, benign growths and skin cancers by spraying or applying liquid nitrogen with a cotton swab. In the field of construction, the demand of liquid nitrogen has been rising due to its applications in hardening of concrete at accelerated rates. In addition, liquid nitrogen covers the other industrial applications such as metal hardening, temporary ground freezing, rubber removal and pipe freezing. Presently, modern electronics incorporated with semiconductors, which enable conductivity between metals and insulators. As the supercomputers run highly complex calculations and perform millions of functions, semiconductors usually subjected

to higher temperature that need to be maintained at constant temperature and liquid nitrogen has become one of the top choices to control the temperature. Thus, liquid nitrogen market valued globally at USD 15.98 billion in 2021 and predicted to reach USD 23.61 billion by 2029, registering a CAGR of 5.00% during the forecast period of 2022-2029 [DBMR 2023].

Adversely, liquid nitrogen has a high liquid-gas expansion ratio of 1:694 at room temperature, causes a tremendous force generation if it vaporized rapidly in an enclosed container and it can destruct the surroundings and harm to humans as well [GVRR 2023]. In general, cryogenic liquid gases are highly hazardous and causes cold burns if it comes to contact with biological species including humans. Mishandling of liquid nitrogen could lead to spillage and pose to significant threats to the surrounded people. Such probable hazardous effects in handling procedures anticipated to restrain market growth over the forecast period. However, by following the safety guidelines properly and maintaining necessary personal protective devices, such hazards could be prevented.

Cryogenic distillation is a dominant technology in the production of liquefied industrial gases coupled with low investment and few utility consumption and today it accounts for 65-70% of total nitrogen production [SRI Consulting 2023]. Nevertheless, pressure swing adsorption (PSA) technology is expected to lead in air separation applications without liquefaction [GVRR 2023]. In addition, in-situ applications of gases such as oxygen and nitrogen demand PSA technology that makes favor with little investments and avoidance of hazards in handling liquefied gases along portable plant features. Unfortunately, in many plants when PSA technology meant for the production of oxygen, nitrogen rich gaseous streams are simply emitted into atmosphere. Instead such waste N<sub>2</sub> rich gases

can be liquefied to facilitate the benefit of available liquid nitrogen in the local market.

Several cryogenic cycles can be employed in liquefaction of gases such as Linde Hampson cycle, Claude's cycle, Kapitza's cycle and Collins liquefaction cycles [Yilmaz.C et al 2019, Saini. A et al 2019]. Many different methods can be adopted in cooling of gases to liquefy including Faraday's principle, adiabatic expansion, Linde's and Claude's methods [Schimd. J 2023, Nag. P. K. 2006]. The effect of cooling can be facilitated by expanding high pressure gases to lower pressure in Faraday's method to liquefy the gases that possess critical temperature above or just below the ambient conditions. Adiabatic expansion featured by altering pressure at constant total heat of the system, which causes gaseous molecules to be liquefied. Linde's method includes a Joule-Thompson's valve that reduces pressure and cools the gas to partially liquefy. Non-liquefied gases can be recycled back along with fresh feed to improve the yield of liquid fraction. However, the Claude's method is a modified version of Linde's practice and specially facilitated to extract some amount of work while gases expand to lower pressures. In addition, Kapitza's cycle and Collins cycles follows Claude's cycle with some changes in number of heat exchangers used for cooling and the choice high pressure stream that allows to produce some work.

Liquefaction of nitrogen from air separation has been modeled and studied by several people [Yilmaz.C et al 2019, Saini. A et al 2019]. However, in the present work, Precooled Linde-Hampson's [Yilamz.C et al 2019, Schimdt.J. 2023] and Modified Claude's cycle (Kapitza's Cycle) [Schmidt.J 2023, Nag.P.K 2006] have been adopted to study the production of liquid nitrogen using waste N<sub>2</sub> rich gases that are emitted from PSA plant operating for air separation. The systems are modeled for pure N<sub>2</sub> and waste N<sub>2</sub> gaseous feedstocks in Aspen HYSYS® to identify the effect of presence of impurities

and change in pressure on liquefaction rate, cooling temperature patterns and specific energy consumption. Energy consumptions are compared without recycle and with recycle of gaseous fractions in both Linde's and Claude's methods.

### 1.1 Oxygen Production Plant of Orotta Hospital (OPPOH)

Orotta Hospital is the nationalized medical centre that provide services in most specialized treatments in Eritrea and always in need of oxygen for life supporting systems. The Orotta Hospital has established its own oxygen plant that utilizes air and produces oxygen using pressure swing adsorption (PSA) technology. In general, PSA devices take fresh air and stores in a collector tank and then it allowed through pre-filters for the removal of mist or particulate matter (PM).

Later the pre-screened air stored in the tank 1 as depicted in figure 1. and passed through second set of filters which are packed with zeolite and activated by the chemicals such as aluminium oxide that captures N<sub>2</sub> with dipole creation and allows O<sub>2</sub> to pass through at an elevated minimum pressure of 1.5 atm. After a certain volume of air separated the zeolite bed gets saturated with N<sub>2</sub> absorption, which requires periodic regeneration that should be facilitated by dropping pressure back to atmospheric conditions [TPPL 2023, Rao & Muller 2007]. PSA devices are mainly preferred to generate oxygen in place where it can be utilized to avoid transportation risks although it produces O<sub>2</sub> of less purity and portable capacities, thus OPPOH produces O<sub>2</sub> of 92% (volume) purity in addition to other components of 7% N<sub>2</sub> and 1% Ar at a rate of 37 N m<sup>3</sup>/hr.

Since the OPPOH is not meant to recover any N<sub>2</sub> that is released during air separation, huge amount of N<sub>2</sub> rich waste gases are

emitted into the atmosphere. So far in Eritrea there is no local production of liquid N<sub>2</sub> to support cryogenic refrigeration systems applicable for both industrial and medical

applications. Thus the estimated rate of N<sub>2</sub> rich emissions of 156.6 S m<sup>3</sup>/hr with 96.4% of N<sub>2</sub> content attracts to utilize by means of liquefaction.

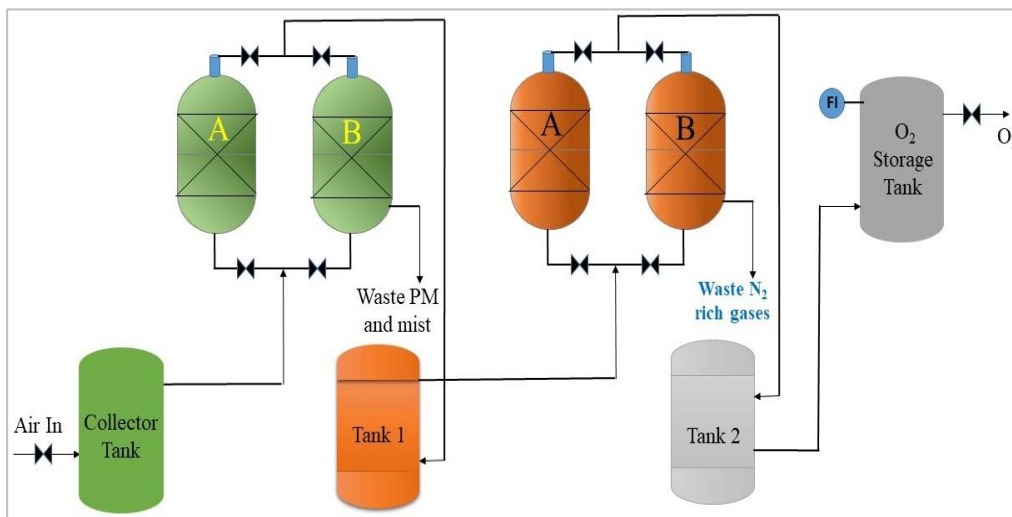


Figure 1. Pressure Swing Adsorption(PSA) Process for O<sub>2</sub> Production in OPPOH

## 2. Materials & Methods

### 2.1 Feedstock Materials

Waste N<sub>2</sub> rich gases at a rate of 156.6 S m<sup>3</sup>/hr with the composition shown in the Table1. and Pure N<sub>2</sub> has been considered for the comparative study in both Linde-Hampson and Kapitza's cryogenic cycles.

**Table 1.** Chemical composition of Waste N<sub>2</sub> gaseous resources from OPPOH [Personal Communication 2023]

Component	Volume (%)
N <sub>2</sub>	96.4
O <sub>2</sub>	2.62
Ar	0.91
CO <sub>2</sub>	0.07

## 2.2 Methods

### 2.2.1 Precooled Linde Hampson's Method

The precooled Linde Hampson's cycle has been adapted to develop the liquefaction process [Yilmaz.C et al 2019]. The Feed gas first compressed to the desired pressure level that causes significant rise in temperature which must be reduced in a cooler to attain ambient temperature of 25 °C as shown in figure 2. Then the pressurized gas passed through a heat exchanger where its further cooled by utilizing the cold recycled gaseous streams from the separator. Later the gasses are allowed to get through a Joule-Thompson's valve in which highly compressed gas throttled to atmospheric pressure adiabatically that experiences drastic drop in temperature and a fraction of liquid gets separated from the cold gases. Thus the extremely colder gases could be

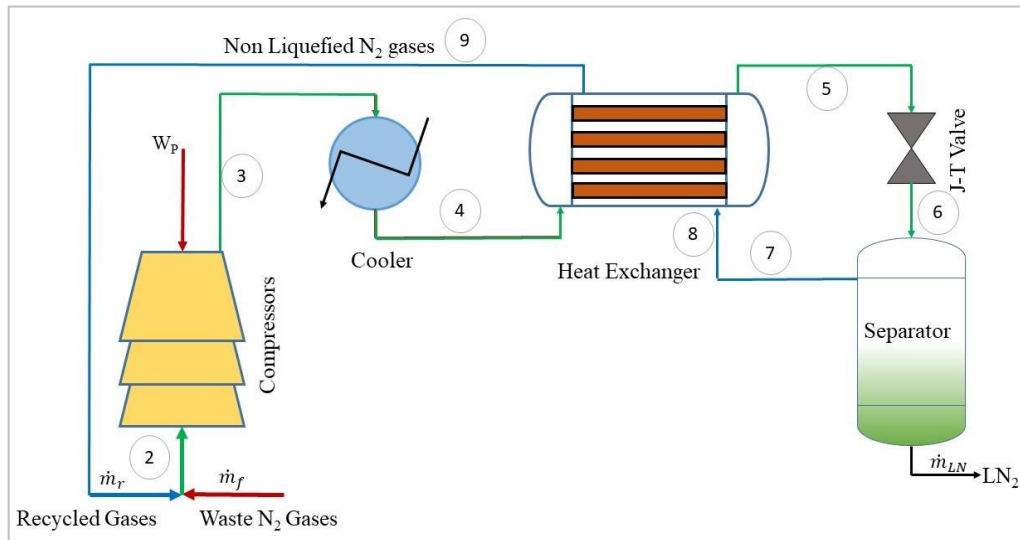


recycled back in to the process through a heat exchanger and mixed with fresh feed to undergo for compression. The gas compressed to a pressure range of 100 atm - 500 atm to determine the optimized liquid yield. If r is refrigerant or the recycled gases that are utilized as refrigerant in the heat exchanger, the fraction of gases that are liquefied can be calculated in terms of

corresponding stream enthalpies using the following relation

$$y = \frac{h_4 - h_9}{h_{LN} - h_9} = \frac{\dot{m}_{LN}}{\dot{m}_f + \dot{m}_r}$$

Where  $\dot{m}_{LN}$ ,  $\dot{m}_f$  and  $\dot{m}_r$  represents the volumetric flow rates of liquid nitrogen, fresh feed and recycled feeds respectively.



**Figure 2.** Precooled Linde-Hampson Cycle for the Liquefaction of waste N<sub>2</sub> gases

The energy balance for compressor can be written in terms of enthalpies ( $h$ ) and entropies ( $s$ ) of the corresponding streams as

$$W_p = (h_3 - h_2) - T_2(s_3 - s_2)$$

The actual coefficient of performance of the overall cycle can be expressed as

$$\begin{aligned} COP_{act} &= \frac{\text{heat transferred per unit mass of gas}}{\text{Total energy input of the system}} \\ &= \frac{Q_L}{W_{in}} = \frac{(h_3 - h_2) + r(h_8 - h_9)}{(h_3 - h_2) - T_2(s_3 - s_2) - r(h_8 - h_9)} \end{aligned}$$

Where  $r = \frac{\dot{m}_r}{\dot{m}_f + \dot{m}_r}$ , the fraction of recycled stream

And the energy consumption per L of liquid nitrogen ( $\dot{E}$ ) is estimated according to

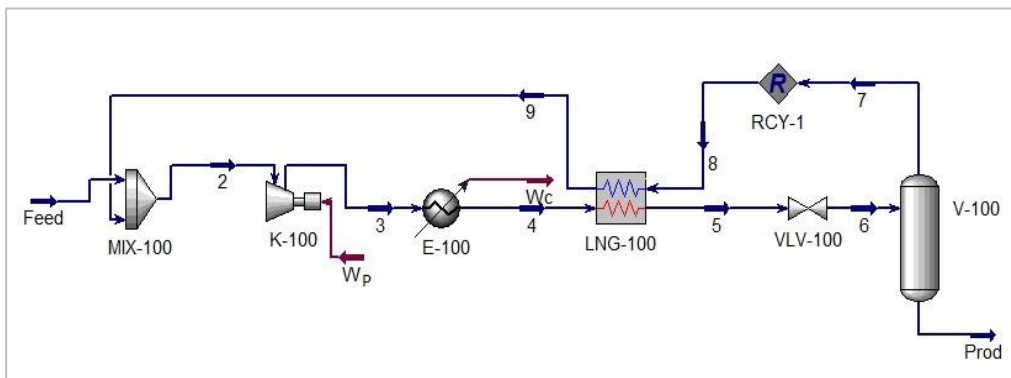
$$\dot{E} = \frac{W_p}{Y} \quad \left( \frac{kJ}{l} \right)$$

Where  $W_p$  is the power consumed for the compression in kW and  $Y$  is the amount of liquefied gases in liter/sec.

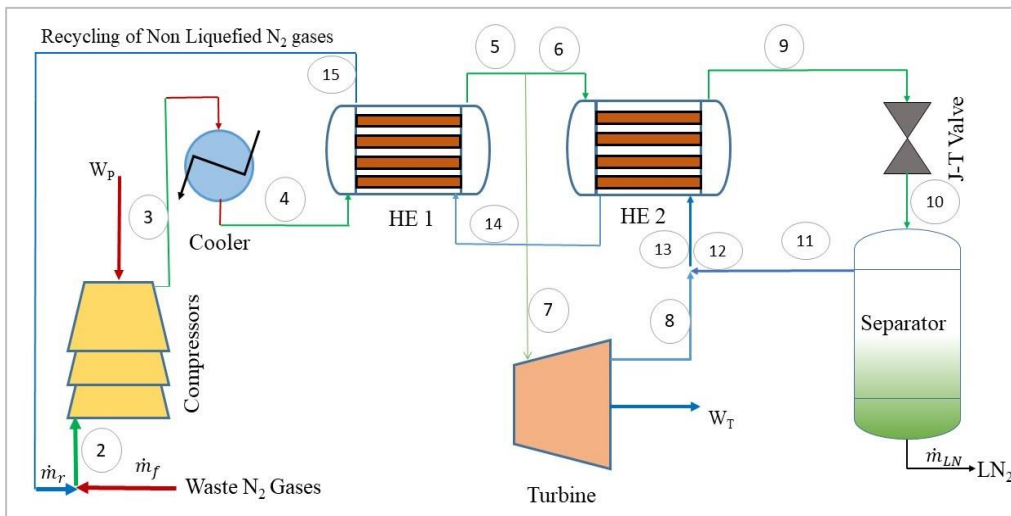
**2.2.2 Aspen HYSYS® Model for Precooled Linde-Hampson Cycle**

Pure nitrogen and other impurities such as oxygen, argon and CO<sub>2</sub> are added to component list and Peng-Robinson fluid package opted for the estimation of thermodynamic properties and other system calculations. The Linde's cycle is modelled as shown in figure 3 using the objects such as a mixer (MIX-100) to blend fresh feed with recycled one, compressor (K-100) to increase pressure to the desired level, cooler (E-100) to bring down the temperature of high pressure gases to ambient conditions followed by a cryogenic heat exchanger (LNG-100) to decrease the temperature of gases to further lower levels using cold gases that are recycled from the separator (V-100). Joule-Thompson's expansion valve (VLV-100) applied to decrease pressure to atmospheric levels at where the separation of liquid and gases takes place. 75% of isentropic efficiency for compressor is assumed in simulating the model.

(E-100) to bring down the temperature of high pressure gases to ambient conditions followed by a cryogenic heat exchanger (LNG-100) to decrease the temperature of gases to further lower levels using cold gases that are recycled from the separator (V-100). Joule-Thompson's expansion valve (VLV-100) applied to decrease pressure to atmospheric levels at where the separation of liquid and gases takes place. 75% of isentropic efficiency for compressor is assumed in simulating the model.



**Figure 3.** Aspen HYSYS® model for Waste N<sub>2</sub> gases liquefaction using Linde Hampson's cycle.



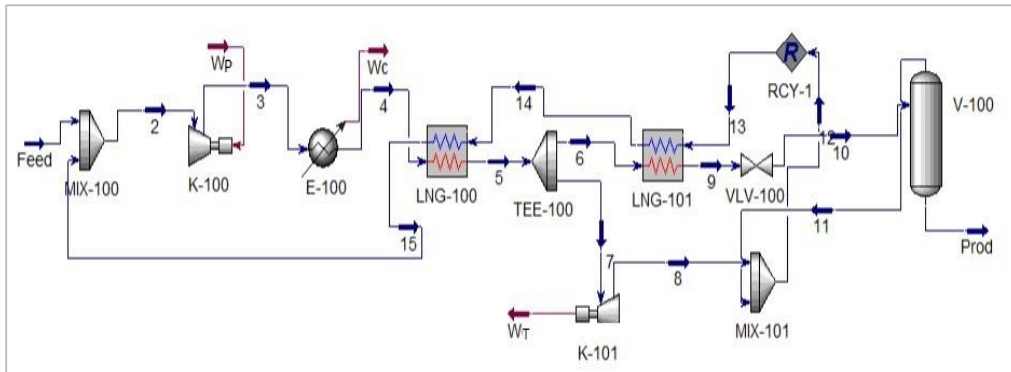
**Figure 4.** Schematic representation of modified Claude's cycle (Kapitza's Cycle)

### 2.2.3 Modified Claude's (Kapitza's Cycle) Method [Yilmaz.C et al 2019]

In the present work, modified Claude's cycle known as Kapitza's cycle has been considered to study the liquefaction of waste N<sub>2</sub> gases. As shown in figure 4. Fresh feed along with recycled one enters into the compressors to achieve desired pressure level of 40 atm and then it is cooled to ambient temperature of 25°C and subsequently cooled to cryogenic conditions in the heat exchangers 1 and 2 (HE1 & HE2). But, before the stream is allowed for

further cooling in HE2, a portion of gas is diverted to a turbine to produce some work and then it allowed to join with non-liquefied gases to recycle back into the process through HE2 & HE1.

Since J-T valve is the most economical to expand the gases to atmospheric conditions, it has applied to cool the gases and separate liquefied gases from the non-liquefied. If  $x$  is the fraction of total gases that are diverted to the expander and an isentropic work produced by the turbine then the heat balance on turbine



**Figure 5.** Aspen HYSYS® model for Waste N<sub>2</sub> gases liquefaction using Kapitza's cycle.

can be written as

$$h_T = h_5 - \eta_T(h_5 - h_8)$$

The work produced by the turbine can be estimated by the following relation

$$W_T = h_5 - h_T = \dot{m}_8(h_8 - h_5)$$

The net work done in the entire Kapitza's cycle is expressed as

$$\begin{aligned} W_{net} &= W_p - W_T \\ &= [(h_2 - h_3) - T_2(s_2 - s_3)] - z(h_5 - h_T) \end{aligned}$$

The yield of liquid fraction produced from the Kapitza's cycle given by

$$y = \frac{x(h_8 - h_5) + (h_4 - h_{15})}{h_{LN} - h_{15}}$$

Where  $x = \dot{m}_8/\dot{m}_4$ , the fraction of gas that is diverted to expander and  $y = \dot{m}_{LN}/\dot{m}_4$ , the fraction of gas that is liquefied.

The coefficient of performance of the cycle can be calculated as

$$\begin{aligned} COP_{act} &= \frac{\text{heat transferred per unit mass of gas}}{\text{Net Power Consumed in the cycle}} \\ &= \frac{(h_2 - h_3) + z(h_5 - h_T)}{[(h_2 - h_3) - T_2(s_2 - s_3)] - z(h_5 - h_T)} \end{aligned}$$

And the energy consumption per L of liquid

nitrogen ( $\dot{E}$ ) is estimated according to

$$\dot{E} = \frac{W_{net}}{Y} \left( \frac{kJ}{l} \right)$$

Where  $W_{net}$  is the net power consumed in the entire cycle in kW and  $Y$  is the amount of liquefied gases in liter/sec.

### 2.2.4 Aspen HYSYS® Model for Kapitza's Cycle

Following the same initial steps as the Linde's cycle, Pure nitrogen and other impurities such as oxygen, argon and CO<sub>2</sub> are added to component list and Peng-Robinson fluid package selected for the estimation of thermodynamic properties and other system calculations. The Claude's cycle is modelled as shown in figure 5. That includes two mixers (MIX-100, 101), compressor (K-100), cooler (E-100), two heat exchangers (LNG-100, 101), a splitter (TEE-100), turbine (K-101), a J-T valve (VLV-100), a separator (V-100) and a recycle stream (RCY-1). A turbine of 75% isentropic efficiency has been considered to produce some work from 80% of total gas stream that is diverted before it enters into the second heat exchanger (LNG-101).

## 3. Results and Discussion

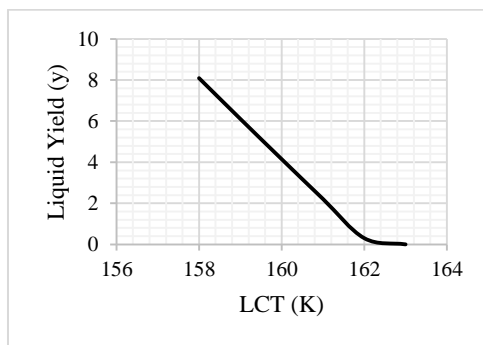
The performance of gas liquefaction cycle depends on the parameters such as feed composition, compressor discharge pressure, temperature approaches in the heat exchangers, lowest cooling temperature, number of heat exchangers, the presence of turbines to extract work and gas fraction diverted to expander in case of Claude's cycle. In the present study, the performance of Precooled Linde-Hampson cycle and modified Claude's cycle were tested with pure N<sub>2</sub> and waste N<sub>2</sub> streams, with and without recycling of non-liquefied gases to examine several performance indicators such as liquid yield, actual COP and energy consumptions per liter of liquid nitrogen

produced.

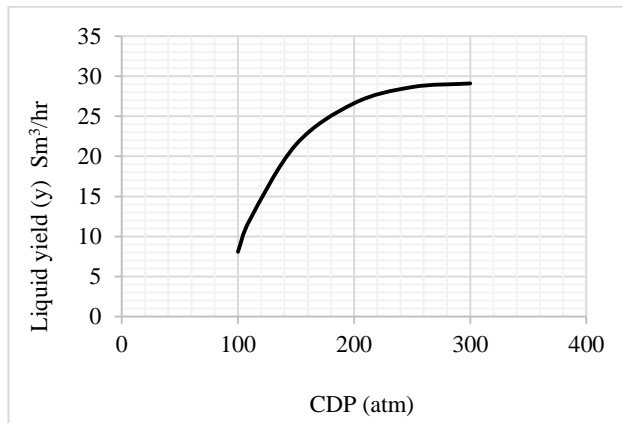
### 3.1 Liquefaction of Pure N<sub>2</sub> Gases by Precooled Linde-Hampson Cycle (PLHC)

Initially the feed considered at atmospheric pressure and 25 °C of temperature, then it allowed through a compressor with a discharge pressure of 100 atm to examine the possibility of liquefaction by changing the lower cooling temperature ( $T_5$  in figure 3) with and without recycling non-liquefied gases to determine maximum liquid yield and optimal energy consumption. The open loop (without recycle) precooled Linde's machine investigated to find the optimal LCT of 158 K in the heat exchanger at where the highest liquid yield of 8.091 Sm<sup>3</sup>/hr was recorded for a pure N<sub>2</sub> feed rate of 156.6 Sm<sup>3</sup>/hr. The temperature cross noted in the heat exchanger beyond 158 K on the lower end whereas on the higher end, it was not producing any liquid product beyond 162 K as depicted in the figure 6.

A similar kind of study for closed loop (with recycle) precooled Linde-Hampson cycle was performed at the optimal conditions derived based on the results obtained from the open loop machine analysis.



**Figure 6.** The effect of LCT on Pure N<sub>2</sub> liquefaction in open loop PLHC machine



**Figure 7.** The effect of CDP on Pure N<sub>2</sub> liquefaction in open loop Precooled Linde's cycle

At the LCT of 158K, closed loop system has provided 156.6 Sm<sup>3</sup>/hr of liquid N<sub>2</sub> and the relative energy consumption per L of liquid N<sub>2</sub> has reduced significantly when compared with the open loop cycle. The specific energy consumption of 6878.16 kJ/L was determined in the precooled Linde's cycle while it was calculated as 17259.17 kJ/L for the open loop cycle.

### 3.2 The Effect of Compressor Discharge Pressure (CDP) on Pure N<sub>2</sub> liquefaction

Firstly, at a fixed LCT of 158 K, the effect of changing CDP was tested in between 100 atm - 300 atm to understand the variation in the liquid yield (y) from the open loop precooled Linde's cycle as shown in figure7.

**Table 2.** The effect of discharge pressure on liquid yield and its N<sub>2</sub> composition for the liquefaction of waste N<sub>2</sub> gases using open loop PLHC.

CDP atm	LCT °C	Liquid Yield (y), Sm <sup>3</sup> /hr	Composition of N <sub>2</sub> in the liquid (vol fraction)
150	-108.2	11.12	0.8936
200	-105.2	12.61	0.8964
300	-103.2	13.82	0.8984
400	-106.2	17.12	0.9033
500	-108.2	16.86	0.9029

**Table 3.** Comparison of Liquefaction of waste N<sub>2</sub> with Open loop and Closed loop PLHC systems

Parameter	Open loop PLHC	Closed loop PLHC
CDP (atm)	400	400
LCT (°C)	-106.2	-107.2
Liquid yield (Sm <sup>3</sup> /hr)	17.12	168.2
N <sub>2</sub> Composition (vol fraction)	0.9033	0.9630
Energy consumption (kJ/L)	13543.6	13148.5

**Table 4.** Comparison of Liquefaction of Pure N<sub>2</sub> gases with Waste N<sub>2</sub> gases using PLHC system.

Parameter	Liquefaction of Pure N <sub>2</sub> gases using PLHC at optimal conditions	Liquefaction of Waste N <sub>2</sub> gases using PLHC at optimal conditions
CDP (atm)	150	400
LCT (°C)	-115.2	-107.2
Liquid yield (Sm <sup>3</sup> /hr)	156.6	168.2
N <sub>2</sub> Composition (volume fraction)	1.00	0.9630
Energy consumption (kJ/L)	4195.4	13148.5

A step change of 50 atm in CDP was applied, as the pressure increases from 100 – 150 atm, there was a noticeable change in the liquid yield from 8.091-21.47 Sm<sup>3</sup>/hr when compared with farther step changes in CDP. It was also noted that the yield of liquefied gases increases with increase in CDP while the consumption of the power for compression increases. As mentioned in reference [APCI 2019], pure nitrogen liquefaction, J-T refrigerator working pressure should be in the range of 10-20 MPa, it was validated in between 100-150 atm, to obtain an optimal power consumption per L of liquid N<sub>2</sub> at 150 atm as 7572.1 kJ by the open loop liquefaction. Similar optimal conditions of 158 K, 150 atm of LCT and CDP applied respectively in PLHC (Closed-loop system) and a liquid yield of 156.6 Sm<sup>3</sup>/hr measured with a specific power consumption of 4195.4 kJ/L, which is substantially lower than the case of open loop system. In contrast to the results obtained by the reference [Prasad.S 2009], liquid yield has increased with increase in pressure from 100-300 atm but to avoid pinch point issues it was studied up to a maximum of 300 atm whereas in case of referred study [Prasad. S 2009], liquid yield increased to a higher value at 400 atm and later it got decreased.

### 3.3 Liquefaction of Waste N<sub>2</sub> Gases by PLHC

Waste N<sub>2</sub> rich gases from OPPOH which has a chemical composition as given by the Table 1 were considered to be a potential source for the liquefaction in this work. By setting the operating CDP at 150 atm that was confirmed from the preliminary study using pure N<sub>2</sub>, the effect of LCT was tested to obtain better liquid yield. As displayed in the figure 8, the highest yield of 11.12 Sm<sup>3</sup>/hr coupled with higher N<sub>2</sub> composition (volume fraction) of 0.8936 noted at LCT of 165 K and as LCT increased, both liquid yield and composition of N<sub>2</sub> were diminished to the lower levels of 0.17 Sm<sup>3</sup>/hr and 0.0053 respectively at 175K.

Since the composition of N<sub>2</sub> achieved at CDP of 150 atm and LCT of 165 K was not satisfactory, further change in CDP was made to examine improvement in composition and the corresponding liquid yield along with LCT. Therefore, the effect of CDP change was recorded in the range of 150 - 500 atm as shown in Table 2. When compared the yield and composition of liquid N<sub>2</sub> at different compressor discharge pressures, at 400 atm and -106.2°C maximum liquid product of 17.12 Sm<sup>3</sup>/hr with 90.33% (vol) of N<sub>2</sub> was recorded for the liquefaction of waste N<sub>2</sub> gases using an open loop PLC. Accordingly, at the same CDP and an LCT of 107.2 °C the liquefaction of waste N<sub>2</sub> gases performed on closed loop

PLHC and the maximum liquid yield measured as 168.2 Sm<sup>3</sup>/hr with an improved composition of 96.30 % of N<sub>2</sub> despite of slightly decrement in specific power consumption of about 3 % as mentioned in the table 3.

The composition of waste N<sub>2</sub> gases effects significantly on the operating compressor discharge pressure in the liquefaction cycle and its corresponding lower cooling temperature as displayed in the table4. In addition, the yield of liquid decreased slightly and to higher composition of N<sub>2</sub> achieved at a very high CDP. In other words, liquefaction of waste N<sub>2</sub> gases consume more than 3 times higher specific power than in the liquefaction of pure N<sub>2</sub> gases using precooled Linde's cycle

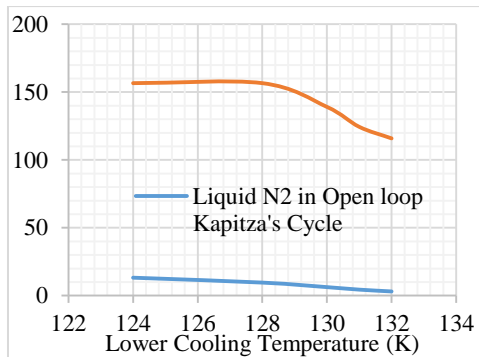
### 3.4 Application of Kapitza's cycle for the liquefaction of Pure N<sub>2</sub> gases

Modified Claude's cycle which is known as Kapitza's cycle with two heat exchangers along with a cooler considered for the liquefaction of N<sub>2</sub> source gases. On prior to the development of a cycle for the liquefaction of waste N<sub>2</sub> gases, liquefaction of pure N<sub>2</sub> gases was examined under the different conditions for understanding the effect of lower cooling temperature at a fixed compressor discharge pressure of 40 atm on the yield of liquid product in both open loop and closed loop Kapitza's cycles. As shown in figure 9, the higher liquid product yields of 156.6 and 9.632 Sm<sup>3</sup>/hr were recorded at an LCT of 128 K with and without recycling of non-liquefied gases respectively. At the temperatures lower than 128 K, liquid yield remained constant at 156.6 Sm<sup>3</sup>/hr for closed loop cycle whereas it gradually increased in open loop system.

### 3.5 Liquefaction of waste N<sub>2</sub> gases using Kapitza's Cycle (KC)

Kapitza's cycle contains two heat exchangers rather than three coolers in the

case of Claude's cycle. The compressed gases pass through a cooler and the first heat exchanger where it gets cooled to a fixed temperature of -53.2 °C and then a fraction of gas (x) diverted to the expander to perform some work (W<sub>T</sub>) and the rest is allowed to throttle through the second heat exchanger in which the lower cooling temperature (LCT) will be determined for the optimal liquid production. As shown in the table 5, liquefaction of waste N<sub>2</sub> rich gases in KC system were analyzed by both open loop and closed loop configurations at 40 atm of CDP and an LCT of -161.2 °C. Despite of achieving similar N<sub>2</sub> compositions, energy consumption per L of liquid produced was cut off by 12.5% in case of liquefaction using closed loop KC system.



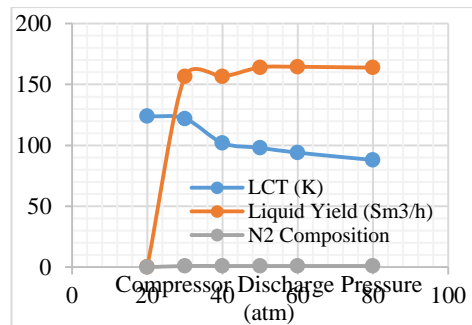
**Figure 9.** Effect of LCT on Liquefaction of Pure N<sub>2</sub> in Kapitza's system at a CDP of 40 atm

**Table 5.** Comparison of Liquefaction of waste N<sub>2</sub> with Open loop and Closed loop KC systems

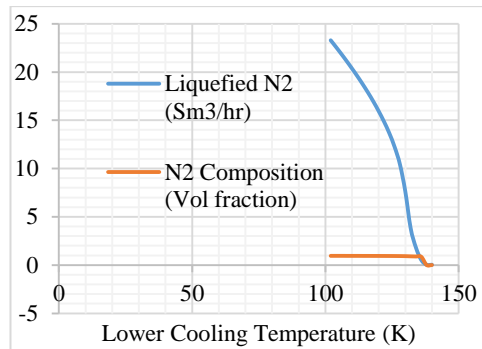
Parameter	Open loop KC	Closed loop KC
CDP (atm)	40	40
LCT (°C)	-161.2	-161.2
Liquid yield (Sm <sup>3</sup> /hr)	23.29	156.5
N2 Composition (vol fraction)	0.9652	0.9651
Energy consumption (kJ/L)	3796.5	3375

Further study focused on understanding the effect of change in compressor discharge pressure on the liquefaction of waste gases in the Kapitza's cycle. The change in CDP from 20 to 80 atm have showed significant fluctuations in LCT, liquid yield and N<sub>2</sub> compositions as demonstrated by the fig.10. It was distinguished that the CDP change in between 30 and 40 atm required typical alterations in LCT values ranges from 122 K to 102 K and a slightly improved N<sub>2</sub> purity

recorded at 40 atm while the liquid yield remained constant at both conditions. Although Kapitza's cycle mostly preferred at relatively lower pressures of about 7-10 atm for liquefaction of gases [Yilmaz.C et al 2019], it was lucid that the higher pressures, very similar to Claude's operating conditions [Smith. J.M et al 2001] that are about 30-40 atm are required to obtain better liquid fraction of waste N<sub>2</sub> gases.



**Figure 10.** The effect of alteration in CDP on the liquefaction of Waste N<sub>2</sub> rich gases using KC system



**Figure 11.** The effect of LCT on Liquefaction of Waste N<sub>2</sub> using Kapitza's Cycle at a CDP of 40 atm

Waste N<sub>2</sub> gases liquefied in Kapitza's Open loop system at a compressor discharge pressure of 40 atm to verify the effect of lower cooling temperature on liquid production and its N<sub>2</sub> composition. Highest liquid yield of 23.29 Sm<sup>3</sup>/hr obtained at 102 K with a high N<sub>2</sub> volume fraction of 0.9562

as depicted in figure 11. But both liquid yield and N<sub>2</sub> compositions have diminished to zero as LCT approaches to 140K. In other words, the second heat exchanger in the cycle has posed a problem by crossing the pinch limits for a LCT lower than 102 K.



**Table 6.** Performance indicators of PLC and KC systems applied for the Liquefaction of waste N<sub>2</sub> gases.

Parameter	Pure N <sub>2</sub> Liquefaction using PLHC	Waste N <sub>2</sub> gases Liquefaction using PLHC	Pure N <sub>2</sub> Liquefaction using KC	Waste N <sub>2</sub> gases Liquefaction using KC
CDP (atm)	400	400	40	40
LCT (°C)	-106.2	-107.2	-171.2	-161.2
Liquid fraction (y)	0.0998	0.1056	0.1480	0.1488
Liquid Yield (Sm <sup>3</sup> /hr)	156.6	168.2	156.6	156.5
N <sub>2</sub> Composition (vol%)	100	96.30	100	96.51
COP <sub>act</sub>	0.8022	0.8032	0.8404	0.8408
Energy consumption (kJ/L)	14558.6	13148.5	3719	3375

**Table 7.** Validation of the liquefaction models applied

References	Precooled Linde-Hampson Cycle		Kapitza's Cycle	
	Liquid fraction (y)	COP <sub>act</sub>	Liquid fraction (y)	COP <sub>act</sub>
This Work	0.1056	0.8032	0.1488	0.8408
Yilmaz et al., [5]	0.13	0.1214	0.1585	0.4090

**Table 8.** Comparison of Physicochemical properties of liquid N<sub>2</sub> products

Parameter	Liquid N <sub>2</sub> from PLHC Process	Liquid N <sub>2</sub> from Kapitza's Cycle	Liquid N <sub>2</sub> from Air Products & Chemical Inc. USA [Hajnus & Chowroski 2012, ]
Boiling Point (°C)	-195.6	-195.6	-195.8
Density (kg/m <sup>3</sup> )	818.9	817.7	808.5
Latent Heat of Vaporization (kJ/kg)	237.4	237.6	199.1
Specific Volume (m <sup>3</sup> /kg)	0.974	0.975	0.861
N <sub>2</sub> Composition (vol fraction)	0.9630	0.9651	NA

### 3.6 Performance Analysis of Liquefaction Cycles

Liquefaction of waste N<sub>2</sub> gases using precooled Linde's cycle and Kapitza's cycle are compared with each other to assess their performance in terms of required operating conditions, fractional conversion of gases in to liquid, the rate liquid yield, purity of N<sub>2</sub> in the liquid product, coefficient of performance and specific energy

consumption in kJ/L. The plant simulation results of both PLHC and KC systems for the liquefaction of waste N<sub>2</sub> rich gases are summarized in the table 6. In both the cycles, pure N<sub>2</sub> liquefaction have shown higher energy consumptions with slightly lower liquid fractions. In other words, KC system evaluated by the improved COP<sub>act</sub> values with marginally recovered quality of N<sub>2</sub> in the liquid product. Inevitably, specific energy consumption decreased by 74 % in Kapitza's cycle when compared with

Precooled Linde's cycle for the liquefaction of waste N<sub>2</sub> gases.

S. Prasad [Yilmaz C. et al 2019] has obtained a maximum yield of 7.13 % and the specific energy consumption of 4843 kJ/L at 8 bars of CDP for pure N<sub>2</sub> liquefaction using Kapitza's cycle model studied using HYSYS<sup>®</sup> whereas in the present study at 40 atm it was optimized to attain 14.8 % of liquid yield with 3719 kJ/L of specific energy requirement. Therefore, increase in pressure has resulted with increased yield with optimal energy consumption.

### 3.7 Validation of Models Adapted

Liquefaction models applied in the present study have been validated with reported works [Yilmaz.C et al 2019] from the literature. As described in the table 7, primary performance indicators of the liquefaction cycles such as liquid fraction recovered and coefficient of performance (COP) of the systems were compared. COP values estimated in the present work are higher in both PLHC and KC systems used for the liquefaction of pure N<sub>2</sub> whereas the liquid yield has decreased marginally, yet the models developed are competitive. Since the present work majorly concerned about liquefaction of waste N<sub>2</sub> gases that emits from oxygen production plants using PSA technology, the liquid products obtained by the proposed models are validated with the products in the market [Schimdt. J 2023] as given in the table 8. Heat of vaporization and specific volume have deviated with slightly higher values in case of the proposed models whereas the rest of the properties are almost merged with available products in the market.

## 4. Conclusions

Many researchers have been focused on liquefaction of nitrogen from the air separation process but the liquefaction of

waste N<sub>2</sub> rich gases that are generated from the oxygen production plants have not yet taken much attention. In the context of that, this work aimed at utilization of such gases for the feasible production of liquid N<sub>2</sub> by developing most commonly practiced cryogenic cycles such as Precooled Linde-Hampson cycle and Kapitza's cycle. Liquefaction of Pure N<sub>2</sub> and waste N<sub>2</sub> rich gases were performed on aforementioned cycles to achieve optimal liquid fractions and improved N<sub>2</sub> compositions. When the systems are not facilitated with recycle (open loop) consumed higher specific energies while energy consumption has reduced significantly in the case of closed loop operation. Compressor discharge pressure and lower cooling temperature of the working fluid are two key parameters that play vital role in liquefaction of gases. Optimal liquefaction of Pure N<sub>2</sub> at 150 atm of CDP and -115.2 °C of LCT in PLHC system generated a liquid yield of 156.6 Sm<sup>3</sup>/hr along with a specific energy requirement of 4195.4 kJ/L. On the other hand, Liquefaction of Pure N<sub>2</sub> in Kapitza's system consume 3719 kJ of energy per L of liquid N<sub>2</sub> while producing the constant liquid yield because of lower CDP levels applied. Since the waste N<sub>2</sub> gases are comprised of different components, composition of nitrogen in the liquid has been given much attention for the model development. In the perspective of that, CDP levels altered to obtain better N<sub>2</sub> quality at the expense of quantity of the liquid. Thus at 400 atm and 40 atm of CDP values have generated the optimal liquid products of 168.2 and 156.5 Sm<sup>3</sup>/hr, besides the improved N<sub>2</sub> compositions of 96.3 % (vol) and 96.51% respectively. Nevertheless, PLHC consume 74 % more specific energy than Kapitza's cycle. Consequently, the Kapitza's cycle model developed proved to be a competitive system when compared with PLHC and other reported models in relation to the key performance indicators such as COP<sub>act</sub> of

0.8404 and a liquid fraction of 0.1488. Both the applied cycles produced similar liquid N<sub>2</sub> products in terms of physicochemical parameters and the properties match merely with the products in the market. However, developed models are constrained by the conditions applied and thermodynamic property packages selected etc., to achieve even more reliable system, attention must be paid for the development of enhanced cycles.

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## CLUSTERING OF LOCALIZED ACOUSTIC EMISSION SOURCES BY THE DBSCAN ALGORITHM IN SEPARATORS

**Abstract:** *In this paper, the method for locating sources of acoustic emission by approximate calculation of potential coordinates using a grid superimposed on the area around the sensors that detected the wave was proposed. Various noises such as electromagnetic pulses and other external noises were removed from input data. The DBSCAN clustering algorithm was applied. The results were compared with the real state of the object under study after additional control. Analytical and practical research points to the possibility of using the presented method as a tool for determining the coordinates of defect development points and wave velocity.*

**Keywords:** *acoustic emission; location; defects; approximate calculation; clusterization; pressure vessel*

### 1. Introduction

When operating objects, it is very important to know their condition in order to avoid emergencies. Objects such as bridge columns, tanks for the transport of liquids, various structures in industry and many others are under constant loads during their use (Balagurin et al, 2020; Rastegaev et al, 2018; Nosov et al, 2017). There is a wide range of non-destructive testing methods that allow monitoring objects without destroying or dismantling it, such as xray inspection (Li et al, 2022), ultrasonic method (Smoqi et al, 2023) One of the most popular approaches is the acoustic emission (AE) method due to its accuracy and environmental friendliness. The AE method finds its application in various areas of technological process monitoring. For example, AE method is allowing to predict the structure of the metal during casting (Yaroslavkina et al, 2020), in (Ser'eznov et al, 2020) AE method was applied in aircraft construction, (Makhnutov

et al, 2020) applied AE methods to monitor composite fiber failures. The essence of the AE method is to detect the acoustic waves that arise in the object when defects occur during the operation of the object. To perform this method, AE sensors are installed on the investigated area of the object, then during the continuous loading of the object, various defects begin to appear in it: cracks, splits, material crumbling, and others. When they occur and during their growth, defects emit acoustic waves propagating through the object, which are recorded by sensors. Various parameters of the acoustic wave are recorded: amplitude, energy, time of arrival at the sensor, and many others. This is similar to complex systems with non-periodical dynamics (Pyko et al, 2018). Assessing the condition of an object can be very time consuming due to the size of the object under examination, so it is extremely important to reduce the areas that need to be checked by a specialist. Acoustic emission data sets are usually quite large, but the correlation of some of the

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parameters allows them to be reduced for more convenient and faster processing. Analysis of the data allows obtaining information about the defects in the object, their size, development progress and location. At the moment, many methods have been developed for analyzing acoustic emission data for various materials. However, there are still no universal automatic methods of analysis that give an accurate result without the participation of a specialist, therefore, this area is relevant to this day.

At the moment, there are quite a lot of different software for analyzing acoustic emission data, however, the operation of their methods is often hidden from users by trade secrets, and the algorithms used are often not updated along with the development of technologies. (Valen Systeme, Interunis, Diaton, etc.)

Analysis of large areas of the object under study takes a lot of time for specialists, so location and clustering methods are needed to indicate the areas in which defects are most likely to be located.

There are various approaches to source location: frequency and wave mode analysis (Jiao et al, 2008), laser-based reversal time concept (Park et al, 2012), analytical approach (Grigorieva et al, 2022). The result of the work of location methods are areas in which there will be a defect with the highest degree of probability. The location accuracy is influenced by many factors: the structure and shape of the object under study, its condition, the presence of cavities in it, design features, and much more. Different location methods take these factors into account to varying degrees.

After using location methods, various machine learning methods are often applied to the results obtained to determine the type of signal source and predict the further appearance of defects. In recent years, the field of machine learning has been developing rapidly, various approaches, such

as neural networks, clustering and classification algorithms, and others, allow you to get more and more accurate results. Clustering and classification algorithms are used to group data from located sources and form many types of defects. To date, there are many approaches to data clustering that differ in data type and clustering algorithm. Different algorithms have different advantages and disadvantages, as well as different requirements for input parameters. In (Feifei et al, 2011) K-means algorithm was used with cluster centers initializing with random uniform distribution to separate different types of AE signals sources. In (Calabrese et al, 2010) two different unsupervised clustering approaches were used to reduce set of data parameters and identify clusters of different AE signals: Kohonen map and principal component analysis. In (Feifei et al, 2012) DBSCAN (Density-based spatial clustering of applications with noise) (Ester et al, 1996) and K-means were applied to specific material 2.25Cr-1Mo experiment data and were used to separate different types of signals and to extract burst cracking signals. Solving the problem of localization and clustering of AE signals when examining thin-walled cylindrical vessels used for transporting and storing explosive combustible substances is relevant, as it helps to prevent their early failure, downtime, and even a technogenic or environmental disaster.

## 2. Primary Data Processing

When fixing the signals of acoustic emission to sensors on thin-walled vessels, the task goes from spatial to flat - to development of a cylindrical object on a plane. For analysis, the size of the object, the coordinates of the sensors placed on it, various signal parameters, the signal arrived on the sensor and others detected by sensors are used. Various design features of object such as

hatches, manholes, supports, unions and others are also taken into account. In Vallen, a single propagation velocity is set for all signals of the experiment, which does not take into account the design and material features, therefore, it is not used in the location and clustering algorithms of this work.

Among the unfavorable factors that have the most negative impact on the result of applying the method are noise-like signals that accompany all modes of operation of most industrial equipment, especially dynamically loaded equipment, and therefore noise is an integral part of any AE diagnostic signals. A high level of noise can lead to a failure in the correct operation of AE signal detectors, which is accompanied by: skips in signal registration; errors in calculating the time of their arrival; the appearance of false or displacement of real location events; incorrect assessment of the hazard class of acoustic sources and, in general, an incorrect assessment of the technical condition of dangerous production facilities. (автореферат , цитирование Игоря Анатольевича).

To solve the problem of detecting signals at the noise level and the possibility of recognizing from several, simultaneously acting acoustic sources, a method was chosen that is used by almost all major scientific groups involved in AE methods, namely: filtering (noise suppression) of the recorded signals in order to bring them to an impulse form for estimation by the amplitude threshold method.

In this work, filtering is carried out: by the amplitude threshold, by the number of sensors that recorded the signal, by the electromagnetic attribute. There are also technical limitations of AE sensors that do not capture the low frequency range below 40 kHz. These technical characteristics lead to forced filtering on a frequency basis. This work uses the VS150-RSC. The VS150-RSC is a piezoelectric AE sensor with integrated

Vallen Smart Line preamplifier. Its frequency response is characterized by a peak at 150 kHz

Acoustic emission data obtained during real experiments often contain a large number of various noises (human factor, electromagnetic oscillations, cosmic rays (Bonvech et al, 2022), etc.), which are also detected by sensors and significantly increase size of data set, thus it is essential to filter useful information from interference before further work (Davydova et al, 2015; Barat et al, 2010). There are various ways to separate signals from noise: Agletdinov et al, 2020; Rastegaev et al, 2020; Sedlak et al, 2009; Van Der Baan et al, 2015. In this paper, the recorded signals were filtered from obvious noises, the wave amplitude of which does not fall within the range of wave values from AE sources from 40 [dB] to 100 [dB], similarly to Balagurin et al (2020). Next, the signals that were recorded by no more than 4 sensors were removed. Considering the error of the equipment, it is impossible to establish any reliable location of AE sources using less than 4 sensors. The choice of this number of fixed sensors is due to the fact that with a smaller number of sensors, it will be impossible to solve the system of equations for finding the location of the signal source (the method with mathematical equations is used later to verify the reliability of the results obtained by the grid overlay method, see paragraph 3). On the other hand, if information from more than 6 sensors is taken into account, then the set of obtained solutions is sometimes truncated to an empty set due to the influence of data from the last distant sensors, and the more distant the sensor, the greater the error in the information it recorded. Thus, during preprocessing, it is necessary to limit ourselves to 4-6 nearest priority sensors. Then, hypothetical electromagnetic pulses were removed from the remaining data, which can also be captured by sensors from external objects and devices during the

experiment. These waves do not carry information about the state of the object and therefore also in this case refer to noise. Such data are distinguished by the fact that their fixation by sensors occurs almost simultaneously, since electromagnetic waves propagate at the speed of light. In the method, it was assumed that signals are electromagnetic, in which the difference in arrival at the sensors is less than 0.2 microseconds [μs]. After filtering the data, the method of approximate calculation on the grid was applied.

### 3. Grid overlay location method

#### 3.1. Problem Statement

When an acoustic wave propagates through an isotropic material, its velocity in all directions is almost the same. To locate the source, it is assumed that the wave is recorded by, at least, 4 sensors and its speed changes insignificantly. It is also assumed that the wave velocity lies within the range of possible values in the investigated object. The range of velocity values arises in view of the division of waves into Lamb and Rayleigh waves, which have different magnitudes. Depending on the distance from the source to the sensor, different waves of the same signal can be recorded (Grigorieva et al, 2022). Since the calculations take place on the development of the object, it is also necessary to consider the possibility of wave propagation through the edges of the plane along the shape of the object.

#### 3.2. Location method

The method is based on the approximate calculation of the possible coordinates of the wave source. Let several sensors record the wave. For first and second sensors in wave arrival order, the maximum distance at which the wave source can potentially be

relative to them is calculated.

$$d_{\max} = \frac{\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}}{2} \quad (1)$$

where  $x_i, y_i$  - coordinates of the  $i$ -th sensor in order that recorded the wave.

Further, a grid with a certain step is superimposed on the area in which the sensors that recorded the wave are located within this distance. For every point grid, the condition of changing the velocity within the specified accuracy is checked:

$$|v_1 - v_2| < accuracy \quad (2)$$

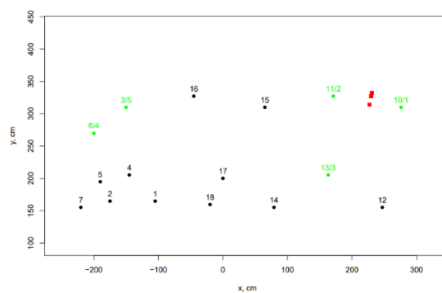
where accuracy is predefined,

$$\begin{cases} v_1 = \frac{\sqrt{(x_2-x)^2+(y_2-y)^2} + \sqrt{(x_1-x)^2+(y_1-y)^2}}{t_2-t_1} \\ v_2 = \frac{\sqrt{(x_3-x)^2+(y_3-y)^2} + \sqrt{(x_2-x)^2+(y_2-y)^2}}{t_3-t_2} \end{cases} \quad (3)$$

After calculations for all grid vertices, a set of potential source points for different velocities is formed. Then, for each point of the resulting set, it is checked that among the three closest sensors to the given point there are at least 2 detected corresponding signal, allowing some error in the operation of the sensors.

**Table 1.** The set of possible AE source points for a single signal.

	x	y	speed
1	226.82	314.32	141.23
2	229.62	327.22	164.11
3	229.82	328.12	165.48
4	230.72	332.12	171.26



**Figure 1.** Grid overlay location method result



The Table 5 shows an example of data processing for a signal recorded by 5 sensors and shows the result of the proposed location method. The first and second columns indicate the most probable coordinates of the AE signal source, and the third column indicates the probable propagation velocity of this signal.

Figure 1 shows the result of the method for a single acoustic wave: the sensors that detected the wave are highlighted in green, red - set of potential points. At the last stage sets with more than 4 solutions (possible location points) were removed and the average value was calculated for each set of points.

After averaging the values in each set of points, a data set was obtained for further clustering.

#### 4. Data clusterization

For data clustering, the DBSCAN algorithm was chosen because it does not require knowing in advance the number of clusters, it gets the same result for the same data set, and it is resistant to outliers.

The clustering algorithm was applied to the previously obtained data set to determine the points clustering areas. The data obtained using the algorithm (Grigorieva et al, 2022) applied to the experimental data were also clustered to check the correctness of the location method.

The essence of the developed clustering method is to automatically calculate the ranges of characteristics characteristic of this particular object for one of the dangerous zones in which there is definitely a defect and, based on this, find the remaining zones of probable defects. For the method to work, the coordinates of the rectangle in which the required zone is located and the number of high-amplitude pulses in this rectangle are required. The number of pulses is determined empirically and varies from 3 to 10 depending on how damaged the object is,

based on (Gomera et al, 2014).

Since it is important to take into account not only the location of the points, but also the values of the amplitude and speed, for the correct formation of clusters. The selection of parameters was based on the following articles: Gomera et al, 2014; Yaroslavkina, 2018; Rastegaev et al, 2022.

The following metric was developed and applied:

$$f(i, j) = w_1 * l + w_2 * v + w_3 * a \quad (4)$$

$i, j$  – points in data set;  $w_1, w_2, w_3$  – weight coefficients of distance, speed and amplitude, respectively;

$$l = \sqrt{\left(\sum_{k=0}^n \frac{x_{ik}}{n} - \sum_{k=0}^m \frac{x_{jk}}{m}\right)^2 + \left(\sum_{k=0}^n \frac{y_{ik}}{n} - \sum_{k=0}^m \frac{y_{jk}}{m}\right)^2} \quad (5)$$

$$v = \left| \sum_{k=0}^n \frac{v_{ik}}{n} - \sum_{k=0}^m \frac{v_{jk}}{m} \right| \quad (6)$$

$$a = \min\left(\sum_{k=0}^n \frac{a_{ik}}{n}; \sum_{k=0}^m \frac{a_{jk}}{m}\right) \quad (7)$$

where  $x, y, v, a$  – averaged coordinates, speed, amplitude of points in sets which were described in section 3.2.,  $n, m$  - number of points in this sets.

For each of the parameters (distance, speed and amplitude) the corresponding threshold values were used to calculate the global epsilon used in the DBSCAN algorithm:

$$EPS = w_1 * eps_l + w_2 * eps_v + w_3 * eps_a \quad (8)$$

Weights  $w_1, w_2, w_3$  and epsilons  $eps_l, eps_v, eps_a$  are automatically calculated for each object of study based on data values. Automatic calculation of parameters for each object is increasing the accuracy of clustering.

After applying the algorithm, clusters with a large number of elements were removed from the resulting set of clusters, since in real cases such clusters are most likely signals received as a result of friction of object against a support that are not defects. Depending on how the experiment was conducted, clusters with 10-20 elements were considered as large.

As a result, the resulting clusters display areas on the object that are most likely to

have defects and that should be checked by a specialist.

## 5. Experiment

Data from several real experiments were used to test the methods. The formation and development of defects in the process of object loading were controlled by recording acoustic emission signals in real time with an Amsy-5 Vallen system (Germany) as in (Damaskinskaya et al, 2021). The technical features and characteristics of piezoelectronic sensors were given in paragraph 2. Software was developed for processing AE data using the proposed method. It is implemented on a modular basis, i.e., is a sequentially executed scripts of procedures: reading data, converting it, processing it according to the algorithm described above, unloading, clustering and visualization. The scripts are implemented in R, C# and Python programming languages.

### 5.1. Experiment 1

In the first experiment, the object of the study was a cylindrical pressure vessel: a separator made of steel 09G2S-17+08Kh13 with a height of 3200 [mm], an inner diameter of 2000 [mm] and a wall thickness of 12 [mm]. A hydraulic test was carried out: the vessel was filled with water and been under increasing pressure for 50 minutes. During the loading process, several cracks appeared in the object, which were recorded by specialists. The initial data contained 24579 lines of sensor data, of which 4856 remained after the primary data processing, making up 1061 signals.

### 5.2. Experiment 2

In the second experiment, the object of the study was a low-pressure separator made of steel 09G2S-12+08Kh13 with a height of 6674 [mm], inner diameter of 2400 [mm].

and wall thickness of 14[mm]. The capacity of the device - 31.0 [m3]. The same hydraulic test as in experiment 1 was carried out. The initial data contained 24579 lines of sensor data, of which 4856 remained after the primary data processing, making up 1061 signals.

### 5.3. Experiment 3

In the third experiment, the sensors were calibrated, during which AE events were simulated using a special device in different places of the object. By applying this device to the object under study, acoustic waves are simulated, similar to the waves that occur during the occurrence of defects, in order to fine-tune the AE. After applying the location method, 5 groups of AE sources were correctly identified, corresponding to the simulated signals. The initial data contained 431 lines of sensor data, of which 148 remained after the primary data processing, making up 37 signals.

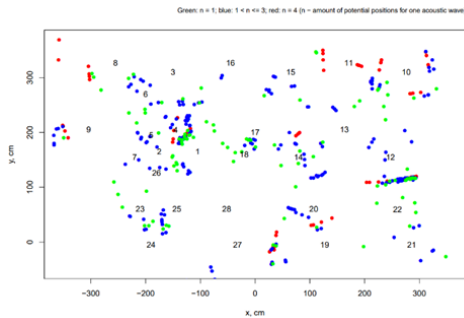
## 6. Results

After applying the location method to first experiment data, the sets of possible AE source coordinates were calculated for 206 signals from the data set. For each of resulting signals, sets as in Figure 1 were received and displayed on a single location diagram in Figure 2.

Signals with 1 solution are shown in green, signals with 2 or 3 solutions – in blue, signals with 4 solutions are shown in red. It is important to note that the speed is calculated for each signal and for each solution individually. Thus, Figure 2 shows all the points of location of AE sources obtained by the method for the object under study. Moreover, the speeds of different AE signals are various. They are allowed to be different even for each of the four solutions of one signal.

Dot clustering areas coincide with the areas

indicated by specialists for additional control, due to the possible presence of defects in these areas.



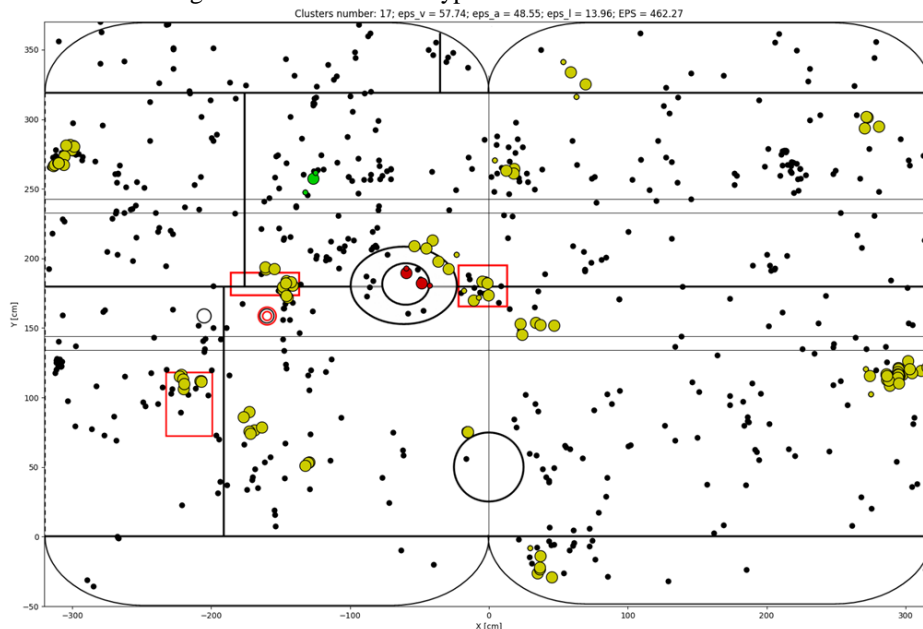
**Figure 2.** Sets of the possible positions of AE sources.

It shows the correctness of the application of this method when method significantly reduces the areas of the object that should be checked by a specialist. In the future, it is planned to optimize the metric function in the DBSCAN algorithm for different types

of objects and apply more examining objects of this type. In the second experiment, after applying the location method 534 points dataset was obtained. As a result of clustering, 5 clusters were obtained.

In the second experiment, after applying the location method 534 points dataset was obtained. As a result of clustering, 5 clusters were obtained.

In Figure 3, the red rectangles mark the areas in which defects were actually found. Points with an amplitude of 40[dB] to 55[dB] are colored green, those with an amplitude of 55[dB] to 60[dB] are yellow, and red with an amplitude greater than 60[dB]. Points that did not fall into any cluster are colored black. Figure 3 shows that clusters were formed next to each problem area, and several clusters were formed near the area of the structural supports, where many AE signals often occur.



**Figure 3.** Experiment 1 clusterization result

In Figure 4 clusters of simulated AE sources shown as colored circles. The location of all sources was correctly determined and clustered.

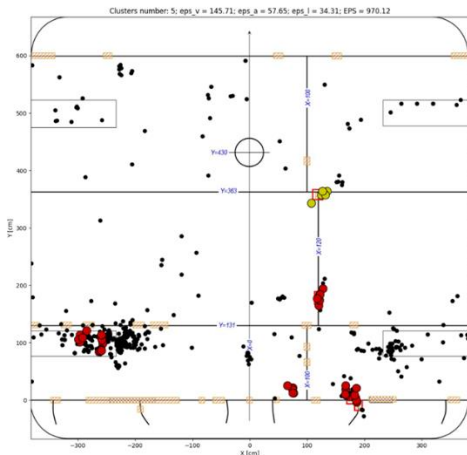


Figure 4. Experiment 1 clusterization result

## 7. Conclusion

The results obtained demonstrate that the proposed methods adequately reflect areas containing defects and their development. The method has been tested on the real experiments. The application of the developed method significantly reduces the areas of the object that should be checked by a specialist. In the future, it is planned to optimize the metric function in the

DBSCAN algorithm for different types of objects and apply more complex criteria for epsilon.

When developing various methods for working with AE data, it was decided to combine all the results described in this article and the results obtained in previous works into a single code library. The library will allow to apply methods and combine the results more conveniently and faster. The library will contain methods for primary data processing for cleaning them from noise, locating sources of AE signals, and methods for clustering and classifying sources.

To develop the library, the C# programming language was chosen in view of the convenience of working with data, as well as the availability of various packages with functionality for applying machine learning and mathematics methods. At the moment, the problem of combining all the developed methods is being solved in view of the fact that they were written in different programming languages, and therefore it is required to refactor the code written over several years.

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## CONTROL OF THE ULTRASONIC EMITTERS PARAMETERS TO DETERMINE THE DEGREE OF TOOL MATERIALS AND PROTECTIVE COATINGS CAVITATION DESTRUCTION

***Abstract:** The article presents the results of studies aimed at identifying the possibility of using piezoelectric ultrasonic oscillatory systems (USOS), used to form cavitation effects in liquid media, as a sensor for controlling the degree of cavitation erosion of materials for working tools and protective coatings. The studies were carried out on the basis of the analysis of the piezoelectric ultrasonic oscillatory systems (emitters) physical equivalent circuits, formed from electromechanical analogues, taking into account the attached test samples. Dependences of the input electrical impedance of ultrasonic emitters and its active and reactive components for different variants of assemblies of ultrasonic emitter structures on the degree of cavitation erosion of individual structural elements obtained. The results obtained made it possible to confirm the possibility and effectiveness of monitoring the ultrasonic oscillatory system parameters to determine the degree of cavitation destruction of tools and protective coatings, as well as to establish the sensitivity of the proposed control method.*

***Keywords:** Ultrasonic; Cavitation Wear; Modeling; Electromechanical Analogies; Control*

### 1. Introduction

Studies of cavitation materials destruction relate to the field of the durability (strength) control of materials and their protective coatings under the influence of concentrated flows of matter and energy. The control can be used to predict the properties of known materials and to search for new materials and coatings that can ensure reliable and long-term operation of parts of mechanisms and machines used in a wide variety of industries.

Cavitation is one of the possible mechanisms of destruction of metals (and other materials) and their coatings. It is a process of formation and subsequent collapse of vapor-gas bubbles in a liquid. This phenomenon occurs everywhere, since hydrodynamic

cavitation occurs as a result of a local decrease in pressure in the liquid. It happens due to the elements of various mechanisms moving in it (pumps, for example) or when liquid flows around stationary elements. Acoustic cavitation occurs in liquid media when acoustic vibrations of high intensity propagate in them.

The cavitation process on the surfaces of products (coatings) accompanied by a number of secondary phenomena. These phenomena include: shock waves, cumulative jets, local temperature rise, electrical discharges, released gases that can be aggressive or contribute to oxidative processes. All these phenomena negatively affect the condition of the surfaces of elements, parts and machines that are directly located or working in a liquid medium. They lead to rapid wear of reactors,

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heat exchangers, pipelines, pumps and other elements. They also reduce the productivity of the equipment and shorten its service life.

Therefore, the efforts of the creators of new equipment for special industries (nuclear, chemical and metallurgical) aimed at finding and using such materials and coatings that can ensure long-term reliable operation of equipment, including in conditions of cavitation.

Currently, to determine the degree of cavitation erosion of materials and their coatings, a test method for cavitation erosion used, regulated by the ASTM G32-10 standard "Standard Test Method for Cavitation Erosion".

This method of cavitation erosion testing consists in placing a sample with the tested material or coating in a liquid medium in front of the end surface of the ultrasonic vibration emitter. Next, ultrasonic vibrations of a certain intensity formed to originate in the gap between the end surface of the radiator and the sample of the cavitation process. After the expiration of the ultrasonic exposure time sufficient to destroy the surface of the material or coating under study, their cavitation resistance is determined by changing the mass or thickness of the material or coating under study.

This standard not only regulates the conduct of tests, but also defines the requirements for the equipment used. Thus, for the implementation of this method of testing materials for resistance to cavitation erosion under normal conditions, there is specialized testing equipment.

Currently, the situation is significantly complicated by the fact that the liquid media used in the working mechanisms may have an abnormally high temperature or be under high overpressure, as well as be chemically aggressive due to the presence of chemical reagents in them in the form of acids, alkalis or aggressive gases (such as ozone).

In this regard, the selection and search of materials cannot be provided without studies of cavitation erosion of these materials and their coatings at high temperatures, pressures and in chemically active liquids.

Unfortunately, it is impossible to use this method for testing cavitation erosion of materials (regulated by the ASTM G32-10 standard) at high pressures, temperatures up to 1000 degrees Celsius and in liquid media of various properties (including aggressive ones) for the following reasons:

- due to the impossibility of carrying out tests of cavitation erosion in high-temperature and aggressive environments without the use of special means and methods for the formation of vibrations and their introduction into the media, i.e. without the use of special working tools and special technological volumes;

- due to the inability to control and management the degree of ultrasonic action (the amplitude of the instrument's vibrations) in different environments and conditions to ensure the same ultrasonic effect in different liquid media in which the research carried out.

The revealed shortcomings of the method of controlling the cavitation strength of materials and their coatings (prescribed by the ASTM G32-10 standard) are the reason for obtaining unreliable research results. They also exclude the possibility of making the right decisions when choosing materials for operation under cavitation conditions. This makes it impossible to apply this method of testing materials for cavitation strength under abnormal conditions.

In this regard, there is a need to create a method for testing cavitation erosion of materials and coatings at abnormally high temperatures and overpressure. I.e., a method is required that can ensure high efficiency (accuracy, reliability) of determining the cavitation strength of various materials intended for operation



under conditions of cavitation exposure in abnormal conditions.

The relevance of the works on development of the method and means of control of cavitation destruction of materials and protective coatings (Hardes et al., 2019; Lamana, Pukasiewicz, Sampath, 2018; Lin et al., 2019; Romero, Tschiptschin, Scandian, 2019; Tudela, Verbickas, Burmistroviene, Zhang, 2018) is caused by the need to solve the problem of determining the applicability of created and used materials, especially for their exploitation in abnormal conditions of liquid media at elevated temperatures and pressures. One of the promising directions of solving this problem is the development of the method of indirect control of cavitation wear of materials and protective coatings by changing the electrical parameters of ultrasonic oscillatory systems (USOS). Studies (Khmelev et al., 2020; Khmelev et al., 2019) show the possibility of controlling the properties of media subjected to ultrasonic cavitation by controlling the parameters of piezoelectric ultrasonic oscillatory systems (emitters).

However, the earlier works have not established the dependence between the dimensions of the destructible working tools and protective coatings and the electrical characteristics of USOS with different design features. Determination of the magnitude of the relationship between the parameters of the prototype with the electrical parameters of ultrasonic radiators and the establishment of the sensitivity of controlling the degree of cavitation destruction of materials and coatings makes the presented work relevant.

## 2. Main part

Leave one clear line before and after a main or secondary heading and after each paragraph. Ultrasonic oscillatory systems designed to form ultrasonic oscillations and introduce them into the processed media

contain a certain number of different components, the major of which are: piezoelectric transducer, waveguide structures (boosters), concentrating waveguides (amplifiers of amplitude), working tools (ends), attachment assemblies, etc. The designs of ultrasonic emitters on the one hand determine their functional features, and on the other hand affect their electrical parameters and characteristics, the degree of influence of acoustic load on their electrical parameters and characteristics.

To study ultrasonic emitters and obtain their characteristics, many researchers resort to modeling them using equivalent electrical replacement circuits, relying on a system of electromechanical analogies. This approach makes it possible to avoid solving wave equations when studying various designs of ultrasonic emitters and use modern software packages to simulate equivalent electrical circuits of ultrasonic emitters, as well as to study them and obtain their various characteristics. According to the theory of electromechanical analogies, the electrical analogues of mass, elasticity, active losses, force, and oscillatory velocity are electrical inductance, electrical capacitance, electrical resistance, electrical voltage, and electric current, respectively. There are many variants of equivalent ultrasonic emitter circuits proposed by various authors. They describe the behavior of real ultrasonic emitters in varying degrees of approximation. When considering the operation of ultrasonic emitters near their resonant frequency, their equivalent electrical replacement circuits are significantly simplified.

Based on the theory of electromechanical analogies, such an USOS with a prototype can be presented in the form of a physical equivalent RLC substitution diagram (figure 1).

An equivalent electrical model describing an ultrasonic emitter consists of series-connected four-poles, each of which is an

electrical analogue of the following elements of an ultrasonic emitter: an electromechanical piezoelectric converter, several series-connected waveguides of the same type, an acoustic load. The circuit, which is an analogue of an electromechanical converter, constructed taking into account its transformation coefficient, the physical, geometric and acoustic properties of the materials of its components, its resonant frequency. The circuit, which is an analogue of waveguide elements (concentrators), constructed taking into account the transformation coefficient, physical, geometric and acoustic properties of materials, and the resonant frequency. The scheme, which is an analogue of the acoustic load on the ultrasonic emitter (test sample), is constructed taking into account its physical and acoustic properties.

The equivalent electrical circuit of the ultrasonic emitter replacement (shown in figure 1) is a serial connection of the same type (T-shaped) circuits with each other.

In the scheme shown in figure 1 the test sample is considered as a part of the waveguide system of an USOS and presents an attached half-wave test cylindrical waveguide with or without coating, which parameters will change in the process of its cavitation destruction (erosion). It is obvious that the electrical analogue of the test sample, being a part of the electrical model of the USOS, affects its parameters and characteristics as a whole.

Let us consider how some electrical parameters of ultrasonic radiators change in the process of cavitation erosion of the test sample for different variants of USOS (radiators) assembly. Table 1 shows different variants of USOS assemblies consisting of one transducer, different number of waveguide elements with different transformation coefficients and a half-wave cylindrical test working tool (test sample). Let us consider the influence of the cavitation wear value of the tool in the range of 0...100 μm.

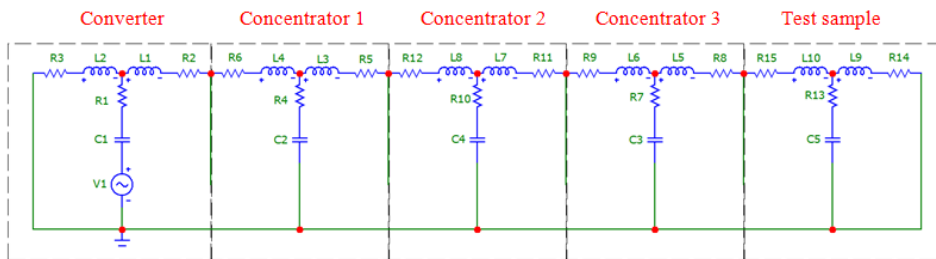


Figure 1. Electrical model of an USOS with different components

Table 1. Variants of USOS assemblies

Converter (half-wave, $K_C = 1, 1.5, 2$ )	Concentrator 1 (half-wave, $K_1 = 1, 1.5, 2$ )	Concentrator 2 (half-wave, $K_2 = 1, 1.5, 2$ )	Concentrator 3 (half-wave, $K_3 = 1, 1.5, 2$ )	Half-wave cylindrical working tool
		...	...	

Let us assume the maximum number of concentrating elements (concentrators) connected in series to the converter is equal to three. Such a number of concentrators is due solely to the practical experience of using ultrasonic emitters of this type. Suppose that each of the hubs has a transformation coefficient equal to 1, 1.5 and 2. The transformation coefficient of the half-wave converter is also assumed to be equal to 1, 1.5 and 2.

The diameter of the half-wave cylindrical working tool is assumed to be equal to the smaller diameter of the concentrator to which the working tool is attached.

In the course of obtaining the dependencies presented below, the transformation coefficient of the converter and the connected concentrators changed in the same range and were assumed to be equal to each other.

An ultrasonic oscillatory system, as an electrical load on an electronic generator, is a complex electrical load. The magnitude and nature of such a load depends on the acoustic load on the ultrasonic emitter, the mode of operation of the ultrasonic emitter (below its resonant frequency, at its resonant frequency, above its resonant frequency). Thus, the impedance  $Z$  of the ultrasonic emitter is complex and has active  $Re$  and reactive  $Im$  components.

It should be note that all curves obtained when the ultrasonic emitter was excited at its resonant frequency.

Figure 2 shows the dependences of impedance  $Z$  of the USOS on the amount of wear  $\Delta L$  of the cylindrical tip for different versions of the assembly (the number of waveguide elements of the same type connected in series) of the USOS and the amplification coefficients  $K$  of its elements.

Three designs of ultrasonic emitters are considered, consisting of a converter and a test sample, between which there are 0, 1, 2 or 3 concentrating links (concentrators). In each

of the structures under consideration, the transformation coefficient of all the elements forming it is taken to be equal to 1, 1.5 and 2.

From the curves shown in figure 2, a, it follows that consecutive build-up of the USOS construction by half-wave elements without gain ( $K = 1$ ) has no effect on the dependence of impedance  $Z$  on the wear value of the test sample (the curves are almost identical). The range of impedance change  $\Delta Z$  when changing  $\Delta L$  with series connection of half-wave elements with  $K = 1$  does not change.

Sensitivity of control of  $\Delta Z$  from  $\Delta L$  is  $\frac{\Delta Z}{\Delta L} = 0.09 \text{ Ohm}/\mu\text{m}$  and does not depend on the parameters of the current assembly.

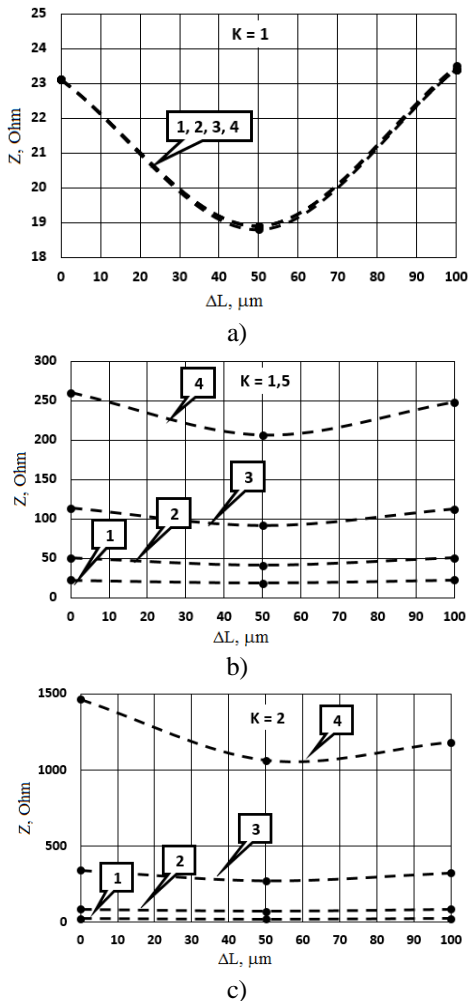
From the curves shown in figure 2, b, it follows that  $t$  consecutive build-up of the USOS construction by half-wave elements with gain coefficients  $K = 1.5$  leads to an increase in the range of impedance change  $\Delta Z$  when changing  $\Delta L$ .

At consecutive increasing of the construction by half-wave elements "Concentrator 1", "Concentrator 2", "Concentrator 3" the range of change  $\Delta Z$  at change  $\Delta L$  increases by 120%, 400% and 1127%, respectively, with respect to the assembly "Converter + Test sample". Absolute values of the range of change  $\Delta Z$  are 4.4 Ohm, 9.7 Ohm, 22 Ohm and 54 Ohm, respectively.

The sensitivity of the control of  $\Delta Z$  when changing  $\Delta L$  is  $\frac{\Delta Z1}{\Delta L} = 0.088 \frac{\text{Ohm}}{\mu\text{m}}$ ,

$$\frac{\Delta Z2}{\Delta L} = 0.194 \frac{\text{Ohm}}{\mu\text{m}}, \quad \frac{\Delta Z3}{\Delta L} = 0.44 \frac{\text{Ohm}}{\mu\text{m}},$$

$$\frac{\Delta Z4}{\Delta L} = 1.08 \frac{\text{Ohm}}{\mu\text{m}} .$$



**Figure 2.** Dependence of impedance  $Z$  of the ultrasonic radiator on the wear value of the cylindrical tip  $\Delta L$  for different variants of the USOS assembly and amplification coefficients of its elements. 1 - converter + test sample; 2 - converter + 1st concentrator + test sample; 3 - converter + 1st, 2nd concentrators + test sample; 4 - converter + 1st, 2nd, 3rd concentrators + test sample; 4 - converter + 1st, 2nd, 3rd concentrators + test sample

From the curves shown in figure 2, c, it follows that consecutive build-up of the USOS construction by half-wave elements with gain coefficients  $K = 2$  leads to a greater increase in the range of impedance change  $\Delta Z$  when changing  $\Delta L$ . At successive increasing of the construction by half-wave elements "Concentrator 1", "Concentrator 2", "Concentrator 3" the range of change  $\Delta Z$  at change  $\Delta L$  increases by 295%, 1700% and 10000% respectively, with respect to the assembly "Converter + Test sample". Absolute values of the range of change  $\Delta Z$  are 4 Ohm, 15 Ohm, 72 Ohm and 405 Ohm, respectively. The sensitivity of  $\Delta Z$  control is

$$\frac{\Delta Z1}{\Delta L} = 0.08 \frac{\text{Ohm}}{\mu\text{m}}, \quad \frac{\Delta Z2}{\Delta L} = 0.316 \frac{\text{Ohm}}{\mu\text{m}},$$

$$\frac{\Delta Z3}{\Delta L} = 1.44 \frac{\text{Ohm}}{\mu\text{m}}, \quad \frac{\Delta Z4}{\Delta L} = 8.1 \frac{\text{Ohm}}{\mu\text{m}}$$

From the dependencies shown in figure 2, it follows that two different values of  $\Delta L$  correspond to one value of impedance. Therefore, the obtained dependencies can be used either in the range when  $\Delta L = 0 \dots 50$  or when  $\Delta L = 50 \dots 100$ .

The presence of a minimum on the curves shown in figure 2 is due to the fact that with the wear of  $\Delta L = 50 \mu\text{m}$ , the length of the cylindrical test sample is equal to half the wavelength propagating in it. In this case, the ultrasonic emitter operates at its resonant frequency, which determines the minimum value of its impedance  $Z$ . Thus, in the process of cavitation wear, the  $\Delta L$  of the test sample in the range from 0 to 100  $\mu\text{m}$ , when the  $\Delta L$  is equal to 50  $\mu\text{m}$ , the ultrasonic emitter begins to work in resonance mode. In other cases, the ultrasonic emitter operates near its resonant frequency.

Figure 3 shows the dependences of the real part of impedance  $\text{Re}$  of the ultrasonic radiator on the amount of wear of the cylindrical tip  $\Delta L$  for different versions of the assembly (the number of waveguide elements of the same type connected in series) of the

USOS and the amplification coefficient K of its elements.

Three designs of ultrasonic emitters are also considered, consisting of a converter and a test sample, between which there are 0, 1, 2 or 3 concentrating links (concentrators). In each of the structures under consideration, the transformation coefficient of all the elements forming it is taken to be equal to 1, 1.5 and 2.

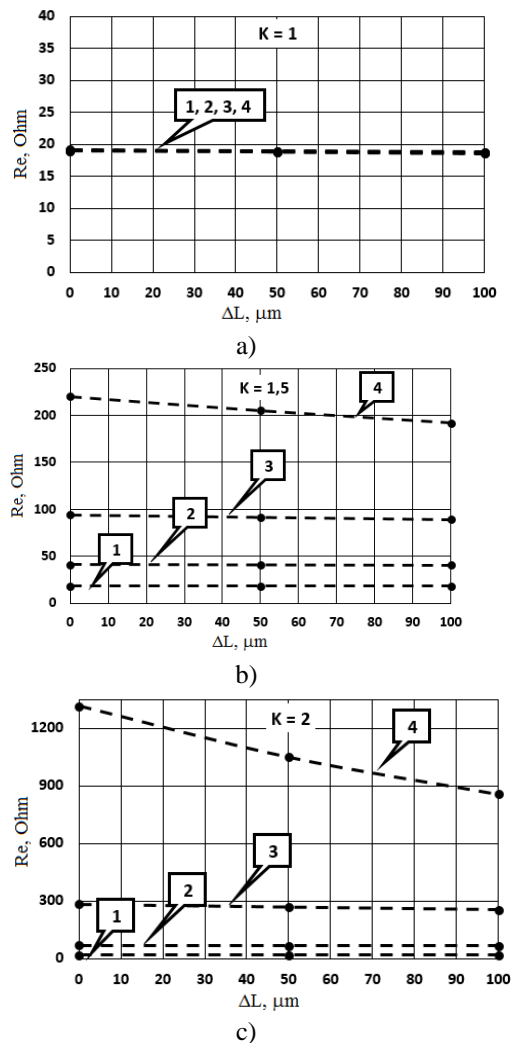
From the curves shown in figure 3, a, it follows that the consecutive build-up of the USOS construction by half-wave elements without gain (K = 1) has no effect on the dependence of the real part of impedance Re on the wear value of the test sample (the curves coincide). The range of impedance change ΔZ when changing ΔL is 0.

From the curves shown in figure 3, b, it follows that consecutive build-up of the USOS construction with half-wave elements with gain K = 1.5 leads to an increase in the range of change in the real component of impedance ΔRe when changing ΔL. If the construction is equipped consequently with half-wave elements "Concentrator 1", "Concentrator 2", "Concentrator 3" the range of ΔRe change at ΔL is 0.8 Ohm, 5 Ohm and 28 Ohm, respectively. Without the elements "Concentrator 1", "Concentrator 2", "Concentrator 3" the range of ΔRe change ΔL is close to zero.

Sensitivity of control of ΔRe parameter by change of ΔL is  $\frac{\Delta Re1}{\Delta L} = 0 \frac{Ohm}{\mu m}$ ,

$$\frac{\Delta Re2}{\Delta L} = 0.008 \frac{Ohm}{\mu m}, \quad \frac{\Delta Re3}{\Delta L} = 0.05 \frac{Ohm}{\mu m},$$

$$\frac{\Delta Re4}{\Delta L} = 0.28 \frac{Ohm}{\mu m}.$$



**Figure 3.** Dependence of the real component of the impedance Re of the ultrasonic radiator on the wear value of the cylindrical tip for different variants of the USOS assembly and the amplification coefficients of its elements. 1 - converter + test sample; 2 - converter + 1st concentrator + test sample; 3 - converter + 1st, 2nd concentrators + test sample; 4 - converter + 1st, 2nd, 3rd concentrators + test sample; 4 - converter + 1st, 2nd, 3rd concentrators + test sample

From the curves shown in figure 3, c, it follows that consecutive increasing of the USOS construction by half-wave elements with gain coefficients  $K = 2$  leads to a greater increase in the range of change of the real component of impedance  $\Delta Re$  when changing  $\Delta L$ . At consecutive increasing of the construction by half-wave elements "Concentrator 1", "Concentrator 2", "Concentrator 3" the range of change  $\Delta Re$  at change  $\Delta L$  increases by 1600%, 28900% and 450000% respectively, in comparison with the assembly "Converter + Test sample". The ranges of change  $\Delta Re$  in absolute values for the considered assembly variants are 0.1 Ohm, 1.7 Ohm, 29 Ohm, 459 Ohm, respectively.

Sensitivity of control of  $\Delta Re$  by change of  $\Delta L$

$$\text{is } \frac{\Delta Re 1}{\Delta L} = 0.001 \frac{\text{Ohm}}{\mu\text{m}},$$

$$\frac{\Delta Re 2}{\Delta L} = 0.017 \frac{\text{Ohm}}{\mu\text{m}}, \quad \frac{\Delta Re 3}{\Delta L} = 0.29 \frac{\text{Ohm}}{\mu\text{m}},$$

$$\frac{\Delta Re 4}{\Delta L} = 4.59 \frac{\text{Ohm}}{\mu\text{m}}.$$

With increasing the number of series-connected elements of the ultrasonic oscillating system construction with amplification coefficients different from 1, the relationship between the actual impedance component  $Re$  and the parameter  $\Delta L$  becomes stronger.

The use of the real component of the impedance  $Re$  of the ultrasonic emitter as an informative parameter depending on the wear value  $\Delta L$  is possible, however, an increase in both the number of sequentially connected concentrators and an increase in their transformation coefficient is required. In most cases, increasing the number of concentrators and their transformation coefficients is not possible, since this may affect the conditions for matching the ultrasonic emitter and the acoustic load. It should be remembered that the task is related not only to increasing the

sensitivity of the proposed method for controlling the degree of cavitation erosion, but also to effectively influencing liquids to create cavitation phenomena in them.

In figure 4 the dependences of imaginary part of impedance  $Im$  of ultrasonic radiator on the value of cylindrical tip wear  $\Delta L$  for different variants of USOS assembly (number of one-type waveguide elements connected in series) and amplification coefficients  $K$  of its elements are shown.

From the curves in figure 4, a it follows, that consecutive build-up of the USOS construction by half-wave elements without gain ( $K = 1$ ) has no influence on the dependence of the imaginary part of impedance  $Im$  on the wear of the test sample (the curves coincide). Range of variation of imaginary part of impedance  $\Delta Im$  for all options under consideration is 27 Ohm. The sensitivity of the control of the parameter  $\Delta Im$

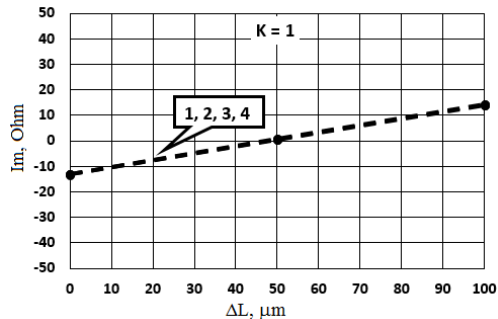
by the change  $\Delta L$  is  $\frac{\Delta Im}{\Delta L} = 0.27 \frac{\text{Ohm}}{\mu\text{m}}$  and is

a constant.

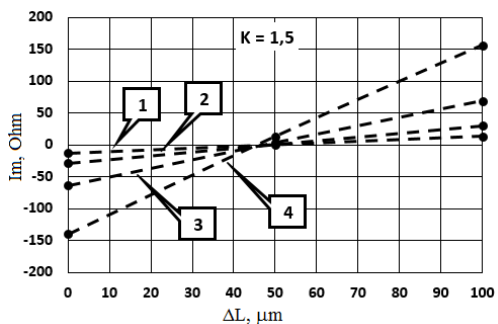
Three designs of ultrasonic emitters are considered again, consisting of a converter and a test sample, between which there are 0, 1, 2 or 3 concentrating links (concentrators). In each of the structures under consideration, the transformation coefficient of all the elements forming it is taken to be equal to 1, 1.5 and 2.

From the curves shown in figure 4, b, it follows that consecutive build-up of the USOS construction by half-wave elements with gain coefficients  $K = 1.5$  leads to an increase in the range of change of imaginary component of impedance  $\Delta Im$  when changing  $\Delta L$ . At consecutive build-up of the USOS construction by half-wave elements "Concentrator 1", "Concentrator 2", "Concentrator 3" the range of change  $\Delta Im$  at change  $\Delta L$  is increased by 124%, 400% and 1000% respectively, in comparison with the assembly "Converter + Test sample". The

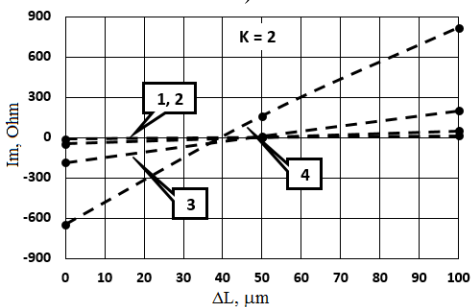
ranges of  $\Delta Im$  change in absolute values for the considered assembly variants are 26 Ohm, 58 Ohm, 132 Ohm, 296 Ohm, respectively.



a)



b)



c)

**Figure 4.** Dependence of the reactive component of impedance  $Im$  of the ultrasonic radiator on the wear value of the cylindrical tip for different versions of the USOS assembly and amplification coefficients of its elements.

Sensitivity of  $\Delta Im$  parameter to the change of

$$\Delta L \quad \text{is} \quad \frac{\Delta Im 1}{\Delta L} = 0.262 \frac{\text{Ohm}}{\mu\text{m}},$$

$$\frac{\Delta Im 2}{\Delta L} = 0.588 \frac{\text{Ohm}}{\mu\text{m}}, \quad \frac{\Delta Im 3}{\Delta L} = 1.3 \frac{\text{Ohm}}{\mu\text{m}},$$

$$\frac{\Delta Im 4}{\Delta L} = 2.96 \frac{\text{Ohm}}{\mu\text{m}}.$$

From the curves shown in figure 4, c, it follows that consecutive build-up of the USOS construction by half-wave elements with gain coefficients  $K = 2$  leads to a greater increase of the range of change of the imaginary component of impedance  $\Delta Im$  when changing  $\Delta L$ .

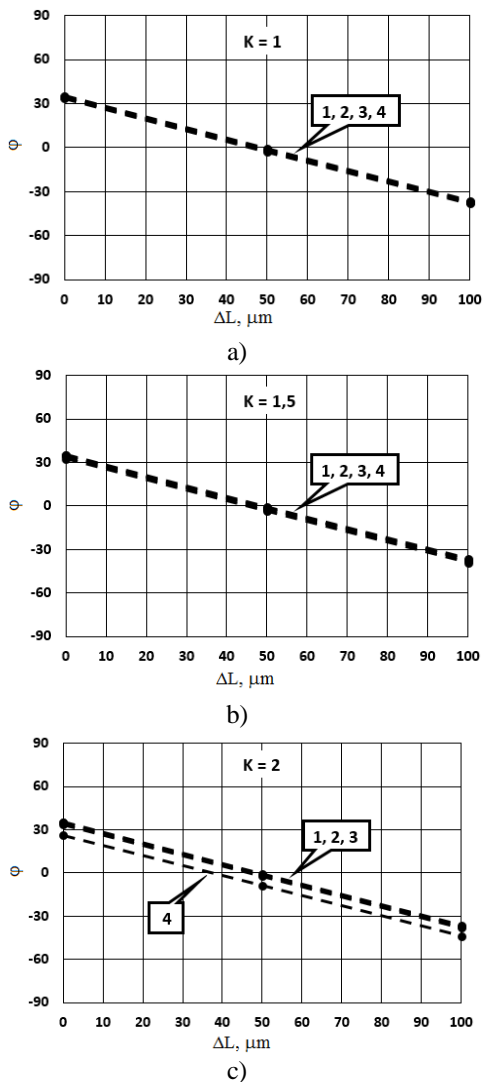
At consecutive build-up of the USOS construction by half-wave elements "Concentrator 1", "Concentrator 2", "Concentrator 3" the range of change  $\Delta Im$  when changing  $\Delta L$  increases by 300%, 1400% and 6000% respectively, in comparison with the assembly "Converter + Test sample". The ranges of change  $\Delta Im$  in absolute values for the considered assembly variants are 24 Ohm, 97 Ohm, 386 Ohm, 1463 Ohm, respectively. Sensitivity of control of  $\Delta Im$  parameter by change of  $\Delta L$  is

$$\frac{\Delta Im 1}{\Delta L} = 0.242 \frac{\text{Ohm}}{\mu\text{m}}, \quad \frac{\Delta Im 2}{\Delta L} = 0.97 \frac{\text{Ohm}}{\mu\text{m}},$$

$$\frac{\Delta Im 3}{\Delta L} = 3.38 \frac{\text{Ohm}}{\mu\text{m}}, \quad \frac{\Delta Im 4}{\Delta L} = 14.6 \frac{\text{Ohm}}{\mu\text{m}}.$$

Thus, when the number of series-connected elements of USOS construction with amplification coefficients different from 1 increases, the correlation between the real component of impedance  $Im$  and the parameter  $\Delta L$  enhance.

From the curves shown in figures 4, a,b,c, it follows that there is a possibility of increasing the sensitivity of the cavitation erosion control method when using the  $Im$  parameter as a controlled parameter.



**Figure 5.**Dependence of the phase  $\varphi$  of the ultrasonic emitter on the wear value of the cylindrical tip for different variants of the USOS assembly and the amplification coefficients of its elements. 1 - converter + test sample; 2 - converter + 1st concentrator + test sample; 3 - converter + 1st, 2nd concentrators + test sample; 4 - converter + 1st, 2nd, 3rd concentrators + test sample

However, there are a number of technological and physical limitations that do not allow to increase the design of the ultrasonic emitter. It makes it possible to increase the transformation coefficient of individual hubs. Nevertheless, the sensitivity of the imaginary component of the impedance  $Im$  to a change in the parameter  $\Delta L$  is higher than the sensitivity of the impedance  $Z$  or its real component  $Re$  to a change in the parameter  $\Delta L$ , other things being equal

Figure 5 shows the dependences of the piezoelectric system phase  $\varphi$  on the wear value of the cylindrical tip for different variants of USOS assembly and the amplification coefficients of its elements.

The parameter  $\varphi$  is a phase shift between the current and voltage on the ultrasonic transducer of the emitter and theoretically can vary in the range from -90 to +90 degrees.

In this case, three designs of ultrasonic emitters are also considered, consisting of a converter and a test sample, between which there are 0, 1, 2 or 3 concentrating links (concentrators). In each of the structures under consideration, the transformation coefficient of all the elements forming it is taken to be equal to 1, 1.5 and 2.

From the curves shown in figure 5 it follows that consecutive build-up of the USOS construction by half-wave elements with different amplification coefficients ( $K = 1, 1.5, 2$ ) does not influence on phase dependence  $\varphi$  of ultrasonic radiator from parameter  $\Delta L$  (the curves for different number of links of the USOS with different amplification coefficients  $K$  coincide). Nevertheless, the variation range of parameter  $\Delta\varphi$  is 60 degrees, the dependence on  $\Delta L$  is close to linear.

Sensitivity of parameter control  $\Delta\varphi$  when changing  $\Delta L$  is  $\frac{\Delta\varphi}{\Delta L} = 0.6 \frac{\text{degree}}{\mu\text{m}}$  and is a constant.



From the curves shown in figures 4, a,b,c, it follows that the parameter  $\varphi$  affected only by the amount of wear of the test sample. This fact is of great practical importance. In practice, the developers of ultrasonic emitters, in order to achieve their specific parameters, often vary the number and characteristics of individual elements of the design of ultrasonic emitters. In this case, this does not affect the sensitivity of the parameter  $\varphi$  to cavitation erosion of the cylindrical tip, which makes it attractive for monitoring the degree of cavitation wear of test samples.

### 3. Conclusion

As a result of the conducted research, the possibility of using piezoelectric ultrasonic oscillatory systems (USOS), used for formation of cavitation impact in liquid media, as a sensor to control the degree of cavitation erosion of working tools materials and their protective coatings was confirmed.

Therefore, the same emitter is capable of performing two functions:

- the ultrasonic emitter is capable of operating in a power mode while providing the intensity of ultrasonic exposure necessary for the formation of cavitation phenomena in a liquid medium. In this case, cavitation wear of the cylindrical working tool or its coating occurs;
- the ultrasonic emitter is capable of operating in measurement mode. In this case, a small voltage is applied to the ultrasonic emitter, at which the greatest amplitude of oscillations of the ultrasonic emitter is achieved. In this mode, the cavitation wear of the working tool or its coating stops and indirect control of the degree of cavitation erosion occurs by changing the parameters of the ultrasonic emitter.

The results obtained on the basis of the analysis of the developed models allowed to identify the dependences of the electrical parameters of ultrasonic oscillatory systems

on the degree of cavitation wear of the coupled half-wave cylindrical working tool.

This effect obviously caused by a change in the resonant frequency of the attached half-wave cylindrical working tool, which is subject to cavitation erosion from the free end. Since the working tool is part of the design of the ultrasonic emitter, the change in its geometric dimensions, even in the range of 100  $\mu\text{m}$ , affects both its parameters and the parameters of the ultrasonic emitter as a whole.

The influence of the constructional composition of USOS and its individual components on the control parameters has been established. This allowed to identify the most sensitive to the value of cavitation erosion characteristics of USOS and to establish the sensitivity of the control of cavitation erosion of the tools depending on the different parameters of USOS.

The following parameters of ultrasonic emitters considered: the input electrical impedance of the ultrasonic emitter, the real part of the input electrical impedance of the ultrasonic emitter, the imaginary part of the input electrical impedance of the ultrasonic emitter, the phase shift between current and voltage on the transducer of the ultrasonic emitter. The evaluation of these parameters carried out when the ultrasonic emitter was excited at a frequency close to its resonant frequency.

On the basis of the developed electrical models, the dependences of the following parameters of ultrasonic emitters were obtained for the first time when they work in pre-cavitation mode:  $Z=f(\Delta L)$ ,  $\text{Re}=f(\Delta L)$ ,  $\text{Im}=f(\Delta L)$ ,  $\varphi=f(\Delta L)$ , where  $\Delta L$  is the magnitude of the change in geometric size a half-wave working tool made of the investigated coated material subjected to cavitation erosion due to its cavitation wear;  $Z$ ,  $\text{Re}$ ,  $\text{Im}$ ,  $\varphi$  –electrical impedance of the ultrasonic emitter, its real and imaginary components, phase shift between current and

voltage on the electromechanical transducer of the ultrasonic emitter, respectively. These dependences were obtained for different variants of the ultrasonic emitter assembly, namely for a different number of sequentially connected concentrating waveguides (from 0 to 3) with different transformation coefficients (from 1 to 2).

The most sensitive (to the degree of cavitation erosion of the connected half-wave cylindrical working tool) parameter of USOS is imaginary part of impedance of USOS, sensitivity of which strongly depends on the number of connected half-wave elements and their amplification factor. The phase-frequency characteristic of USOS is also of interest, which also has a strong correlation with the degree of cavitation wear and does not depend on the design features of USOS.

The sensitivity of the electrical parameters of the ultrasonic emitter to changes in the acoustic load directly depends on the product  $P = K_1 * K_2 * \dots * K_i$ , where  $K_i$  is the transformation coefficient of the  $i$ -th waveguide element,  $i=1\dots N$ , where  $N$  is the number of sequentially connected waveguide elements.

The conducted research and the theoretical data obtained allow us to formulate requirements for the structure and operating modes of ultrasonic equipment of a new generation. It becomes possible to create

ultrasonic devices capable of "feeling" changes in the acoustic load. Devices of this kind are capable not only of influencing ultrasonic objects with energy, but also of controlling the processes occurring in ultrasonic fields. For example, there are opportunities:

–indirectly control the drilling depth of hard and brittle materials when making holes in them by ultrasonic impact method. As the working tool is buried into the drilled object, the degree of its lateral damping increases, which affects the parameters of the ultrasonic emitter;

–indirectly control the process of obtaining mixtures of two or more liquids with different acoustic properties in ultrasonic fields. When mixing such liquids, the acoustic properties of the voiced medium will change for some time. Eventually, when the new medium becomes homogeneous, its acoustic properties will also become stable, therefore, the parameters of ultrasonic emitters will also cease to change.

–other processes occurring in ultrasonic fields, during the implementation of which there is a change in the acoustic properties of objects and media having acoustic contact with the ultrasonic emitter.

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## MAIN CHARACTERISTICS OF NONCONTACT CONVERTERS OF LARGE CURRENTS WITH LONGITUDINALLY DISTRIBUTED PARAMETERS FOR CONTROL AND MONITORING SYSTEMS

**Abstract:** *The article shows that the necessity of breaking current circuits to temporarily switch on electric measuring instruments, the presence of large power losses on shunts, undesirability or impossibility under technological process conditions of breaking circuits, as well as safety requirements have caused noncontact conversion and measurement of large direct currents in circuits without breaking them in metallurgy, electrochemical industry, railway transport, melioration, irrigation and in general in agriculture. The results of the development of one of them are presented in the paper. Considered its static characteristic, the error of calculation, which does not exceed 3 percent, its degree of nonlinearity, and its average and current sensitivity, which throughout the range of current transformed practically remain constant in magnitude. The developed galvanomagnetic noncontact converter can be widely used in control and management systems in water supply, melioration, and irrigation, industry, railway transport, metallurgy, science, engineering, as well as for the verification of electric meters at the place of their installation for non-contact control of direct and alternating currents.*

**Keywords:** *Noncontact Converter; Direct Current; Hall Element; Water Supply; Reduced Error; Monitoring And Control Systems; Integrating Loop*

### 1. Introduction

At present, in many domestic enterprises in the production of copper, sodium, tungsten, molybdenum, zinc, hydrogen, oxygen, phosphorus and others, in the rolling of refractory and heat-resistant metals on rolling mills, in the production of products on drawing machines and others, it is very important to control the functioning technological processes and product quality management [1, 2].

From an informational point of view, any technological process has two sides: control and monitoring. The purpose of observation is to ensure the quality of the technological process and the created products by collecting information about the state of the technological process, evaluating this information, building a model of the state of the observed process and making a decision that ensures optimal control of this process [3].

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So, in electrolysis shops, full information about the functioning of technological processes in electrolyzers, about the quality and quantity of products being created, is carried by the value of direct current, controlled either by a device or a converter built into the monitoring and control system. Since modern electrochemical enterprises contain many hundreds of electrolyzers, and the domestic instrument-making industry does not produce reliable lightweight non-contact transducers and devices for product quality control, the development of lightweight, both portable and stationary, accurate, simple in design and inexpensive non-contact transducers and devices for non-destructive testing the quality of manufactured products and the functioning of technological processes through non-contact monitoring of currents in circuits without breaking them, i.e. without violating their integrity is important and timely [4].

Similar problems exist in many industries and, in particular, in the production and rolling of molybdenum, tungsten and alloys based on them, in the production of tungsten wires on drawing machines, yellow phosphorus in ore-thermal furnaces, in laser technology in the formation of pulse energy, and others.

All these processes for obtaining industrial products are characterized by the fact that during non-destructive testing of product quality and the functioning of technological processes (TP), including control of the speed of rotation of engines, their main control parameter is a large direct current (BDC), the value of which is used to judge the quality of industrial products and the functioning of technological processes, as well as the speed of rotation of the engines. Its value is controlled by a number of quality control transducers - measuring transducers (MT) [5].

The problem of increasing the accuracy, reliability and efficiency of monitoring these TPs is topical, which together will improve

the quality and quantity of industrial products and the stability of TP, including control of the speed of rotation of engines [6].

As a result of the analysis of the studies carried out, an urgent need was revealed at many enterprises of the Republic of Uzbekistan to conduct non-destructive control of the quality of industrial products and the functioning of TP, including control of the speed of rotation of engines, by contactless control of BPT using both portable and stationary non-destructive non-contact transducers (BP) and meters (BI) for non-destructive quality control with an error of 1 - 3%, using in some cases multi-limit, as well as with a flexible integrating circuit BP and BI [7].

Among the first BP and BI are the designs developed by K. B. Karandeev, M. D. Gurevich, R. E. Albrandt, A. V. Fremke and others [6].

Subsequently, a number of original designs of BP and BI were proposed by Yu. G. Tolstov, S. A. Spektor, A. E. Kaplyansky, I. A. Zaitsev, I. N. Prudnikov, E. A. Meerovich, L. I. Andreevskaya, V. P. Figurnov, V. V. Serkov, V. N. Bogomolov, G. V. Abramzon, N. G. Semenko, Yu. A. Gamazov, A. M. Safarov and others. Noteworthy are the designs of converters that were developed abroad by V. Kremer, E. Reich, L. Zoltan, N. Bardal, A. L. Schilling, R. G. Arey, T. B. Brovn, E. V. Eddy, Jukki, Hitachi and others [6,7].

In view of the ease of manufacture, the speed of signal processing and noise immunity, non-contact MTs using the dependence of the magnetic field on direct current have been predominantly used in technology. Therefore, any device that allows measuring the field strength can be used for non-contact measuring transducers [7]. This includes the following IPs:

1. electromechanical;
2. self-generating;

3. galvanomagnetic;
4. magneto-modulation;
5. magneto-optical based on the Faraday and Kerr effects;
6. quantum based on nuclear magnetic resonance.

The last two groups of converters, due to the complexity of their implementation, high cost, significant dimensions, and low reliability, have not been widely used.

Of the four groups of converters used, the best technical and economic indicators are galvanomagnetic and magneto-modulating non-contact MTs, made on the basis of distributed parameter converters (DRP) [1].

Russian and foreign scientists dealt with the theory and calculation of PRP: V. I. Kovalenkov, B. S. Sotskov, L. F. Kulikovskiy, B. K. Bul, M. I. Belyi, M. F. Zaripov, N. E. Konyukhov, I. Yu. Petrova, M. A. Urakseev, R. K. Azimov, S. F. Amirov, G. R. Shayakubov, A. V. Gordon, A. G. Slivinskaya, G. Kremer, G. Weiss and others [9].

Despite the large number of separate developments in this area, the instrument-making industry both in the Republic of Uzbekistan and in the CIS countries has not yet produced lightweight detachable stationary and portable non-destructive non-contact transducers and devices for non-destructive quality control of industrial products and the functioning of TP by non-contact control of BPT. This is explained, on the one hand, by the lack of a sufficiently tested version of BP and BI, and on the other hand, by the rigidity of the requirements for them [10].

As a result of the analysis of places of non-destructive non-contact quality control, the main requirements for BP and BI were identified. These include: high accuracy, reliability, sensitivity, low weight, dimensions, material consumption and cost, manufacturability of the design, the absence of errors from the influence of external

magnetic fields, the reverse bus with current, the displacement of the bus with current from the center of the integrating circuit, ferromagnetic masses, residual magnetization and the presence of a variable component in the controlled direct current, the absence of energy consumption from the measured circuit, the ability to work in an aggressive environment, explosion safety, as well as the absence of galvanic coupling between the input and output circuits and the presence in some cases of the possibility of both a fixed sensitivity control of the PSU and BI in a wide controllable range and have a flexible integrating circuit, as well as the manufacture of BP and BI portable or stationary [11].

It has been established that none of the known and considered PSUs and BIs fully satisfies the above requirements and that the main element included in almost all designs of light, both stationary and portable PSUs and BIs, is a non-contact ferromagnetic converter of non-destructive quality control, which is a non-destructive non-contact ferromagnetic BPT-to-magnetic flux converter (BFPP), made of ferromagnetic material, and it accounts for the bulk of the mass of the BP and BI, as well as the fact that the main factor limiting the upper limit of the controlled range is the saturation of the ferromagnetic material, therefore, it is important in reducing the mass of BP and BI and in expanding their controllable range belongs to BFPP. It is known, for example, that the I514 DC transformer used in practice for a current of up to 6 kA has overall dimensions of 340 340 175 mm and a weight of up to 42 kg, and the weight of a portable BI according to GOST should not exceed 5 kg [7]. Therefore, the development of light and wide-range BFPs and devices based on them is an important problem [12].

It should be noted that the BFPP, together with the intermediate converter, forms a non-contact ferromagnetic converter for non-destructive quality control of industrial

products and the functioning of the TP (BFP), which converts the constant magnetic flux created by the controlled direct current into an EMF, which is then converted by the processing unit into an output signal in the case of a BP, and in the case of BI, the output signal is fixed by the meter.

In the field of increasing the upper limit of the BFP, the works of both Russian scientists - E. A. Meerovich, L. I. Andrievskaya, V. V. Serkov, D. N. Nasledov, N. V. Zotov, G. V. Abramzon, Yu. A. Andreeva and others, as well as foreign ones - F. Kurt, K. Maz, T. B. Brown, E. M. Eddy and others [11].

All known and proposed methods for expanding the controlled range of the BFP are based on three main methods [7]:

1. a method of increasing the magnetic resistance of a detachable magnetic circuit in the path of a working magnetic flux created by a controlled direct current;
2. method of partial or full compensation of the working magnetic flux;
3. combination method.

According to the first method, the expansion of the controlled range of the BFPP is carried out by increasing the resistance of the magnetic circuit by:

- a) increasing the section of the detachable magnetic circuit  $S_{st}$ ;
- b) inclusion of air gaps  $\delta$  into the detachable magnetic circuit;
- c) reduction of the air gap cross section  $S\delta$ ;
- d) increasing the total length of the working magnetic flux in steel  $l_{st}$ ;
- e) increase in specific magnetic resistance  $\rho\mu$  of the material of the detachable magnetic circuit;
- f) inclusion of transversely distributed gaps;
- g) the inclusion of transversely distributed gaps and an increase in

the total length of the working magnetic flux over steel  $l_{st}$ ;

- h) inclusion of longitudinally distributed gaps;
- i) the inclusion of longitudinally distributed and transverse gaps;
- j) use in combination of methods a, b, c, d, e.

Methods d, f, g, h, and expanding the controlled range of BFPP were first proposed by us [7,11].

Analyzing the above and highlighting as rational

the following ways to expand the controlled range of BFP, the following can be noted:

1. The method of expanding the controlled range of the BFP by increasing the total length of the working magnetic flux over steel in comparison with the method of additional inclusion of air gaps with the same masses and volumes of the BFP makes it possible to increase the sensitivity and reliability of the BFP as a whole.
2. The inclusion of transversely distributed gaps in a detachable magnetic circuit makes it possible to increase the accuracy of the BFP.
3. Expansion of the controlled range of the BFP by including transversely distributed gaps and increasing the total length of the working magnetic flux over steel allows you to fix the sensitivity of the BFP.
4. The inclusion of longitudinally distributed gaps in the detachable BFP magnetic circuit makes it possible to make it flexible.
5. The implementation of a detachable magnetic core with the inclusion of longitudinally distributed and transverse gaps increases the efficiency and versatility of the BFP.



Reducing the mass of the BFP magnetic circuit to a greater extent leads to the appearance of an error from the displacement of the bus under test from the center of the magnetic circuit window and from the influence of external magnetic fields. The reduction of these errors is achieved by increasing the number of "point" meters located evenly along the entire integration contour [12].

At present, it is very important to develop and study BFPs for such BFPs that would have increased efficiency (extended controllable range with small dimensions and weight and increased accuracy, simplified and technological design with low material consumption and cost) and expanded functionality (this is flexibility integrating circuit and the multi-limit nature of the converter).

Therefore, the problem of increasing the efficiency and expanding the functionality of non-contact ferromagnetic converters with distributed magnetic parameters and devices for non-destructive quality control of industrial products and the functioning of technological processes for monitoring and control systems is an important and promising scientific problem, which is of great importance, because. the creation of new non-contact devices and converters for non-destructive quality control, meeting the set of basic requirements for them from monitoring and control systems, will ultimately help accelerate scientific and technological progress and increase the efficiency of numerous enterprises in the chemical industry, non-ferrous and ferrous metallurgy, energy and electrical engineering, electric transport and electrical apparatus construction, as well as in irrigation, melioration and other industries [1,7].

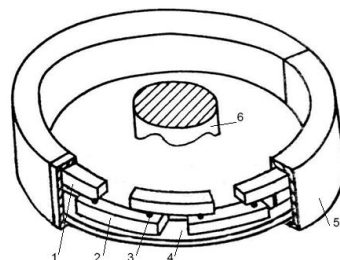
In practice, a large number of individual noncontact converters and large direct current meters are known, the most widely used galvanomagnetic noncontact

ferromagnetic converters of large direct currents (Gilardi, 2013; GB Patent No. 4575111, 2016), but the known converters have some drawbacks, the main of which are: a narrow controlled current range, low accuracy and sensitivity, large dimensions, and mass, and the absence of fixed regulation of their sensitivity. In this regard, the elimination of these disadvantages is an important necessity and the purpose of this work.

## 2. Materials and methods

We have developed some lightweight, universal, energy-saving galvanomagnetic noncontact large direct current converters (GNC), which allow conversion of both direct and alternating large currents in various control and monitoring systems without breaking the circuit. They use different designs of split closed magnetic cores with transversely and longitudinally distributed magnetic parameters and increased path length of working magnetic flux on steel (Plakhtiev, 2017; Plakhtiev et al., 2020).

One of the developed ones is the GNC shown in Figure 1. It is developed based on a galvanomagnetic non-contact ferromagnetic converter of large direct currents (Plakhtiev, 1985). Let's consider its features and static characteristic, its degree of nonlinearity, as well as the issues of its sensitivity.



**Figure 1.** The galvanomagnetic noncontact converter of large direct currents with longitudinally distributed parameters for control and monitoring systems

The GNC contains a closed magnetic core consisting of separate ferromagnetic elements 1 and 2. Ferromagnetic elements 1, as well as ferromagnetic elements 2, are installed with transverse gaps, evenly distributed along the entire length of the split magnetoconductor.

Neighboring ferromagnetic elements 1 and 2 form  $n$  pairs of longitudinal gaps between them, in which Hall elements 3 are placed. The ferromagnetic elements 2 are rigidly fixed on the ring-shaped insulating plate 4, which can be fixedly moved to the set distances, changing the gaps between the ferromagnetic elements 1 and 2, and, consequently, the parameters of transverse gaps. The closed magnetic wire together with the Hall elements 3 is placed in the insulating case 5, which covers busbar 6 with the controlled current in the process of measurement. Current electrodes of Hall elements 3 are connected to the current source. The Hall electrodes of the Hall elements 3 are connected in series with each other, and the Hall electrodes of the Hall elements 3 placed in each pair of transverse gaps formed by one ferromagnetic element 2 and neighboring ferromagnetic elements 1 are connected in opposite directions. To indicate the measurement results, a recording device (not shown) is included in the chain of series-connected Hall electrodes of the Hall elements 3.

The GNC works in the following way. After the busbar 6 with the controlled direct current is encircled by the controlled current, a constant magnetic flux is created in the magnetic core, which, penetrating the Hall elements 3, causes the appearance of the Hall EMF on their Hall electrodes. These EMFs are summed up due to the counter-inclusion of the Hall electrodes of Hall elements 3. As a result, at the output of a chain of series-connected Hall electrodes of Hall elements 3, there is a total output Hall EMF  $E_x$ , which depends on the value of the monitored DC  $I$ .

The value of this total Hall EMF  $E_x$  is measured with a recording device. Increasing the upper limit of measurement of large direct currents is made by increasing the gap between fixed 1 and movable 2 ferromagnetic elements by a fixed transition of plate 4 with ferromagnetic elements 2 at the set distances. This leads to an increase in the longitudinal gaps, and, consequently, to a change in the operating magnetic fluxes, which allows the sensitivity of the GNC to vary over a wide range of currents to be converted. Let's consider the static characteristic of the GNC shown in Figure 1.

### 3. Results

The static characteristic of GNC is a functional relationship between output and input quantities at their steady-state values (Plakhtiev et al., 2021b).

In the GNC the input quantity is the controlled direct current  $I$ , and the output quantity is the Hall EMF  $E_x$ , the expression of which is written in the form

$$E_x = K_x I_p B, \quad (1)$$

where  $K_x$  – Hall transducer proportionality coefficient, which depends on the parameters of the semiconductor material, the ratio of the geometric dimensions of the converter, the mode of its operation, and their number;

$I_p$  – Hall cell supply current;

$B$  – magnetic induction in the longitudinal gap of the split magnetic core.

Let us denote

$$a_x = K_x I_p. \quad (2)$$

For analytical determination of the static characteristic, it is necessary to know in analytical form the dependences  $B = f(H)$ , where  $B$  and  $H$  – induction and strength of the magnetic field penetrating the Hall elements.

To reduce the residual magnetic induction in GNCs, it is recommended to use magnetically soft materials (electrotechnical

steel) (Danilov, 2004). Therefore, we will approximate the main magnetization curve of electrical steel by the sum of the hyperbolic tangent and the straight line with the angle coefficient as

$$B = C_1 th C_p H + C_3 H, \quad (3)$$

where  $C_1, C_2, C_3$  – approximation coefficients.

Taking into account (2) and (3), let us rewrite expression (1) as

$$E_X = a_X \frac{C_3}{C_2} (C_1 \frac{C_2}{C_3} th H + H_x),$$

where  $H_x$  – the strength of the magnetic field permeating the Hall elements, equal to

$$H_x = C_2 H, \quad (5)$$

where

$$H = \frac{I_u}{\pi D_c} \cdot \frac{(1 + C_v) \beta C_v (1 + C_{mv}) \cdot (1 - ch \beta - 4 sh \beta)}{2 \beta sh \beta C_v (1 + C_{mv} + 2 C_v C_{mv}) - (1 - ch \beta) - 2 (C_v (1 + C_{mv}) + 2)}$$

where  $I_u$  – measured direct current;  $D_c$  – diameter of the center axial line of the split closed magnetic core;  $\beta$  – coefficient characterizing the magnetic voltage loss in the magnetic circuit;  $C_v, C_{mv}$  – coefficients that take into account the geometric dimensions of the split closed magnetic core and the grade of steel used in the magnetic core.

Denoting  $C_1 \frac{C_2}{C_3} = C$ , we rewrite (4) as

$$E_X = a_X \frac{C_3}{C_2} (C th H_x + H_x). \quad (7)$$

Denoting in (7)  $a_X \frac{C_3}{C_2} = E_{XB}$ , we obtain the expression of the static characteristic of the GNC in relative units in the following form

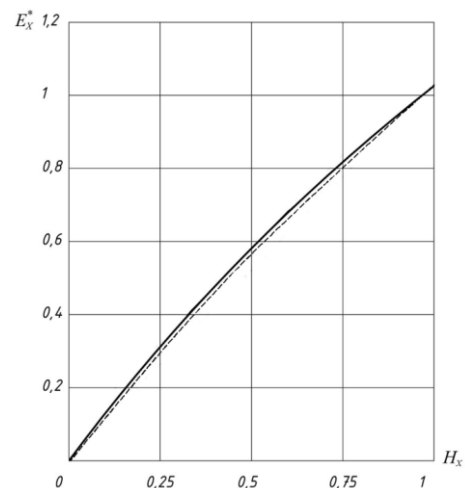
$$E_X^* = \frac{E_X}{E_{XB}} = C th H_x + H_x. \quad (8)$$

Figure 2 shows theoretically (solid curve) and experimentally (dashed curve) obtained plots of the static characteristic of the GNC. The use of the intermediate variable  $H_x$  as a

transformed value is justified by the fact that the output EMF of the GNC is an unambiguous function of  $H_x$ , and, on the other hand,  $H_x$  carries complete information about the value of transformed current  $I$  and the type of steel used in the magnetic core.

The experiments showed that the discrepancy between the experimental and theoretically obtained static characteristics of the GNCs does not exceed 3 percent.

Consider the sensitivity of the GNC shown in Figure 1.



**Figure 2.** Static characteristic of the GNC

To analyze the GNC sensitivity, we will use the expression of its static characteristic (8).

Dividing (8) by  $H_x$ , we obtain an expression for the average sensitivity of the GNC in the following form

$$S_{cp} = \frac{E_X^*}{H_x} = C \frac{th H_x}{H_x} + 1. \quad (9)$$

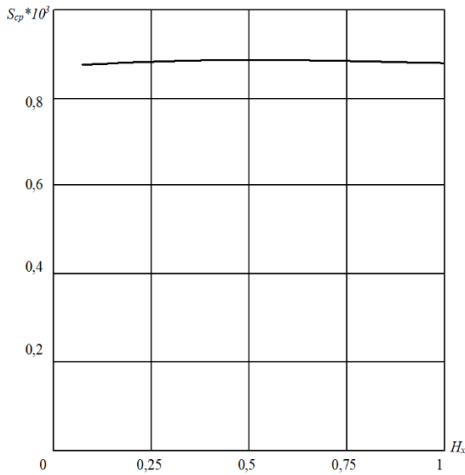
The results of calculating the average GNC sensitivity according to (9) are shown in Figure 3.

The derivative of the output quantity (8) by the measured quantity  $H_x$  is the current sensitivity  $S_I$  of the GNC. The current sensitivity of the GNC is determined from

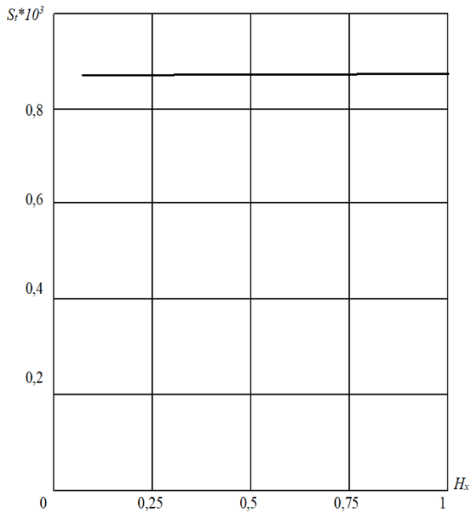
the expression

$$S_t = \frac{dE_x^*}{dH_x} = \frac{c}{ch^2H_x} + 1. \quad (10)$$

Figure 3 shows graphically the dependence  $S_t = f(H_x)$ , calculated by (10).



**Figure 3.** Graph of the dependence of the average GNC sensitivity on the magnetic field strength



**Figure 4.** Diagram of the dependence of the current GNC sensitivity on the magnetic field strength of the magnetic field

The graphs in Figures 3 and 4 show that the average and current sensitivities of GNCs over the entire range of the converted current are almost constant in magnitude.

Let's consider an important characteristic of GNC - the degree of nonlinearity of its static characteristic.

The definition of the degree of nonlinearity of the static characteristic of the transducer is given in (Plakhtiev et al., 2021a). According to this definition, the degree of nonlinearity of the considered section of the GNC static characteristic is the ratio of the maximum deviation of the characteristic ordinate from the straight line approximating it in this section to the whole range of ordinate change in the same section.

To analyze the degree of nonlinearity of the static characteristic of the GBIT we will use the expression of its static characteristic (8).

The degree of nonlinearity of the static characteristic of GNC is determined from the following expression (see Figure 5)

$$\varepsilon, \% = \frac{E_{xT}^* - (H_{xT}) - kH_{xT}}{2E_{xM}^*} 100, (11)$$

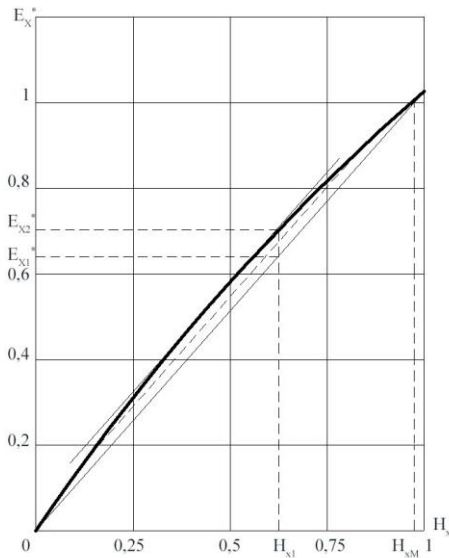
where  $E^*(H_{xT})$  – a value of the output EMF at the point of the static characteristic, where the deviation on the ordinate of the static characteristic from the line approximating it has the maximum value;  $E^*(H_{xM})$  – the maximum value of the GNC output EMF, corresponding to the maximum value of  $H_{xM}$ ;  $E_{aP}^*(H_{xT}) = kH_{xT}$  – equation of the approximating direct static characteristic of GNC;  $k = \frac{E_{aP}^*(H_{xT})}{H_{xT}} = \frac{E(H_{xM})}{H_{xM}} = \text{tg} \varphi$  – coefficient characterizing the slope angle of the approximating line to the abscissa  $H_x$ .

The values  $E^*(H_{xT})$ ,  $E^*(H_{xM})$ ,  $E_{aP}^*(H_{xT})$  are respectively:

$$E^*(H_{xM}) = CthH_{xM} + H_{xM}, (12)$$

$$E_{aP}^*(H_{xT}) = H_{xT} \frac{E^*(H_{xM})}{H_{xM}} = \frac{H_{xT}}{H_{xM}} = (CthH_{xM} + H_{xM}), \quad (13)$$

$$E^*(H_{xT}) = CthH_{xT} + H_{xT}. (14)$$



**Figure 5.** Determination of the degree of nonlinearity of the static characteristic of the developed GNC

Substituting (12) – (14) in (11), we obtain an expression of the degree of nonlinearity of the static characteristic of the GNC in the following form:

$$\varepsilon, \% = 50 \left( \frac{CthH_{xT} + H_{xT}}{CthH_{xM} + H_{xM}} - \frac{H_{xT}}{H_{xM}} \right). \quad (15)$$

The coordinate  $H_{xT}$ , at which the deviation on the ordinate of the static characteristic from the approximating line has a maximum value, can also be determined graphically, as shown in Figure 5, by drawing a tangent to the curve of the static characteristic at the point  $H_{x1}$  parallel to the approximating line.

After substituting the values of  $H_{xT}$  and  $H_{xM}$  into expression (15), we can obtain the value of the degree of nonlinearity  $\varepsilon$ , %. For example, for a static characteristic with  $H_{xT} = 0.625$  and  $H_{xM} = 1$ , its degree of nonlinearity will be  $\varepsilon = 2.83\%$ , which is acceptable for the GNCs under study.

Consider the transfer coefficient of the GNC. The steepness of the GNC characteristic is determined by its sensitivity to a given input signal. It is estimated by the value of the

corresponding transfer coefficient (Amirov et al., 2019). Consequently, the transfer coefficient for a GNC is adequate to its current sensitivity and can be determined by an expression similar to (10) in the following form:

$$K = \frac{dE_x^*}{dH_x} = \frac{c}{ch^2 H_x} + 1. \quad (16)$$

As a result, it should be noted that the transfer coefficient  $K$  of the GNC can be increased by increasing the thickness and width of the ferromagnetic elements of the split magnetic core, the width of the air gap, and reducing the length of these ferromagnetic elements, the number of air gaps between the ferromagnetic elements in the split magnetic core and the specific magnetic resistance of ferromagnetic elements.

We have developed some lightweight, universal, energy-saving galvanomagnetic noncontact large direct current converters (GNC), which allow conversion of both direct and alternating large currents in various control and monitoring systems without breaking the circuit. They use different designs of split closed magnetic cores with transversely and longitudinally distributed magnetic parameters and increased path length of working magnetic flux on steel (Plakhtiev, 2017; Plakhtiev et al., 2020).

## 4. Discussion

A universal energy-saving galvanomagnetic noncontact converter of large direct currents has been developed, which, unlike the known noncontact converters of large direct currents, has a wide controllable range of currents with small dimensions and mass, a simple and technological design at low material consumption and cost, and can be multireference in a wide controllable range of measured currents with high sensitivity and control DC and AC currents with an

error of 1.5%.

The static characteristic of the universal energy-saving galvanomagnetic noncontact converter of large direct currents has been obtained and studied. The discrepancy between the experimentally and theoretically obtained static characteristics of the converter does not exceed 3%.

The average and current sensitivities of the developed galvanomagnetic noncontact converter of large direct currents, which remain practically constant in magnitude over the entire range of the current being converted, were investigated.

An expression for determining the degree of nonlinearity of the static characteristic of a universal energy-saving galvanomagnetic noncontact converter of large direct currents at any point of the static characteristic, depending on the range of the current to be converted, is obtained.

The transfer coefficient of the GNC is considered, which is adequate to its current sensitivity and its value can be increased by increasing the thickness and width of the ferromagnetic elements of the split magnetic core, the width of the air gap, and reducing the length of the ferromagnetic elements of the split magnetic core, the number of air gaps between the ferromagnetic elements in the split magnetic core and the specific magnetic resistance of the ferromagnetic elements.

## 5. Conclusion

Universal multidisciplinary wide-range noncontact galvanomagnetic converters of large direct currents have been developed for modern control and monitoring systems in helio- and laser technology, agricultural sector, and railway transport, characterized by an expanded controllable range of converted direct currents with small dimensions and weight, improved accuracy and sensitivity, simple and manufacturable

design at low consumption of materials and costs, the possibility of non-contact control of direct and alternating currents, as well as the fixed sensitivity control in a wide controllable range.

The static characteristic of the universal energy-saving galvanomagnetic contactless converter of large direct currents is obtained and investigated. The discrepancy between the experimentally and theoretically obtained static characteristics of the converter does not exceed 3%.

The developed converter has an increased sensitivity due to the Hall elements evenly distributed along the whole length of the split magnetoconductor on the path of the working magnetic flux. The average and current sensitivity of the developed galvanomagnetic noncontact converter of large direct currents, which practically remain constant in value over the whole range of the transformed current, were investigated.

The expression for determining the degree of nonlinearity of the static characteristic of the universal energy-saving galvanomagnetic noncontact converter of large direct currents in any point of its static characteristic and taking into account the range of the converted current, which value does not exceed 3%, is obtained.

The developed GNC can contactlessly control direct and also alternating currents with an error of 1.5 % in many modern control and monitoring systems in land reclamation, irrigation, solar and laser technology, renewable energy sources, solar power plants, solar power plants, direct conversion of solar energy into electrical energy using photovoltaic and thermoelectric conversions, in renewable energy sources, laser systems, power supply systems for focusing and turning electromagnets of elementary particle gas pedals, at many domestic enterprises in the production of copper, sodium, tungsten, molybdenum,

zinc, hydrogen, oxygen, phosphorus and others, rolling of refractory and high-temperature metals in rolling mills, in obtaining products on drawing machines, in monitoring and control systems in non-ferrous metallurgy, in railway transport, irrigation, and land reclamation, as well as in the verification of electric meters at the place of their installation.

The authors plan to organize the future serial production of lightweight multipurpose wide-range noncontact galvanomagnetic converters and meters of large direct and alternating currents.

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Vladimir Lantsov <sup>1</sup>

## APPROXIMATION OF THE NONLINEAR DEPENDENCIES IN HARMONIC BALANCE EQUATIONS

**Abstract:** In the author's previous works, the new idea for solving of harmonic balance equations was proposed. In this paper, it is proposed to use the method of averages in the algorithms for solving the harmonic balance equations to approximate the Jacobian. It is important to note that the approximation is performed once and before the start of the main iterations. In our approach the discretized input and output waveforms of responses derivatives of currents of nonlinear elements can be collected in one single matrix form (snapshot matrix). The singular value decompositions method then used for reduce and obtain the average matrix. This matrix reflects all the main changes in nonlinear dependencies with changes in the amplitudes of the input effect and over time. This algorithm reduces computational costs in solving harmonic balance equations. Comparison of the proposed algorithm with the standard harmonic balance method and algorithms developed by the author earlier showed its high efficiency.

**Keywords:** Harmonic Balance, Electronics, Singular Values, Computational Costs

### 1. Introduction

Harmonic balance (HB) methods are widely used for modeling nonlinear circuits in CAD systems in electronics (Rizzoli et al., 1988, Gilmore & Steer, 1991, Kundert, 1999). The main problems of algorithms and software tools of CAD systems based on HB methods are significant memory requirements and huge computational costs for simulation of complex nonlinear electronic circuits containing thousands of electronic components and hundreds of thousands for circuit model equations (White & Sangiovanni-Vincentelli, 1987, Kundert et al., 1988, Rizzoli et al., 2011).

For example, for circuits containing about 10 thousand of circuits nodes and taking into account about one thousand harmonics (with multifrequency excitation), the number of variables (unknowns, equations) of the model will be approximately 10 million. If we use for solving the harmonic balance equations the Newton method when the square of this number of unknowns or the size of Jacobian matrix will be 100 million. All this suggests that new more economical methods of storing and solving of harmonic balance equations in modern electronic CAD systems are needed (Nastovet al., 2007, Lantsov, 2020).

In recent years the methods and algorithms for reducing the memory and computational costs for nonlinear circuits on

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the base the ideas of model order reduction (MOR) were used (Bond & Daniel, 2007, Bond & Daniel, 2009, Lantsov&Dolinina, 2016). Model order reduction methods replace the original model by a system of much smaller dimension, which can be solved by suitable solvers. Model order reduction seeks to reduce the computational complexity and computational time of large-scale dynamical systems by approximations of much lower dimension that can produce nearly the same input/output response characteristics (Lantsov&Dolinina, 2016).

The two best-known methods for reduction of nonlinear systems are Proper Orthogonal Decomposition (POD) (Chaturantabut& Sorensen, 2010), and trajectory techniques (trajectory piecewise-linear, TPWL) (Rewienski& White, 2003).

TPWL techniques linearize the nonlinear system around selected states by a piecewise linearization that is obtained from combining the (reduced) linearized systems via a weighting procedure. The final TPWL model is constructed as a weighted sum of all locally linearized reduced systems (Rewienski& White, 2003).

TPWL method has the advantage that it really approximates the system behaviour of the linearised model. Well-developed linear model reduction techniques can be used to reduce the linearised models. However, to obtain good accuracy a large number of linearisation point is required, which implies a large extraction time. In addition, there are still many nonlinear functions that may not be approximated well by using low degree piecewise polynomials unless there are very many constituent polynomials.

Proper Orthogonal Decomposition extends the projection-based methods that are used for linear systems to nonlinear systems. Consider POD method more detailed because we'll use some ideas of POD in our

new approach of this paper (Chaturantabut& Sorensen, 2010).

Let us the nonlinear systems described the next differential equations

$$dv(t)/dt = Av(t) + F[v(t)]. \quad (1)$$

Here  $t \in [0, T]$  denotes time,  $v(t) = [v_1(t), \dots, v_N(t)]^T \in \mathbb{R}^N$ ,  $A \in \mathbb{R}^{N \times N}$  is a constant matrix, and  $F$  is a nonlinear function evaluated at  $v(t)$  componentwise, i.e.,  $F = [F(v_1(t)), \dots, F(v_N(t))]^T$ . The matrix  $A$  is the discrete approximation of the linear operator, and  $F$  is a nonlinear function of a variable  $v$ .

POD construct a reduced-order system of order  $k \ll N$  that approximates the original system from a subspace spanned by a *reduced basis* of dimension  $k$  in  $\mathbb{R}^N$ . Let  $V_k \in \mathbb{R}^{N \times k}$  be a decomposition matrix whose orthonormal columns are the vectors in the reduced basis. Then, by replacing  $v(t)$  in (1) by  $v(t) = V_k \hat{v}(t)$ ,  $\hat{v}(t) \in \mathbb{R}^k$  and projecting the system (1) onto  $V_k$ , the reduced system of (1) is of the form (Chaturantabut& Sorensen, 2010)

$$d\hat{v}(t)/dt = V_k^T A V_k \hat{v}(t) + V_k^T F[V_k \hat{v}(t)]. \quad (2)$$

The choice of the reduced basis clearly affects the quality of the approximation. The decomposition matrix  $V$  captures the dominant dynamics of original system. For constructs the matrix a time domain simulation of the complete system is done and snapshots of the states are collected in the state matrix, for example  $X$ . It is expected that the samples of snapshots will be on or near the attractive manifold. To extract the dominant dynamics  $V$ , the singular value decomposition (SVD) (Antoulas& Sorensen, 2001, Lantsov, 2012, Charumathi et al., 2019) of  $X$  is computed. Once the reduced model has been constructed from this reduced basis, it may be used to obtain approximate solutions for a variety of initial conditions and parameter settings, provided

the set of samples is rich enough.

The paper (Chaturantabut& Sorensen,2010) illustrates the computational inefficiency that occurs in solving the reduced-order system that is directly obtained from SVD approach. Equation (2) has the nonlinear term

$$NE(\hat{v}(t)) = V_k^T F[V_k \hat{v}(t)].$$

$NE(\hat{v}(t))$  has a computational complexity that depends on  $N$ , the dimension of the original full-order system (1). It requires a full evaluation of the nonlinear function  $F$  at the  $N$ -dimensional vector  $V_k \hat{v}(t)$ . As a result, solving this system might still be as costly as solving the original system(Chaturantabut& Sorensen, 2010).

One of way to overcome the difficulty is to approximate the nonlinear function in  $NE(\hat{v}(t))$  by projecting it onto a subspace that approximates the space generated by the nonlinear function and that is spanned by a basis of dimension  $k \ll N$ . The discrete empirical interpolation method (DEIM) was proposed in paper (Chaturantabut& Sorensen,2010)for these purposes.

In DEIM nonlinear function  $F[V_k \hat{v}(t)]$  or  $f(\tau)$  approximated using new reduced variable as

$$f(\tau) \approx U c(\tau), \quad (3)$$

where decomposition matrix  $U = [u_1, \dots, u_m] \in R^{k \times m}$ , and  $c(\tau)$  is the coefficient vector. To determine  $c(\tau)$ , we select  $m$  rows from the overdetermined system  $f(\tau) \approx U c(\tau)$ (Chaturantabut& Sorensen,2010).

In (Chaturantabut& Sorensen,2010) the special selection matrix is introduced as

$$P^T f(\tau) \approx (P^T U) c(\tau).$$

where  $P = [e_{q_1}, \dots, e_{q_m}] \in R^{k \times m}$ ,  $e_{q_i} = [0, \dots, 0, 1, 0, \dots, 0]^T \in R^k$ ,  $q_i$  is column of identity matrix  $I_k \in R^{k \times k}$  for  $i = 1, \dots, m$ .

The interpolation indices  $q_1, \dots, q_m$ , used for determining the coefficient vector  $c(\tau)$  in the

approximation (3), are selected inductively from the basis  $\{u_1, \dots, u_m\}$  by the DEIM algorithm introduced in (Algorithm 1, Chaturantabut& Sorensen, 2010).

The Algorithm 1 from (Chaturantabut& Sorensen, 2010) select the columns which have the strongest nonlinear dependences. Such selection very important for nonlinear differential equations in general form, but in circuit simulation the selection of columns will depends from the columns where nonlinear elements  $NE(\hat{v}(t))$  are placed.

Although POD has been successfully used in many applications, it has some drawbacks that could make it less applicable in circuit simulation (Chaturantabut& Sorensen, 2010). The TPWL and POD methods use the simulation tools in time domain, and they not applicable to frequency domain like harmonic balance methods.

In the author's previous works, the new idea for solving of harmonic balance equations was proposed. In (Lantsov, 2020a), a new method for solving HB equations was proposed, based on dividing the equations into two components of very small dimension. The reduction of memory and computational costs in the new method was determined by the significantly smaller dimension of the equations and the fact that they were used in solving sequentially.

In (Lantsov, 2020a), a simple iteration method was used to solve the equations. Further development of the method was proposed in (Lantsov, 2020b), where relations were obtained and an algorithm for implementation in software tools based on the use of Newton's iterative method was developed. Further development of the method and implementation algorithms was proposed in (Lantsov&Papulina, 2021), where detailed algorithms for implementing of method in CAD software tools for

electronics are presented.

The method and algorithms of its implementation in the software for modeling complex electronic circuits have shown high efficiency, especially when solving problems of very high dimension (Lantsov, 2020, Lantsov&Papulina, 2021).

The experience of using previously developed software tools has shown that the main costs of computer memory and simulation time are associated with the storage and processing of the Jacobian of full dimension. In this paper, an algorithm is proposed to significantly reduce computational costs using an effective method of approximation of the Jacobian of the harmonic balance equations when solving by the Newton method.

## 2. Basic equations of Harmonic Balance method

The basic relations and algorithms for solving the HB equations for electronic circuits by the new method are given in detail in (Lantsov, 2020b, Lantsov&Papulina, 2021), so here we will give only some basic relations necessary for the presentation of the proposed approach.

Consider the nonlinear circuits which described by the system of nonlinear integro-differential equations

$$f(v(t), t) = i(v(t)) + \frac{dq(v(t))}{dt} + \int_{-\infty}^t y(t - \tau)v(\tau)d\tau + i_E(t) = 0. \quad (4)$$

Here,  $v(t)$  is a vector of node voltages with dimension  $N$ ;  $i(v(t))$  is a vector of currents for resistive elements;  $q(v(t))$  is a vector for capacitor charges;  $u(t)$  are a input sources;  $y(t)$  describes linear part of circuits;  $i$  and  $q$  describe a nonlinear elements; the size of

equations is  $N$ (Lantsov, 2020a).

In the HB method, it is assumed that functions  $v$  and  $f$  are represented as a Fourier series (so, the HB method is referred to as methods in the frequency domain):

$$x(t) = \sum_{k=-\infty}^{\infty} X(k)e^{j\omega_k t},$$

where  $\omega_k = k\lambda$ ,  $\lambda = 2\pi/T$  is the base frequency.

The equations (4) then can be transformed into next form of nonlinear system of equations(Lantsov, 2020a)

$$F(V, k) = I(V, k) + j\omega_k Q(V, k) + Y(k)V(k) + I_E(k) = 0.$$

In vector-matrix form

$$F(V) = I(V) + YV - I_E = 0, \quad (5)$$

where  $V$  is a vector of unknowns (nodal voltages in the circuit); the first term  $I(V)$  describes nonlinear elements; the second term  $YV$  characterizes the linear part of the circuit; the element  $I_E$  is a vector of input sources. The dimension of the equations is equal to  $[N \times (2K+1)]$ , where  $N$  is the number of nodes in the circuit,  $K$  is the number of harmonics taken into account (Lantsov, 2020a).

The solution of harmonic balance equations (5) in the frequency domain is most often performed by the Newton iterative method(Lantsov&Papulina, 2021)

$$J(V^i) \cdot \Delta V^{i+1} = -F(V^i), \quad (6)$$

where  $J(V^i)$  is a Jacobian matrix;  $\Delta V^{i+1} = V^{i+1} - V^i$ ;  $i$  is iteration number. The Jacobian matrix can be found as

$$J(V^j) = \frac{\partial F}{\partial V} |_{V^i} = Y + \frac{\partial I}{\partial V} |_{V^i}. \quad (7)$$

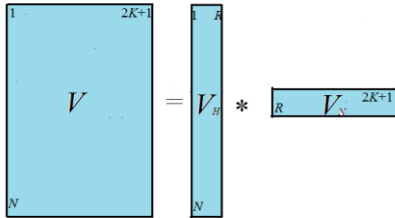
In HB method the dimension of Jacoby matrix  $([(2K+1) \times N] \times [(2K+1) \times N])$  which for complex malty components circuits becomes too large and needs excessive

computer memory and computational costs.

In (Lantsov, 2020) to replace the vector of variables  $V$  of the HB equations (5) with two matrices of reduced dimension (Figure 1) was proposed

$$V = V_H \cdot V_N,$$

where the matrix  $V_H$  reduces the number of harmonics and has dimension  $[N \times R]$ ,  $V_N$  - reduces the number of nodes of the circuit and has dimension  $[R \times (2K+1)]$ ,  $R$  is the reduced dimension of the equations,  $R \ll N$ ,  $R \ll (2K+1)$ .



**Figure 1.** Replacing the matrix  $V$  with two new matrices of reduced dimensions

Replacement of (5) leads to two systems of balance equations of reduced dimension as it was obtained in (Lantsov, 2020a)

$$F(V_H) = I(V_H V_N) \cdot V_N^T + Y V_H - I_E \cdot V_N^T = 0 \quad (8)$$

and

$$F(V_N) = V_H^T \cdot I(V_H V_N) + Y V_N - V_H^T I_E. \quad (9)$$

The equation (8) reduces the number of harmonics in the balance equations and has dimension of equations as  $[N \times R]$ . The equation (9) reduces the number of circuit nodes and has dimension of equations as  $[R \times (2K+1)]$ . Equations with reduced dimension are solved sequentially (Lantsov, 2020a).

In the traditional circuit simulators, the more convenient form of the equations for Newton's method is on the new value  $V^{i+1}$

instead of the increment  $\Delta V^{i+1}$  in (6) (Lantsov, 2020b)

$$\begin{aligned} J(V^i) \cdot (V^{i+1} - V^i) &= -F(V^i), \\ J(V^i) \cdot V^{i+1} &= I_E + \partial I / \partial V |_{V^i} - I(V^i), \end{aligned}$$

As a result, the final expression for calculations (8) by Newton's method gives us the following iterative formula in the form of the system of linear algebraic equations (SLAE) (Lantsov, 2020b)

$$J(V_H^i) \cdot V_H^{i+1} = I_H^i. \quad (10)$$

Here the Jacobi matrix is defined as

$$J(V_H^i) = \partial F / \partial V_H = \partial I / \partial V \cdot V_H^T + Y. \quad (11)$$

The vector of the right parts of the system of equations (10) will have the form (Lantsov, 2020b)

$$I_H^i = I_E V_N^T - \partial I / \partial V V_H^i - I(V) V_N^T. \quad (12)$$

Similarly, to solve the system of equations (9), we have the following basic iterative formulas (Lantsov, 2020b)

$$J(V_N^i) \cdot V_N^{i+1} = I_N^i, \quad (13)$$

$$J(V_N^i) = \partial F / \partial V_N = V_H^T \cdot \partial I / \partial V + Y, \quad (14)$$

$$I_N^i = V_H^T I_E - \partial I / \partial V V_N^i - V_H^T I(V). \quad (15)$$

### 3. Approximation of derivatives for nonlinear dependencies

Note that in equations (12) and (15) there is an element  $I(V)$  that determines the dependence of current on voltages on nonlinear elements in the frequency domain. In standard of circuit simulation tools, all models of nonlinear devices (elements) are described by dependencies in the time domain  $i_{NE}(t) = f[v_{NE}(t)]$  (Lantsov, 2020). The basic HB equations are solved in the frequency domain. Therefore, at each iteration of Newton method, when solving

equations, it is necessary to make transformations from the frequency domain to the time domain and back using the Fast Fourier Transform (Lantsov,2020, Carvalho et al., 2006, Nastov et al., 2007, Lantsov&Papulina, 2021)

$$I(V) = \Gamma \{i(t) = f[v(t)]\} \Gamma^{-1}. \quad (16)$$

Here  $\Gamma$  is the forward and  $\Gamma^{-1}$  is the inverse Fourier transform. The relationship between the representation of the signal in the time and frequency domains will be defined as  $V = \Gamma v$  and  $v = \Gamma^{-1}V$ . Similarly, in the iterative formulas there is an element of calculating the derivatives of currents of nonlinear elements according to the corresponding voltages(Lantsov, 2020b)

$$\partial I / \partial V = \Gamma \left\{ \frac{\partial i(t)}{\partial v(t)} \right\} \Gamma^{-1}. \quad (17)$$

Earlier, in previous works (Lantsov, 2020, Lantsov&Papulina, 2021), the standard part of traditional HB-based software tools and the full dimensions of these equation elements were used to calculate (16) and (17).Unfortunately, the experience of using software tools implementing previously developed methods and algorithms has shown that the main computational costs (memory and time) are associated precisely with the calculation of element  $I(V)$ , and especially with the calculation of the derivative for the Jacobian  $\partial I / \partial V$ .

Note that the element  $\partial I / \partial V$ . will be the same for equations (11 and 12), (14 and 15).

It is proposed to approximate this element and reduce its dimension. This approximation will correspond to the methods of averages used in the algorithms for solving the HB equations to approximate the Jacobian in (Filicori& Monaco, 1988, Kundert et al., 1990, Ushida et al., 1992), where equation (3) can be replaced as

$$J(V^j) = \partial F / \partial V |_{V^j} = Y + G_{av}.$$

In (Kundert et al., 1990) average value was obtained as

$$G_{av} = \frac{1}{T_0} \int_0^{T_0} \frac{\partial i[v(t)]}{\partial v(t)} dt.$$

It is important to note that the approximation is performed once and before the start of the main iterations.

To calculate the average value  $G_{av}$  we use approach which was proposed in POD method. The collection of output waveforms (snapshots or samples of trajectories) is discretized and the times at which the derivatives are crossed are recorded. The discretized input and output waveforms can be collected in one single matrix form (snapshot matrix) of responses of nonlinear elements in the form

$$G(t) = [g_1(t), \dots, g_n(t)]^T \in R^n,$$

where  $g_k(t) = \frac{\partial i(t)}{\partial u(t)} |_{u_k(t)}$  are

derived currents of nonlinear elements (usually in circuit simulators, these derivatives are in analytical form); time  $t \in [0, T]$ ,  $T$  is the period of the lowest harmonic spectrum at the output of the circuit;  $n = N_{NE} \cdot N_{IN}$ ;  $N_{NE}$  is a number of nonlinear dependencies;  $N_{IN}$  is a number of analysis when we change the amplitude of the input.

The total dimension of the matrix of sets  $G$  will be defined as  $n \cdot Nt$ , where  $Nt$  is the number of time (discrete) samples on the period  $T$ .The correct and sufficiently large for selection of a set of snapshots is a decisive factor in building of the SVD algorithm. This choice can greatly affect the approximation of the initial description (Ramalingam, 2007).

It is assumed that the sample set will correspond to the dominant states of the model and the sample set is large enough.

The SVD method creates a reduced basis, which is optimal in the sense that the approximation error with respect to data sets is minimized (Ramalingam, 2007).

The SVD algorithm with respect to the matrix of sets  $G$  gives the following decomposition

$$G = U \Sigma V^T, \quad (18)$$

where the matrices  $U := (u_1, \dots, u_r) \in R^{r \times r}$  and  $V := (v_1, \dots, v_r) \in R^{Nt \times r}$  are orthogonal, i.e.  $UV = I$ , where  $I$  is the unit matrix,  $\Sigma = \text{diag}(\sigma_1 \geq \sigma_2 \geq \dots \geq \sigma_r \geq 0)$  is a diagonal matrix of singular values (Antoulas & Sorensen, 2001, Iantsov, 2012, Charumathi et al., 2019).

The matrix  $U$  is called the left singular matrix and its columns provide the orthogonal basis for the columns of  $G$ . The matrix  $V$  is called the right singular matrix and its columns provide the orthogonal basis for the rows of  $G$ . As noted above, the columns of  $V$  provide the orthogonal basis for the rows of  $G$  and since each row contains a discretized waveform, the columns of  $V$  turn out to be the orthogonal basis for the waveforms in matrix  $G$  (Antoulas & Sorensen, 2001).

Now (18) can be rewritten by post-multiplying both sides by  $V$ . Since  $V$  is orthonormal ( $V^T V = I$ ) we get  $GV = U\Sigma$ . We denote the resultant product matrix as  $M$  called the moments matrix (Ramalingam, 2007)

$$M = GV = U\Sigma.$$

The moments matrix defined here is a linear combination of time points weighed by the right singular vectors (rsv)  $V_j$ :

$$m_{ij} = G_i \cdot V_j = \sum_{k=1}^n g_{ik} v_{kj},$$

where

$$G = \begin{pmatrix} g_{1,1} & g_{1,2} & \dots & g_{1,n} \\ g_{2,1} & g_{2,2} & \dots & g_{2,n} \\ \dots & \dots & \dots & \dots \\ g_{Nt,1} & g_{Nt,2} & \dots & g_{Nt,n} \end{pmatrix}.$$

The right singular vectors transform a waveform from time domain  $t = (t_1, t_2, \dots, t_n)$  to moments domain  $m = (m_1, m_2, \dots, m_n)$  through  $m = tV$  and vice-versa through  $t = mV^T$  (Ramalingam, 2007).

This equivalent representation leads to an interesting possibility in the context of timing analysis. If a waveform can be represented accurately using a few moments then by propagating these moments, one can do an accurate waveform analysis instead of propagating all the  $n$  time points.

A reduced matrix of averaged values of  $G_{av}$  is obtained using the following relation (Ramalingam, 2007)

$$G_{av} = U \Sigma V^T = U \text{diag}(\sigma_1, \sigma_2, \dots, \sigma_r, 0, 0, 0) V^T.$$

The final expressions for calculation by iterative formulas will look like this. For equations (11-12)

$$J(V_H^i) = Gav \cdot V_N^T + Y, \quad (19)$$

$$I_H^i = I_E V_N^T - Gav \cdot V_H^i - I(V) V_N^T. \quad (20)$$

For equations (14-15)

$$J(V_N^i) = V_H^T \cdot Gav + Y, \quad (21)$$

$$I_N^i = V_H^T I_E - Gav \cdot V_N^i - V_H^T I(V). \quad (22)$$

### Algorithm 1 (Solution of equations 10)

- 1: Input:  $V_H^i, V_N^i, Gav$ ;
- 2:  $V_N^T = (V_N^i)^T$ ;
- 3: Access to the library of standard non-linear elements. Calculation of  $I(V^i)$ , equations (16);
- 4: Calculation (19) and (20);
- 5: Solution of SLAE (10).

### Algorithm 2 (Solution of equations 13)

- 1: Input:  $V_H^i, V_N^i, Gav$ ;
- 2:  $V_H^T := (V_H^i)^T$ ;

- 3: Access to the library of standard non-linear elements. Calculation of  $I(V^i)$ , equations (16);
- 4: Calculation (21) and (22);
- 5: Solution of SLAE (13).

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**Algorithm 3** (Newton Iterations)

- 1: DC analysis  

$$V_H^0 = V_H^{DC}; V_N^0 = V_N^{DC};$$
- 2: Calculation  $Gav$ ;
- 3:  $i = 0$ ;
- 4: Algorithm 1;
- 5: Algorithm 2;
- 6: if  $(V_H^{i+1} - V_H^i \leq \varepsilon) \wedge (V_N^{i+1} - V_N^i \leq \varepsilon)$  stop.
- 7:  $i = i + 1$ ;
- 8: go to 4.

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All the developed algorithms are implemented as a supplement to the general-purpose circuit modeling program SMORES

(Bond, 2010), implemented as open code in the Matlab/Simulink system.

Verification of the proposed algorithms based on the circuit simulation software tools (Lantsov, 2020, Lantsov&Papulina, 2021) was performed on a well-known example from the author's previously published works and examples known from publications in the world literature (Fig. 3, Bond& Daniel, 2007, Fig. 1, Lantsov&Dolinina, 2016).

This example is characterized by the fact that by changing the number of nonlinear cascades of the circuit, it is possible to increase the dimension of the circuit to very high dimensions determined by the memory of a particular computer.

The comparison was performed both with the standard HB method and with previously published results. Since the convergence in all the examples coincided with the calculations by the standard HB method, we do not provide graphs of the results. The table below shows the results of the comparison.

**Table.** Comparison of methods by calculation time

	Calculation options: the number of repeating cascades of the circuit, the number of nodes, the number of harmonics taken into account	New algorithm	Standard HB method	The algorithm is in paper (Lantsov, 2020a)]
1	3, 11, 3	5 s	4 s	6 s
2	3, 11, 99	9 s	9 s	11 s
3	14, 42, 3	20 s	22 s	23 s
4	14, 42, 99	112 s	135 s	128 s
5	45, 135, 3	175 s	206 s	196 s
6	45, 135, 99	271 s	342 s	302 s

#### 4. Conclusion

As in POD methods and like in our approach the choice of the number of snapshots depends on many factors. On the one hand one desires the number of snapshots to limit the computational costs involved with the

SVD, on the other hand all the dominant states should be captured. Also, the choice of the snapshot discreet times can be a challenging task. Third, the influence of the training input may be very big, making the reduced order models unsuitable for reuse in practice.



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## THE NEW PROCESSING METHOD OF QUASI-PERIODIC PULSE SIGNALS USING WAVELET ANALYSIS AND HERMIT TRANSFORM

**Abstract:** *The article considers the basic principles of constructing a method for processing quasi-periodic pulse signals. The method is based on the combined use of wavelet analysis and the Hermite transform, in particular, the Gauss-Hermite function. Wavelet transform is considered as a cross-correlation function. The Gauss-Hermite functions are used as a basis in the wavelet analysis. Approbation of the method is carried out as on a test signal, in the form of a rectangular pulse with additive noise, which at some point in time has a local inhomogeneity, also on the real signal received from the bearings of the gas turbine engine.*

**Keywords:** *Wavelet Transform, Gauss-Hermite Functions, Gas Turbine Engine*

### 1. Introduction

The analysis of form and parameters of quasi-periodic pulse signals against the background of noise, which is a slowly changing process, is an integral part of the information processing procedure in order to diagnose the state of an object. For example, signals appear during the functioning of dynamic systems: various machines and mechanisms, living organisms and other objects. In most cases, these objects operate in a cyclical manner. In mechanical systems, this is due to the presence of rotating parts, in a living organism - the leading centers of nervous excitation. Very often, such systems are subject to random disturbances. In particular, in a biological object due to various pathologies, disturbances in the rhythm of its functioning occur. In mechanical systems due to interaction with the environment, under the influence of a time factor or other reasons, disturbances in the cyclicity of work occur. If these

violations go beyond the permissible limits, then there is a reason to draw a conclusion about the malfunction of machines and mechanisms or about a person's disease.

The most common processing method to state the value of quasiperiodic impulse systems is spectral analysis. Due to well-studied mathematical apparatus, it allows you to detect various defects in the system. Spectral analysis confidently copes with the task of diagnosing dynamic systems if the defect is of a periodic nature. This is expressed by the characteristic frequency components in the spectrum of the signal under investigation. But if the defect is not periodic or quasi-periodic, has a random character, then the efficiency of the spectral analysis is significantly reduced.

This problem can be partially solved using the windowed Fourier transform. In this case, the frequency resolution depends on the duration of the window, and the dynamics of the system functioning is assessed by using the average frequency. It

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is difficult to estimate the quasiperiodicity of the system from the average frequency, thereby reducing the accuracy of its diagnostics. In addition, using this processing method, we are faced with the uncertainty of the choice of the window width. With a small width, we lose exactly in frequency. With a large width, the estimate of quasiperiodicity is lost.

Thus, to solve the above problem, it is necessary to measure the distance between quasiperiodic pulses. Then we are faced with the need to adapt to the shape of the impulses so that the assessment of the dynamics of their repetition is more accurate. This is complicated by the fact that the shape of the pulses is constantly changing, i.e. the system under study is nonstationary.

The method that is based on the combined use of wavelet analysis and Hermite transform was developed to eliminate the above disadvantages.

The basic functions in the Hermite transform are the Gauss–Hermite functions. The Gauss–Hermite functions are the product of the Hermite polynomials and the Gaussian function. Hermite polynomials have a number of advantages over other polynomials known in mathematics: Chebyshev and Legendre. The Chebyshev polynomials are orthogonal on the interval  $[-1,1]$  and beyond it rapidly increase in comparison with polynomials of the same degree, which contributes to the design of linear filters. However, such a small orthogonality interval does not allow more accurate adaptation of the reference signal to the local properties of the signal, in contrast to the Hermite polynomials, in which the orthogonality interval is  $(-\infty, \infty)$ . As well as for Chebyshev polynomials, the orthogonality interval for Legendre polynomials lies in the range  $[-1,1]$ . Similar properties to the Gauss–Hermite functions have the Gauss–Laguerre functions, which are actively used in image analysis. Due to their properties, Gauss–Laguerre functions

are excellent for analyzing circular image neighborhoods. It is possible to make a transition from circular harmonic Gauss–Laguerre functions to Gauss–Hermite functions, thereby achieving acceleration of calculations due to the fact that the Gauss–Hermite functions are separable, i.e., independent of each other. In the context of signal processing, an important distinguishing feature of Gauss–Hermite functions compared to Chebyshev and Legendre polynomials and Gauss–Laguerre functions is that they are orthogonal in both space time and the frequency domain. This allows you to synthesize filters not only by matching impulse responses, but also by direct synthesis with a given frequency response.

## 2. Basic principles of the method

The traditional interpretation of the wavelet transform is based on the consideration of basis functions as time-limited oscillation segments. Variation their scale is equivalent to changing the frequency composition of these functions.

$$W_s(a, \tau) = \int_{-\infty}^{\infty} S_m(t) \Psi_{a,\tau}(t) dt \quad (1)$$

As can be seen from (1), the wavelet coefficients in the general case are determined by the integral transformation of the signal. Continuous wavelet transform  $W_s(a, \tau)$  is the scalar product of the process under study  $S_m(t)$  and basis functions  $\Psi_{a,\tau}(t)$ .

The basic functions are real, defined on a certain interval and fluctuate around the abscissa axis:

$$\Psi_{a,\tau}(t) = \frac{1}{\sqrt{a}} \Psi\left(\frac{t-\tau}{a}\right) \quad (2)$$

$\tau$  – shift parameter, shows the location in time,  $a$  – scale parameter.

The pulses of a quasi-periodic signal can have an arbitrary shape. Therefore, for more efficient diagnostics, it is necessary to use orthogonal basis functions. The most popular orthogonal wavelets are the Haar and Daubechies. They have a number of limitations and disadvantages. Haar wavelets poorly describe smooth functions, and Daubechies functions have an asymmetric shape, which narrows the area of their practical use. Thus, with the help of classical wavelets, it is not possible to take into account all the features of the signal shape. In addition, when processing real signals, it is necessary to construct basis functions based on the discrete recording of the signal, and this is absent in the classical interpretation of the wavelet transform. As a basic function, it is proposed to use the Gauss-Hermite functions (FGH), defined in the Hermite transform. The energy of the FGH is concentrated on a limited interval in both the time and frequency domains. Therefore, FGH work with a finer time-frequency localization. This representation of the process under study is less robust to noise, but it retains a much larger number of characteristic features of the signal. The inherent localization of the FGH in the time domain makes them very suitable for representing the bearing support signals in the form of a generalized Fourier series based on these functions.

The FGH have the following form:

$$\Psi_n(t) = H_n(t) \exp(-0.5t^2) / \sqrt{n!2^n \sqrt{\pi}} \quad (3)$$

where  $H_n(t)$  – Hermite polynomials,  $n$  – FGH order.

The feature of functions (3) is that they are eigenfunctions of the Fourier transform in the space  $L_2(-\infty, \infty)$  with values  $\pm 1, \pm \sqrt{-1}$ . Also, an important advantage is that FGH are localized from a computational point of view on a finite time interval as a consequence of

$\lim_{|t| \rightarrow \infty} (H_n(t) \exp(-0.5t^2) / \sqrt{n!2^n \sqrt{\pi}}) \rightarrow 0$ , and the localization segment is the interval  $[-\sqrt{2n+1}, \sqrt{2n+1}]$  containing all inflection points (3).

Transformation (1) can be considered as a cross-correlation function of the signal and the basis function sliding over it. The higher the upper limit of the correlation integral, the greater the degree of similarity between the signal and the function. Taking into account the above said, substituting expression (3) into expression (1) taking into account expression (2), we have the following correlation integral:

$$R_{out}(a, \tau) = \int_{-\infty}^{\infty} S_{in}(t) \tilde{S}_{ptrn}(a, t - \tau) dt \quad (4)$$

where  $\tilde{S}_{ptrn}(a, t)$  – basic function.

In turn, the basic function has the following form:

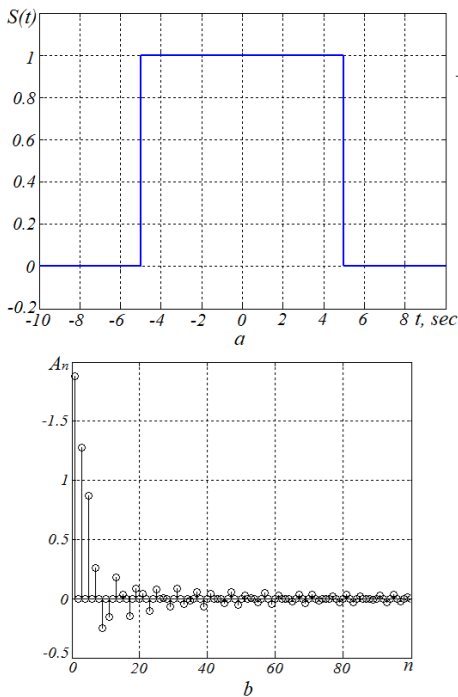
$$\tilde{S}_{ptrn}(a, t) = \frac{1}{\sqrt{a}} \sum_{n=0}^{\infty} W(n, n_c) A_n(a) \Psi_n(t/a) \quad (5)$$

where  $A_n(a)$  – the spectrum of the signal in the FGH basis,  $W(n, n_c)$  – the smoothing window for weakening the Gibbs effect in the FGH space,  $n$  – the number of the FGH. For a more detailed understanding of the formation of the basis function, consider the rectangular pulse shown in Figure 1a.

Traditionally, in radio engineering and digital electronics, a rectangular pulse is of great importance both from a theoretical and practical point of view. A good model for debugging various algorithms is a square wave. Within the framework of the model problem being solved, a rectangular pulse with an unknown duration is considered as an input signal  $S_{in}(t)$ . For the formation  $\tilde{S}_{ptrn}(a, t)$ , we represent the pulse in the

basis of the PGE, using the following decomposition into spectral components:

$$A_n(a) = \int_{-\infty}^{\infty} S_{in}(t) \Psi_n(t/a) dt \quad (6)$$



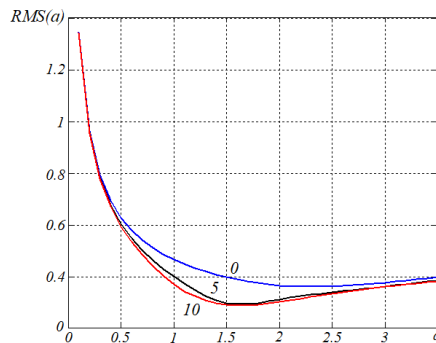
**Figure 1.** Function in the form of a rectangular pulse (a) and its spectrum in PGE space (b)

The spectrum of a rectangular signal in the FGH basis is shown in Figure 1b. Moreover, at this stage, it does not matter what scale the FGH has, since for any parameter, an infinite number of FGH accurately reproduces the process under study. Figure 1b shows that the signal spectrum in the FGH space has a discrete form, since each spectral component of a rectangular pulse corresponds to a FGH of an integer order.  $\tilde{S}_{ptrn}(a,t)$

Since the FGH system is complete, an infinite number of discrete FGH provides a

zero value of the standard deviation (RMS) of the sum of the series from the function. However, in reality the series is always finite. The scale parameter allows you to reduce the standard deviation of the truncated series. Figure 2 shows the dependence of the RMS on the scale parameter for different numbers of FGH ( $n = 0, 5, 10$ ) in (5).

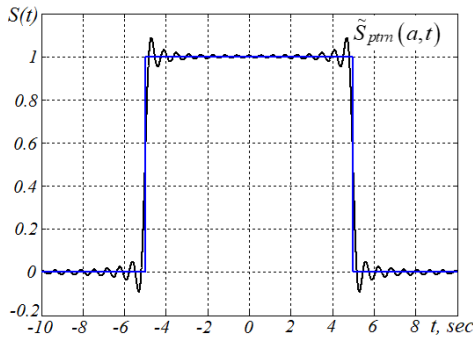
It is clearly seen that the minimum standard deviation is reached at  $a \approx 1,6$ . Based on the results of our calculations, it can be argued that for a rectangular pulse, the optimum of the parameter weakly depends on the FGH number. From this it follows that for a rough definition of the scale, the zero-order FGH is sufficient - the Gaussian function.



**Figure 2.** RMS dependence on the scale parameter, numbers are the limiting values of the sum of the inverse Gauss-Hermite transform (basic function)

Figure 3 shows the basis function (5) derived from the calculated scale parameter ( $a = 1,6$ ) consisting of 140 FGH.

The rectangular pulse is reproduced inaccurately, with small oscillations, due to a sharp transition from the transmission frequency to the suppression frequency in the FGH space. This effect, as well as in harmonic analysis, is called the "Gibbs phenomenon", the essence of which is that the Fourier series of a discontinuous function does not converge to the expanded function in the vicinity of the discontinuity.



**Figure 3.** Rectangular pulse and basic function

The truncation of the FGH series can be considered as low-frequency filtering in the FGH space. With the help of such filtering, the influence of the “Gibbs phenomenon” can be weakened. As filter prototypes, we use filters whose frequency response are based on the classical approximations of Gauss, Butterworth, Chebyshev and Bessel. As the frequency in the corresponding formulas, we will use the FGH order, for simplicity, assuming it to be a continuous value. Based on the property of the FGH localization segment, it can be expressed  $n_c$  in terms of the cutoff frequency  $f_c$ :

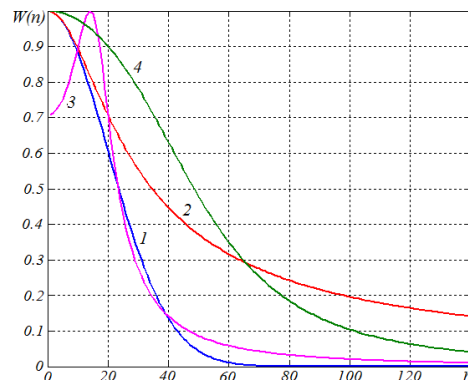
$$n_c = 0,5 \left[ (2\pi f_c a)^2 - 1 \right].$$

Thus, the value can be calculated from a priori information about the spectrum of the signal under study.

As an example of the attenuation of the “Gibbs phenomenon” in the FGH space, we will use the frequency response of the following filters: Gauss, Butterworth of the 1st order, Chebyshev of the 2nd order, Bessel of the 3rd order. The simulation results for are shown in Figure 4.

The Butterworth filter provides the flattest passband response, at the cost of smoothness in the transition region between the passband and stopband. When using the Chebyshev filter, significant ripples in the passband are visible. However, it provides the highest slope in the transition region. The Bessel

filter has the flattest portion of the latency curve in the passband, but has the flattest transitional portion between the passband and stopband. The Gaussian filter has a sharp slope of the frequency response and a flat section in the passband.



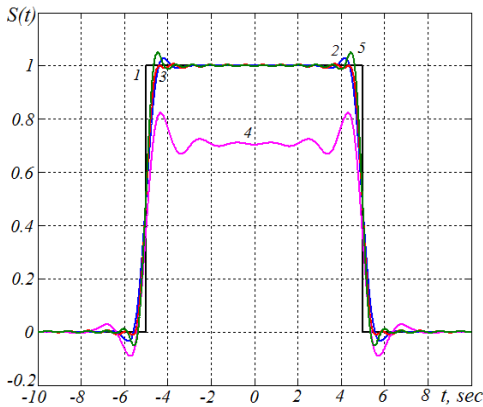
**Figure 4.** Frequency response of filters: 1 - Gaussian filter, 2 - Butterworth filter of the 1st order, 3 - Chebyshev filter of the 2nd order, 4 - Bessel filter of the 3rd order

The result of low-frequency filtering in the FGH space of a rectangular pulse with a fixed scale parameter is shown in Figure 5

Based on the calculated frequency response of the filters (Figure 4), we can conclude that the basis function most accurately describes a rectangular pulse, built using a 3rd order Bessel smoothing filter. A better match can be achieved by increasing the order of the filter, however, this entails the complexity of the filter gain in a digital implementation. Acceptable frequency response results can be achieved using Gaussian and Butterworth filters.

Chebyshev filters give significant distortion in the form of a basis function, and therefore they cannot be recommended for use.

In the presented article, as a smoothing filter, a Gaussian approximation filter is used, since it is optimal from the point of view of digital implementation and filtering properties (frequency response shape).



**Figure 5.** Rectangular pulse after filtering: 1 – initial rectangular pulse, 2 – after Gaussian filter, 3 – after Butterworth filter, 4 – after Chebyshev filter, 5 – after Bessel filter

Summarizing, we note that by applying a low-pass filter in the FGH space, it is possible to weaken the "Gibbs phenomenon" and thereby more accurately bring the reference signal closer to the standard, which, in turn, increases the probability of a more confident signal detection.

Having determined the main points in the construction of the basis function, let us consider a test example of the calculation: a rectangular pulse with additive noise, which at some point in time has a local inhomogeneity in the form of a third order FGH with a fixed scale parameter (figure 6a).

Since the inhomogeneity is characterized by one feature, the correlation integral (4) has the following form:

$$R_{out}(a, \tau) = \int_{-\infty}^{\infty} S_{in}(t) \Psi_3(a, t - \tau) dt \quad (7)$$

By varying the scale parameter, the duration of the local inhomogeneity and its location can be found. The results of such a procedure are reflected in the form of level lines (figure 6b). Having found the local maximum of the surface in figure 6b, one can find the location ( $t = 0$ ) of the local

inhomogeneity and its duration 0.2. The result of calculating the correlation integral (7) with the scale parameter  $a = 0.2$  is shown in figure 6c.

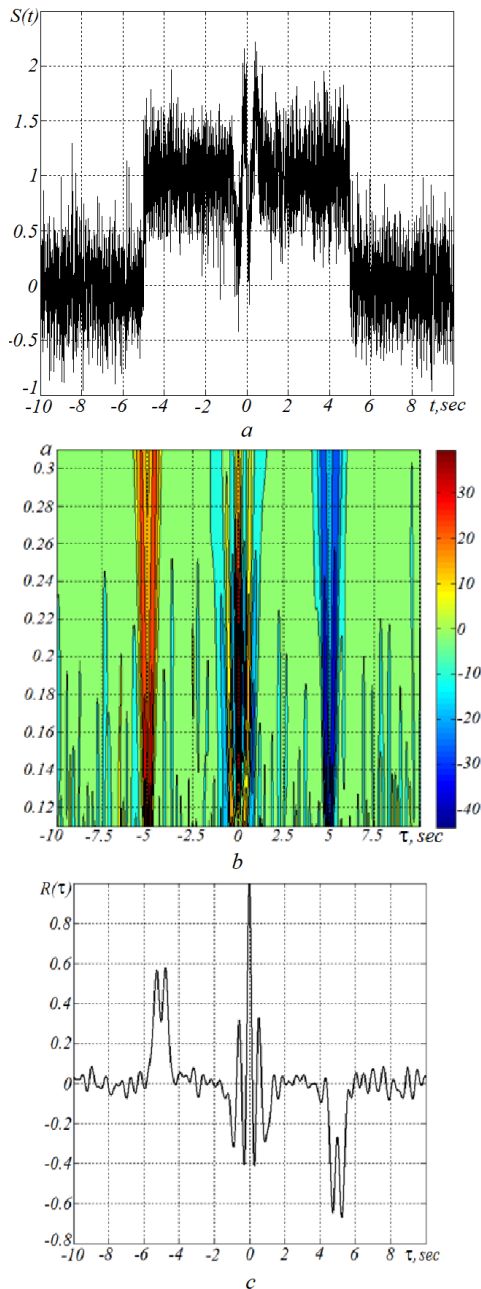
We can compare the obtained result with the classical wavelet transform. Figure 7 shows the wavelet spectrograms of a rectangular pulse, constructed with various basic functions. The construction of the basic functions was carried out with the standard tools of the MATLAB package, so the values of the scale parameter are different. It is advisable in this case to compare not quantitatively, but qualitatively: to identify the fine structures of the process under study.

Local inhomogeneity is more confidently distinguished by processing using the MHAT function, since it is adapted for analyzing complex signals due to its narrow energy spectrum and two moments (zero and first) equal to zero.

The key difference between the two processing approaches is that at the output of the algorithm under consideration we have a cross correlation function, which allows us to estimate the degree of similarity of the reference signal and the reference, and at wavelet processing, the spectral distribution.

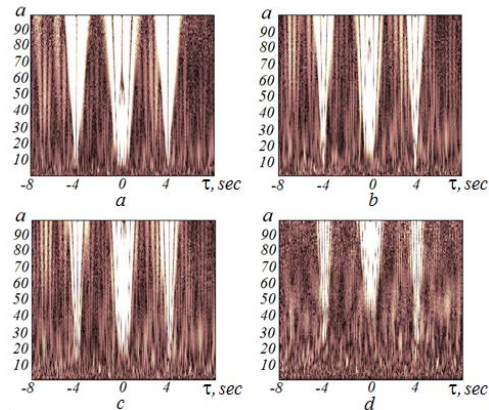
The main idea of the processing method is as follows: from the investigated quasi-periodic pulse signal, we select a fragment, on the basis of which we construct the basis function (5). A fragment can represent a local inhomogeneity, the dynamics of which we want to trace. Next, we calculate the correlation integral (4), where the result is a cross correlation function, which is a complex surface with many local extrema, due to the scale variation and time shift. Supposing that a working system operates cyclically, we determine the distance between each extremum. If this distance is in the limit of the confidence interval, then the system is in good order, otherwise it is not.





**Figure 6.** Processing results: rectangular pulse with a singularity in the form of a third order FGH(a), the result of calculating the cross correlation function (b, c).

It is convenient to reflect such a dynamic picture using scatterograms. The speed of calculating the correlation integral can be increased by going to the frequency domain.



**Figure 7.** The results of processing using: MHAT function(a), Gauss 3 orders(b), Gauss 4 orders(c), Morlet wavelet(d)

For this, it is necessary to replace the operation of calculating the correlation integral by filtering in the spectral region. This procedure is carried out using the generalized Rayleigh formula. As a result, the correlation integral has the following form:

$$R_{out}(a, \tau) = \frac{1}{2\pi\sqrt{a}} \int_{-\infty}^{\infty} \mathcal{S}_{in}(\omega) \mathcal{K}_n(a\omega) \exp(j\omega\tau) d\omega \quad (8)$$

where  $\mathcal{S}_{in}(\omega)$  – complex Fourier spectrum,

$\mathcal{K}_n(a\omega)$  – complex filter gain, which is

$$\mathcal{K}_n(a\omega) = j^n \sqrt{\frac{\sqrt{\pi}}{n!2^{n-1}}} \exp(-0,5a^2\omega^2) H_n(a\omega) \quad (9)$$

Let us consider in more detail the operation of the method using the example of bearings of rotor supports.

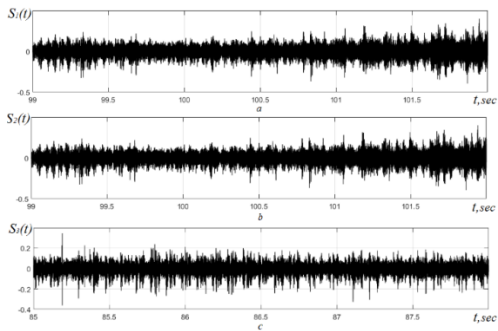
### 3. Signal processing of bearings of a gas turbine engine

Gas turbine engines (GTE) are one of the most complex technical developments of mankind and are widely used in aviation, energy, marine and other fields. The complexity of GTE is evidenced by the number of parts in their design, the variety of loads acting on them, the modes and conditions of operation, the implemented parameters of the working cycle, the complexity of control and maintenance of performance. As a result, even small deviations from the calculated operating conditions, the slightest inaccuracy in control can lead to failure and destruction of the gas turbine engine. Trends in the improvement and development of these engines are always aimed at improving their specific characteristics, which always leads to an increase in stresses that occur in structural details, and even minor deviations in parameters during production or the development of a malfunction caused by functional damage or aging can lead to catastrophic consequences. This fact indicates a constant increase in the need for timely fault diagnosis.

A gas turbine engine is a complex technical system with many different vibration sources. One of these sources is the rotor bearing arrangements, the failure of which interrupts the further operation of the gas turbine engine. In good condition, the bearing arrangements function cyclically. However, it is at an early stage of development that the cyclicity is violated, which manifests itself in the form of quasi-periodicity of pulse repetition. At the same time, not one method of technical diagnostics used in various branches of mechanical engineering is not able to determine this malfunction and only states the fact of engine destruction. Currently, an urgent task is not only the assessment of the current technical condition, i.e. determining

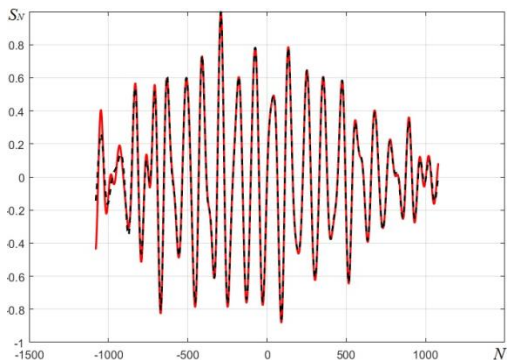
the actual characteristics of gas turbine engines that change over time, but also forecasting and assessing the life cycle of a gas turbine engine as a whole or its individual components. Let us estimate the quasiperiodicity using the method presented.

Figure 8 shows fragments of three bearings. The first one is in good condition, the other two are defective. In accordance with the processing method, first one need to isolate the local heterogeneity from the process under study.



**Figure 8.** Bearing vibration recordings: a – no damage, b and c – there is damage.

After analyzing the records of a bearing without a defect, a fragment was selected, which is shown in figure. 9, since it is most often found in the record.



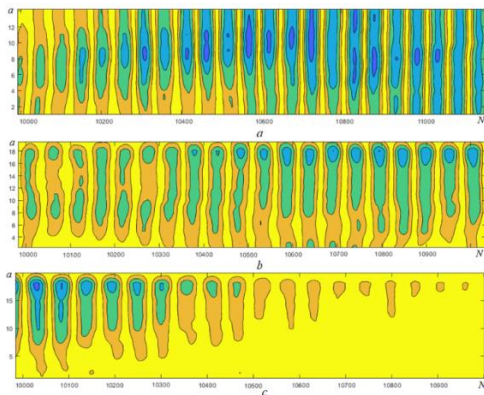
**Figure 9.** Basic function (black dash-dotted line), selected fragment (red solid), N - number of samples.

Based on (5), we construct a basis function from a fragment of a record of a serviceable bearing. Given the approximation error, one can find the optimal number of FGH in (5). Figure 5 shows a 5% approximation error for various parameters of the scale and the number of FGH.

The approximation error in the general case can be calculated using the following formula:

$$Er(a, n) = \left( \frac{\int_{-\infty}^{\infty} (\tilde{S}_{ptm}(a, t) - S_{ptm}(t))^2 dt}{\int_{-\infty}^{\infty} S_{ptm}(t)^2 dt} \right) 100\% \quad (10)$$

Then in accordance with (4), we construct the correlation function. Fragments of the cross-correlation function for bearing signals are shown in figure 10. By finding the distance between the extrema, for example, using the steepest descent method, one can display the dynamics of pulse repetition or quasiperiodicity.



**Figure 10.** The result of calculating the cross-correlation function: a – no damage, b and c – there is damage.

It is convenient to display quasi-periodicity using rhythmograms and scatterograms. To build a rhythmogram, the correlation function was subjected to threshold processing. As a threshold, the minimum positive value from the set of maxima of the correlation function of the signal in Figure 10 is used. The rhythmogram is a random

process with many outliers. Rhythmogram surges indicate an increase (upsurges) or a decrease (downsurges) of vibration non-linearity parameters. A scatterogram is a correlation rhythmogram or a topographical equivalent of Puncaré's spots. The more clustered the points are, the less the quasi-periodicity. The shift of the points to the right along the coordinate axis reflects a decrease in the rhythm, while the shift to the left reflects an increase. If the points are far from the whole population, then this may indicate a defect. More details about the processing of rhythmogram and scatterogram of a GTE can be found at the links provided.

## 4. Conclusions

The presented processing results both on the test signal and on the real signal allow us to state that the method based on the combined use of the wavelet transform and the Hermite transform can be applied to detect and estimate the quasiperiodicity of various local inhomogeneities. A fundamentally new element in the proposed processing method is the construction of a basis function based on the Hermite transform. Also new is the construction of a correlation integral based on the integral of the wavelet transform. Due to the main properties of the wavelet transform (scaling, localization), it is possible to construct a basic signal with lower computational costs, as well as to track the dynamics of changes in the duration of the reference signal in the process under study. The use of mathematical techniques embedded in the wavelet transform takes the processing method to a qualitatively new level. It is able not only to detect a useful diagnostic signal, but also to diagnose one or another anomaly or inhomogeneity in cyclic systems, for example, in a gas turbine engine.

In turn, inhomogeneities can characterize both the correct operation of the system

under study and the system defects. The choice depends on the thing, the dynamics of which process the researcher wants to trace. The key feature of the method is that it is possible to display the dynamics of pulse repetition of arbitrary shape in order to diagnose quasiperiodic pulse systems. The obtained processing results confirm the state of the system under study, in particular the bearing arrangements. The presented method in turn can be applied as an additional diagnostic tool to the proven classical spectral analysis.

As a result, the proposed unique diagnostic method allows not only to solve the problems of determining and predicting the technical condition of engine components that previously did not have such an opportunity, but also to determine the quality of manufacture and assembly of rotor systems.

In the future, it is planned to establish general and particular patterns of behavior of common faults originating in a GTE or its components. Deciphering the algorithm for the occurrence of key mechanisms, the

appearance of such malfunctions will make it possible to create special software that will find its practical application in industries where GTE are actively used.

The scientific novelty of the project lies in the use of innovative interdisciplinary approaches to the processing and analysis of vibration signals generated by a GTE, combining developments in the fields of vibration diagnostics, radio engineering and medicine, which will make it possible to create an integrated system for diagnosing and predicting the technical condition and improve the existing class of analytical equipment for development of new generation diagnostic systems. The implementation of the development will reduce material costs, due to a decrease in the likelihood of a complete or partial destruction of the GTE and the object on which it is installed (aircraft, stand, vessel, etc.), as well as additionally avoid human casualties, which will undoubtedly increase public and social significance of the project.

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## **COMPARATIVE ANALYSIS OF SOFTWARE TOOLS FOR AGILE PROJECT MANAGEMENT**

**Abstract:** *In order to achieve a competitive advantage on the market, companies must effectively manage projects, which includes the application of different methodologies, skills and knowledge during the planning, implementation and monitoring of projects. Also, the quality of the software product is largely determined by the management of the realization of that project. Therefore, the use of automated software tools is essential for successful project planning and management. There are many project management tools and software being developed every day to help managers automate the tracking of key parameters of projects throughout their life cycle. This paper describes in detail the features, advantages and disadvantages of the five most commonly used agile project management software, namely Jira, Trello, Asana, Basecamp and MS Project. These software are used in a large number of not only large corporations but also small and medium-sized enterprises. The main goal of the work is a comparative analysis of these software according to criteria such as the size of the organization, the size of the team, the type and scope of the project, for which a certain software is intended/suitable. Different projects require the use of different software tools. When choosing a tool, it is very important to consider the fact that the chosen tool corresponds to the requirements of the project. Each of these project management tools has its own unique features and strengths. It is important to evaluate each tool carefully and consider factors such as ease of use, feature set, and pricing before making a decision.*

**Keywords:** *project planning, management, project management tools, agile project management software*

### **1. Introduction**

Increasing project success rates is one of the biggest challenges facing modern organizations. The authors (Tawfik M. Samarah and Sulieman Al-Safi, 2020) conclude that agile project management tools have a positive impact on project success, but their effectiveness depends on how well

they are used by the project team. Due to the failure of the project, large amounts of financial resources can be lost. In order to meet project requirements, projects must be managed effectively. Modern projects are more and more complex, at the same time data monitoring is more and more complex. The use of software tools makes it much easier to see all important project parameters

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and enables better project management. Project management software tools are used for project planning, scheduling, resource allocation and change management, control costs and manage budgeting, quality management and documentation etc (Jones, C. 2004).

Agile project management software tools enable tracking and more efficient and effective project management throughout its life cycle by ensuring tracking of data that is critical to increasing project success. In a study by Toor and Ogunlana (2010), it was found that agile project management practices, including the use of agile project management tools, were associated with higher project success rates. The study found that the use of agile practices led to increased customer satisfaction, better team performance, and higher project quality.

The most significant advantages of agile project management software are: project planning (Multiple project views for planning and scheduling), team collaboration, document management, task management (Gantt charts, kanban boards or task lists to schedule and manage tasks), resource management, cost management etc. There is a large number of solutions on the market and each of them has some specific features. Some of the software is based on the traditional waterfall methodology, which involves planning all aspects of the project in advance, and some solutions are agile, i.e. adapted to the needs of the environment, i.e. user requirements (Bernardino, 2013). When choosing the appropriate software, it is necessary to take into account several factors - the complexity of the project, the size of the team, the type of project, its scope, etc. On the market there are available proprietary solutions, but also a large number of open source tools (Ferreira & Tereso, 2014). Choosing the right software tool for project management will increase productivity and effectiveness and direct the work of the team in the direction of improving project results.

It is important to evaluate each tool carefully and consider factors such as ease of use, feature set, and pricing before making a decision. Each of the software tools has its advantages and disadvantages. Agile tool selection process should consider the project size, complexity, and team characteristics to ensure that the selected agile project management tool is suitable for the specific needs of the project. So, for example Jira is the most comprehensive tool for managing big agile projects, while Asana and Trello are more suitable for small teams and startups. (Fadwa Ahmed and Ahmed M. AlEroud, 2019 ).

The paper provides a comparative overview of agile tools for project management. The motivation for writing the paper is found in the fact that a small number of research papers have been written that provide a comparative analysis of agile project management tools. The contribution of the research paper is reflected in the systematization of the basic characteristics, advantages and disadvantages of each tool in one place.

## 2. Literature review

Research paper evaluates five popular agile project management tools, including Trello, Jira, Asana, Microsoft Project, and Basecamp (A. Elshafei, M. Azab, and E. Hammad, 2019). The authors compare the features, capabilities, and limitations of each tool, and provide recommendations for selecting the best tool based on the needs of the team and project. The authors conclude that Trello and Asana are suitable for small teams, while Jira and Microsoft Project are more appropriate for larger teams with complex projects. Basecamp, according to the authors, is ideal for small projects with simple requirements. Paper (N. Qureshi, M. Iqbal, and A. Khalid, 2019) show survey of agile project management tools and techniques used in software development.

The authors analyze the popularity, features, and limitations of different tools, and discuss the benefits and challenges of using agile methodologies in project management. According to that paper, Jira is the most effective tool for managing agile projects, followed by Trello, Asana, and Basecamp. The authors also identified factors such as ease of use, customization, and integration with other tools as important considerations when selecting an agile project management tool. Paper (" S. Seetharaman and K. Ramanathan, 2018) proposes a framework for selecting agile project management tools based on the project characteristics, team characteristics, and tool features. The authors use a case study to demonstrate the effectiveness of the framework in selecting the appropriate tool for a specific project. The authors suggest that the tool selection process should consider factors such as project size, complexity, and scope, team size, experience, and location, and tool features such as project tracking, team collaboration, and reporting. Paper ( M. Iqbal and N. Qureshi, 2017) presents an empirical study of agile project management tools used in software development. The authors evaluate the effectiveness of different tools in supporting agile methodologies, and identify the factors that influence the selection and adoption of agile project management tools. The authors evaluated the effectiveness of different tools in supporting agile methodologies and identified the factors that influence the selection and adoption of agile project management tools. The study found that Jira is the most commonly used tool for managing agile projects, followed by Trello, Asana, and Basecamp. The authors also found that Jira is the most effective tool for managing agile projects, followed by Trello, Asana, and Basecamp. However, the authors noted that the effectiveness of each tool depends on the specific needs of the team and project. Also, the authors identified

several factors that influence the selection and adoption of agile project management tools, including ease of use, customization, integration with other tools, cost, and team preferences.

Similarly, in a study ( N. Nasser and N. Aldmour ,2016) authors showed comparative analysis of some popular agile project management tools, including Trello, Jira, Asana, Redmine, and Agilefant based on various criteria such as project tracking, team collaboration, reporting, customization, and pricing. The study found that Jira is the most comprehensive tool in terms of project tracking and reporting, while Trello and Asana are more suitable for small to medium-sized teams with less complex projects. Basecamp is ideal for small projects with simple requirements, while Agilefant is suitable for distributed teams with a high level of customization. A study by Patah and Carvalho (2016) found that agile project management tools, specifically Jira and Trello, were associated with improved communication and collaboration among team members. The study found that the use of these tools led to better team coordination, faster decision-making, and improved project visibility. Najafi and Mohammadi (2016) found that the use of agile project management tools, including Jira and Trello, led to higher project success rates. The study found that the use of these tools led to improved project planning, better team communication, and more effective project monitoring. In a study by Schuh et al. (2019), it was found that the use of agile project management tools, including Trello and Jira, led to improved project performance in terms of project duration, budget, and quality. The study found that the use of these tools improved team communication, reduced project risks, and increased project transparency.

### 3. Methodology

Software tools can be classified based on the size of the software, the difficulty of use and the scope of the projects for which it is intended. Based on these criteria, the software is divided into three categories: light, medium and heavy. Lightweight software is meant to be designed for short-term, temporary projects or teams and is easy to use. Their disadvantage is that they are not flexible, i.e. do not offer the possibility of adaptation to the needs of a specific company. Trello belongs to these softwares. Middleware is more complex and is used in more complex projects where a balance between ease of use and adaptability needs to be established. Examples of these software include Basecamp and Asana. Heavy software stands out because it is highly customizable and has a steep learning curve. They are used for very complex projects and when it is necessary to manage large teams. Representatives of these software are Jira and Ms Project. Jira is more intended for agile projects while MS Project is intended for both traditional or waterfall model projects and agile projects. The paper presents the following software tools for agile project management: Jira, Trello, MS Project, Basecamp, Asana.

Jira is a project management tool developed by Atlassian (see more on <https://www.atlassian.com/software/jira>).

Jira is one of the most popular project management tools and is a safe choice for organizations. Jira is used by agile teams to plan, track, and manage their work. It provides a range of features, such as sprint planning, backlog management, and progress tracking, that support agile workflows. It is used for agile software development, but can also be used for other types of project management. Jira allows teams to create and track issues or tasks, assign them to team members, and track their progress. It also allows for the creation of custom workflows

and issue types to fit the needs of a specific project. Jira has a range of features including a customizable dashboard, agile boards, reports and charts, time tracking, and integrations with other tools like GitHub, Bitbucket, and Confluence.

The biggest benefits are for large companies, which have to coordinate multiple complex projects and need to adjust the work flow. It allows teams to plan and track their work using agile methodologies such as Scrum and Kanban. Jira enables the planning of tasks that need to be performed, monitoring the execution of tasks, managing stakeholders and their requests, creating reports on the results that have been achieved, and managing the budget. This tool features outstanding adaptability and the ability to analyze huge amounts of data. It offers a wide range of features, including backlog management, sprint planning, issue tracking, and reporting. Jira Software also integrates with other Atlassian tools, such as Confluence and Bitbucket, to provide a complete software development solution. Jira is highly customizable, with a wide range of configuration options that allow you to tailor the tool to fit your specific needs. Jira offers a range of collaboration features, including comments, attachments, and mentions. This makes it easy for team members to communicate and share information, and to keep everyone on the same page. The most common disadvantages of this tool are its price, inability to manage costs and assess risks. Also, some plugins and integrations don't work well.

Trello is a simple and easy-to-use visual project management tool that is particularly useful for agile teams (see more at <https://trello.com/agile>). Jira can handle large and complex projects, making it a good fit for teams of all sizes. It enables teams to create boards, lists, and cards that represent their workflow, and to move items between these elements as they progress through their work. Trello boards are organized into lists,

and each list contains cards. Agile teams can use Trello boards to create a Kanban board that represents their workflow. This can help teams to visualize work in progress, identify bottlenecks, and optimize their workflow. This tool can be used to plan sprints by creating a new board for each sprint. Teams can then create cards for each task, prioritize the cards, and assign them to team members. Trello's drag-and-drop interface makes it easy to move cards between lists as work progresses. Trello can be used to manage a product backlog, which is a prioritized list of features or tasks that need to be completed. Agile teams can create a backlog board in Trello and use cards to represent features or tasks. They can then prioritize the cards and move them to the appropriate list when they are ready to be worked on. Trello provides a range of collaboration features that enable teams to communicate, share files, and work together on tasks. Trello has a range of power-ups that can be added to boards to extend their functionality. Agile teams can use power-ups like the Agile Tools power-up to add features like burndown charts, velocity tracking, and cumulative flow diagrams to their boards. Trello also offers a range of integrations with other tools, such as Slack and Google Drive.

Some of the basic functions that can be performed within the software tool Trello are: agile project management, budgeting, monitoring problems that arise during project implementation, reporting, resource management, etc. Trello is a highly flexible tool that can be adapted to fit a wide range of project management workflows and use cases. Trello allows team members to collaborate and communicate in real-time, making it easy to share updates, feedback, and ideas. Its commenting and tagging features make it easy to stay connected and on the same page. Its customizable boards, lists, and cards make it easy to create a system that works for your team. Its user-friendly interface and flexible design make it

easy to customize to fit a wide range of workflows and use cases.

Trello may have some limitations when it comes to certain project management requirements. One potential deficiency is that Trello may not provide robust reporting capabilities for tracking project progress or generating detailed reports. Additionally, Trello may not be the best choice for large-scale or complex projects, as it may not offer the same level of functionality as more advanced project management tools. It also may not be the best fit for teams that require extensive collaboration features or complex task dependencies.

Asana is a flexible project management tool that can be used for both traditional and agile projects (see more on <https://asana.com/agile>). Asana provides agile teams with a range of features, such as task tracking, project management, and team collaboration. It can be used to manage all aspects of agile projects, from planning to execution. Asana can be used for task tracking because Asana enables teams to create tasks, assign them to team members, and track progress on these tasks. This can be particularly useful for agile teams, as it enables them to break down work into small, manageable tasks and track progress on these tasks over time. Also, Asana can be used to manage a product backlog, which is a prioritized list of features or tasks that need to be completed. Agile teams typically use a backlog to prioritize work and ensure that the most valuable items are completed first. This software tool is used to plan sprints, which are short periods of time (typically one to four weeks) during which a team works to complete a set of tasks. Agile teams typically plan sprints based on their backlog, with the most important items being selected for each sprint. This tool provides a visual project management feature called Kanban boards, which can be used to visualize work in progress and optimize workflow. Agile teams often use Kanban boards to track

progress on tasks and identify bottlenecks in the workflow. Asana provides a range of collaboration features that enable teams to communicate, share files, and work together on tasks. Agile methodologies emphasize collaboration, so these features can be particularly useful for agile teams.

Asana provides extensive reporting capabilities, with built-in reports that show key metrics such as project progress, task completion rates, and team workload. Asana is highly customizable, with a range of features that allow you to tailor the tool to fit your specific needs. You can create custom fields, project templates, and automation rules to match your team's processes and requirements. Asana also offers a range of integrations with other tools, such as Google Drive and Slack. Asana also has certain disadvantages. While Asana offers many powerful features and customization options, some users may find it overwhelming or difficult to navigate. The sheer number of options and settings can be daunting for new users, and it may take some time to fully understand how to use the tool. Also, Asana price can be relatively high compared to some other project management tools, particularly for larger teams or organizations that require more advanced features. Asana does not include built-in time tracking functionality, which may be a drawback for teams that require this feature for accurate project management or billing.

Microsoft Project is a project management tool developed by Microsoft, which supports both traditional and agile project management methodologies. In Microsoft Project, agile project management can be implemented through the use of agile boards, which provide a visual representation of work in progress, and through the use of sprints, which are time-boxed iterations of work. Microsoft Project enables team members to collaborate in real-time, share ideas, and provide feedback on tasks. Team members can use Teams, Outlook, or

SharePoint to communicate and share files (Microsoft. Collaboration in Project for the web, <https://support.microsoft.com/en-us/office/collaboration-in-project-for-the-web-8d4b3644-4efc-444c-aeaa-9b78c2b1d3c3>).

Microsoft Project includes powerful scheduling features that allow to schedule and track tasks, assign resources, and manage timelines. This can be useful for managing agile sprints or iterations. Microsoft Project allows you to manage resources such as team members, equipment, and materials, which can be useful for agile teams that need to manage resource availability and allocation. Another feature of this tool is that it supports the creation and tracking of agile artifacts such as user stories, backlogs, and burndown charts. Agile project management is based on an iterative approach, with regular feedback and adaptation. While Microsoft Project can support this to some extent, it may not be as flexible as other agile project management tools.

Microsoft Project is not specifically designed for agile methodologies, and it lacks some of the features that are essential for agile teams, such as sprint planning, task prioritization, and backlog management. Microsoft Project can be complex and difficult to use, particularly for teams that are new to project management or agile methodologies. Agile project management emphasizes collaboration and communication between team members, and Microsoft Project may not offer the same level of real-time collaboration features as other agile project management tools. Microsoft Project relies on a fixed hierarchy of tasks, which can be challenging for agile teams that need to manage changing requirements and prioritize tasks dynamically.

Basecamp is a simple and straightforward agile project management tool that offers a range of features for task management, team collaboration, and reporting (see more on

<https://basecamp.com/>). It is suitable for smaller teams or simpler projects. Basecamp has a simple and intuitive interface that is easy to use, which can be helpful for agile teams that want to focus on their work rather than spending time learning a new tool. Basecamp offers a range of collaboration features, including message boards, to-do lists, file sharing, and real-time chat, which can help agile teams stay connected and communicate effectively. Basecamp includes time tracking features, which can help agile teams monitor their progress and track how much time is being spent on each task or project. As a disadvantage of this tool we can state that Basecamp has limited customization options, which may not be suitable for agile teams that need more flexibility and control over their workflows. Also, Basecamp has limited reporting capabilities compared to other agile project management tools, which may make it difficult to track and analyze project metrics.

#### 4. Results and discussion

Trello is ideal for small, agile teams. It is easy to use and offers excellent flexibility and customization options. However, it may not be the best choice for larger teams or complex projects. Asana can be used for a wide range of projects, while Jira is specifically designed for software development and agile project management. Asana has more collaboration features, such as team communication and file sharing, which can help team members work together more efficiently. Jira offers a wide range of features, including sprint planning, backlog management, and reporting. It is suitable for larger teams and complex projects, but it may have a steeper learning curve and be more expensive than other tools. Jira offers more options for customization and automation of workflow, which can be very useful for complex projects, while Asana offers a more straightforward approach to

workflow management

Asana provides a clear overview of the project, allowing team members to see what needs to be done, who is responsible for each task, and the project's overall progress (see more on "The Best Agile Project Management Tools of 2021," The Blueprint, <https://www.fool.com/the-blueprint/agile-project-management-tools/>). Asana offers more advanced workflow features, such as task dependencies, custom fields, and automation, which can be very useful for complex projects. Asana includes task management, collaboration, and reporting. However, it may not offer as many agile-specific features as other tools, and the reporting capabilities may be limited for some users. While Microsoft Project can be used to support agile project management, it may not offer as many agile-specific features as other tools. It may also be more complex and time-consuming to set up and use effectively, which may not be suitable for agile teams that need to be nimble and adaptable. Basecamp offers collaboration features, task management, and time tracking, but it may lack some of the advanced agile-specific features that are available in other tools.

Basecamp has a simpler and more user-friendly interface compared to Jira, which can be more complex and overwhelming, especially for beginners. Basecamp is designed to encourage team collaboration, with features like message boards, group chat, and file sharing. Trello has a more visual and intuitive interface, which makes it easy to use and understand, especially for beginners. Trello, on the other hand, offers a simpler approach to workflow management. Table 1. provides a comparative analysis of tools for agile project management.

**Table 1.** Comparative analysis of agile project management tools

	Kanban Board	Scrum	Gantt Chart	Time Tacking	Calendar View	Mobile Apps	Desktop Apps	API	Free Trial
Trello	Green	Red	Yellow	Yellow	Green	Green	Green	Green	Green
Basecamp	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green
Asana	Green	Yellow	Green	Yellow	Green	Green	Red	Green	Green
JIRA	Green	Green	Yellow	Yellow	Yellow	Green	Yellow	Green	Green
MS Project	Green	Green	Green	Yellow	Green	Yellow	Green	Green	Green

### 5. Conclusion

Different projects require the use of different tools. When choosing a tool, it is necessary to take into account the type of project, the complexity of the project, the size and choose the tool that corresponds to the requirements of that project. For example, maybe the team is used to using Jira, but for short and simple projects, Trello is a better choice. Jira offers a range of features, including user story mapping, sprint planning, backlog prioritization, and real-time reporting. Jira integrates well with other tools such as GitHub, Confluence, and Slack, making it a popular choice for Agile teams. Trello allows teams to organize tasks into boards, lists, and cards. It offers a range of

features, including team collaboration, task assignments, and due dates (The Digital Project Manager, "Trello vs Asana: The Best Project Management App?", <https://thedigitalprojectmanager.com/trello-vs-asana-best-project-management-app/>).

Trello has a more visual and intuitive interface, which makes it easy to use and understand, especially for beginners. Asana enables task management, team collaboration, and project tracking. It has a user-friendly interface and allows teams to track progress in real-time. Basecamp is suitable for smaller teams or simpler projects. It enables task management, team collaboration, and reporting. Trello has a more visual and intuitive interface, which makes it easy to use and understand, especially for beginners (Adams, P. B., Preston, D. S., & Tilley, S. R., 2014). Microsoft Project provides a robust set of features for project scheduling and tracking, including Gantt charts and resource management and integrates with other Microsoft tools such as Teams, Excel, and Power BI (TechRepublic, "Microsoft Project vs. Asana: Which is better for project management?", <https://www.techrepublic.com/article/microsoft-project-vs-asana-which-is-better-for-project-management/>).

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## BUSINESS INTELLIGENT SYSTEMS AND DISCOVERY OF KNOWLEDGE IN DATA

**Abstract:** *Knowledge discovery in data (DM -data mining) is a discipline that is growing extremely fast, currently representing one of the most important paradigms of advanced intelligence systems and decision support systems. In this paper, based on a systematic review of the relevant literature and research conducted in practice, an analysis will be presented and the advantages, opportunities and benefits will be presented on the one hand, as well as weaknesses, threats, challenges, obstacles and limitations that the projects of introduction and implementation of business intelligent systems and techniques and methods will present. the discovery of knowledge in data (DM -data mining) carries with it. The fundamental goal of the research is to determine the key factors for the final success of the data mining implementation project in business through case study analysis. The process of discovering knowledge in data consists of: understanding the field of study, understanding data, data preparation, modeling, evaluation of results, implementation in practice, commonly used methods and techniques of machine learning and basic information about specific software tools.*

**Keywords:** *business intelligence, intelligent systems, data mining*

### 1. Introduction

The term business intelligence has multiple meanings and describes both business information and business analysis within business processes. Business intelligence is essentially an area within information technologies, the goal of which is to put the total information potential of the company into the function of making the best business decisions, in order to achieve the established and planned strategic goals of the company. Since it is a complex field, it includes various types of technologies and approaches from the fields of information technology, management, statistics and mathematics.

Companies in today's business conditions receive huge amounts of data on a daily basis, both from internal and external sources, which presents them with a problem of how to process these large amounts of data and obtain information from them that will be useful for their business. The estimated amount of information in the world doubles almost every 20 months (Dwivedi, Kasliwal, & Soni, 2016, p. 1).

In this sense, one of the possibilities available to business systems is the application of modern information systems with elements of business intelligence, the functional application of which can have a significant and in many cases decisive impact on the improvement of business

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systems. Some authors point out that the process of introducing business intelligence should be seen as an organic cycle that develops over time (Olszak & Ziemba, 2012, p. 9). In order to confirm the initial hypotheses of this paper about the influence of business intelligent systems and knowledge discovery techniques in data on the operations of business systems, adequate systematic research of the relevant literature as well as research in practice was carried out, which unequivocally confirmed that the functional application of business intelligence systems and tools and techniques of business intelligence has a significant impact on the overall operation of business systems. Based on the review of the literature, it is evident that business intelligence comes to life in the full sense of the word only after several years of production and regular improvement of the original prototype.

In this direction, many business systems highlight the choice of technology when introducing business intelligence, at the same time neglecting the importance of organizational approaches, process changes and the introduction of good practices. Certain authors emphasize that for a successful business intelligence implementation project, an activity plan should be developed, including the start of the project, transformation and growth of business systems, that is, it is necessary to harmonize strategic goals with operational activities, establish basic indicators for determining the success of the introduction of business intelligence.

The process of implementing business intelligence into business systems is extremely complex and process oriented and requires the application of appropriate project management methodologies.

## **2. Business intelligence and intelligent systems**

Some authors emphasize that business intelligence is a common term that describes concepts and methods that improve business decisions or provide assistance in the decision-making process (Williams, 2016, p. 52). In this sense, the famous Greek businessman Aristotle Onassis once said: "The secret of business is to know something that no one else knows" [Lorange, 2001, page 32]. In the last decade, many business systems have invested heavily in IT operations. Despite these huge investments, a large number of business systems still have bulky data warehouses, but management is still faced with limited business information, which in principle would lead to a significant increase in productivity and profits (S.Williams and N.Williams, 2007, p. 20). Also, the same authors point out that business intelligence is, on the one hand, a way of business behavior, which enables business decisions to be made at all decision-making levels based on relevant and up-to-date business information, and not on intuition, premonition and subjective impression. Business intelligence is key to decision-making at all levels of management and leads to greater business efficiency, which represents a competitive advantage in challenging market conditions. In this sense, it can be found in the literature that business intelligence develops from increasing the productivity of employees in the first stages of development to the complete automation of decisions. Business intelligence is introduced into the work process to help people work and make decisions. Among other things, benefits from the introduction of business intelligence should be sought in quickly obtaining better quality information, better graphical visualization of results and therefore in faster and quality decision-making. In business practice, contextual graphic visualization is also used to show a

more efficient representation of decision options and the simultaneous possibility of updating decision options in real time directly in workshops with stakeholders. For example, with a contextual diagram, we visualize possible alternatives, and for each of the alternatives in the workshop, strengths, weaknesses and fears are expressed (Taylor, 2014, pp. 83-88). The decision-making process is thus more optimal, because it contains elements of creativity and, at the same time, due to visualization, it is also more useful, because with contextual diagrams we take all aspects of every decision that makes decisions, and therefore it is easier to cooperatively adopt an optimal balanced decision, taking into account all currently known aspects .

In the representative literature and business practice, among the various business opportunities that have already enabled the digitization of business, one of the possibilities stands out as intelligent sales, which, through the collection and processing of large amounts of data, calculates optimal service offers, optimizes the use of sales channels and, among other things, enables automation. and personalization of promotional activities and rewarding sales teams.

Well-known authors emphasize that from the IT point of view, business intelligence is a complex information system that collects data from various sources using automated procedures, processes them, transforms and integrates them, and provides users with access to quality information in an intuitive and easy-to-understand manner, and tools are connected to by detailed, thorough analysis of historical transaction data, stored in the DataWarehouse, or online server connected to the database [Williams, 2007].

According to eminent authors, the process of business intelligence is divided into several subfields (Klisarova-Belcheva, Ilieva and Yankova, 2017, p. 298; Williams, 2016, p. 28):

- ad hoc inquiry;
- indicators and control panels;
- e-mail alerts;
- data mining;
- inquiry and reporting;
- statistical analyses;
- multidimensional analysis.

The potential of business intelligence is being able to process large amounts of different data on a regular basis. Modern algorithms can process unstructured data, such as images and text, with the help of which you can read the mood of the party (Power, 2015, p. 2). In the future, business growth will be ensured by advanced algorithms of business intelligence, which will become a necessary tool for ensuring effective marketing, organizing work, motivating employees, partners and clients. Smart devices will become an increasing part of everyday activities.

In their research, some authors emphasize that the business value of business informatics should be sought in the ability to increase the efficiency of existing work processes (S.Williams & N.Williams, 2014, pp. 2-3). The quality of the established partnership between the information technology sector and the users greatly influences the readiness of the introduction. Poor cooperation resulted in poor planning, leading to significantly higher than planned project closure costs, mutual accusations and reduced engagement of key stakeholders (S. Williams and N. Williams, 2014, pp. 4-6).

The successful introduction of business intelligence is based on a consistent plan for the introduction and maintenance of business strategies and business processes, focusing on core business processes that create added value and alignment of business strategies with the strategy of developing business information, organizations and architectures (S. Williams and N. Williams 2014 , page 7). According to the same authors, when setting the tactics of introducing business intelligence, the decision-making culture

must also be taken into account and even the culture of using information and analytical applications (S. Williams and N. Williams, 2014, pp. 8-9).

One of the fundamental goals of applying business intelligence is to support the decision-making process based on relevant analytical data and thus alleviate the gap between current and desired performance on the company [Turban et al., 2011: 28]

The data readiness analysis should include confirming the complexity of the required information, the quality of the existing data and the convenience of alternative software solutions, taking into account the data and applications of state-owned technology companies (Cordoba, 2016, pp. 1-3).

Research indicates that the main drivers of the introduction of business intelligent systems can often be internal, but also external in nature. Previous research provides an overview of modern business intelligent systems, their evolution and increasing impact on business processes in organizations, as well as analysis through managerial aspects related to implementation based on already available information and interview results in the case of a company generated by a set of guidelines and recommendations for the implementation process business intelligence.

Well-known authors point out that a business intelligence system includes business models, data models, data sources, ETL (Extract, Transform and Load) tools for transforming and organizing data into useful information, data storage, OLAP (Online Analytical Processing) analyzes and reporting tools [Volitich, 2008]. A new approach called data mining appears as one of the recognized terms for the business data processing process (Dwivedi et al., 2016, p. 1).

### **3. Discovering knowledge in data (DM - data mining)**

Data mining is the most important product from the family of Business Intelligence products, the purpose of which is to find hidden patterns in data, increase their usability and transform that data into useful knowledge (Denić N. 2022). Data mining, an interdisciplinary subfield (Paiano & Pasanisi, 2017, p. 66), is a rapidly growing discipline, one of the most important current paradigms of advanced intelligence and decision support systems. There are several definitions of Data Mining. One of them is that, in principle, it is a data search technique in order to identify the required patterns and their mutual relations. Simply put, DM is the process of extracting interesting, new and potentially useful information or samples, contained in large databases, all with the aim of making correct business decisions. It can be defined as the discovery of useful information and knowledge from databases (Verma & Nashine, 2012, p. 604). If they recognize the benefits of using data mining and different data sources, they are likely to be more motivated to invest resources in data analytics in the future (Coleman Shirley, 2016, pp. 850-851).

The process of discovering knowledge in data-Data mining requires intelligent technology, adequate knowledge of the approach and the desire to discover potentially hidden knowledge from the mass of structured and/or unstructured data (Amani & Fadlalla, 2017, p. 2; Farooqi & Raza, 2012, p. 1). In this sense, some authors emphasize that the main purpose of data analytics is the application of advanced analytical techniques to large and diverse data sets (Dwivedi et al., 2016, p. 1). It is very important to note that it is only an approach that does not eliminate the need for knowledge of the business, data and analytical methods behind the tool (Amani &

Fadlalla, 2017, p. 2).

Because of the above condition, discovering interesting, useful patterns in uncertain data is more difficult and the potential benefit is commensurate with it (Leung, MacKinnon, & Jiang, 2017, p. 22). By this we mean return on investment (ROI) or a similar indicator that will be able to measure the benefits of implementation). Data mining is most effective in business systems that can link transactions to specific customers. Discovering knowledge in data offers challenges and opportunities in many fields, including economics, astronomy, chemistry, engineering, climate studies, geology, ecology, physics, biology, health, and computer science (Rawat & Rajamani, 2010, p. 1).

The described measures contribute to higher profitability, because the business system has more good customers in the long term, which is reflected in a better business result. 10 to 20% of customers make 50 to 80% of the profit of the business system and with the help of data mining it is possible to identify the relevant ones in the database of all persons. Business systems that have been operating in the market for several years are faced with a decline in the growth rate, and at the same time they have at their disposal a history of transactions or a huge amount of unused potential (Farooqi & Raza, 2012, p. 2; Gupta & Gupta, 2012, p. 5)

#### **4. Application of knowledge discovery in data in practice**

The use of data mining in practice is not so widespread or the probability of its introduction is lower due to its complexity. (Denić N. 2018). If we exclude the world's largest business systems today, many companies still do not use Data Mining methods to support the decision-making process. The reason is the complexity of these processes, which require many

interested parties with different knowledge and perspectives from different perspectives. According to a 2003 survey by the Cutter Corporation, an IT consulting corporation in the USA, only 15% of companies believe that the use of DM methods contributed to the improvement of their business. Research in practice has confirmed that the key factor is the sponsor of the project, i.e. the person who, with his status in the business system, contributes to the realization of tasks, regardless of the obstacles that appear on the way.

Data mining has found a wide application in the field of business systems in all areas, economics, mechanics, medicine, genetics, traffic, criminology, etc. Data mining can be applied in all those areas where large amounts of data are available, the analysis of which is intended to reveal certain rules, laws and connections. A prerequisite for the realization of the set goals is the right data, collected in an appropriate way. Some authors emphasize that the business system must evaluate the quality, content, availability and quantity of available data (Saarevirta, 1998, p. 5). Data mining may stop at this point for one or more of the reasons listed above. The results of research in practice indicate that new business systems usually do not have a large amount of data available about their clients. One of the largest British agencies for Direct Marketing, Rapp Collins, states that when analyzing databases through DM, only 18% of information from existing databases is used on average.

In terms of applying the technique of knowledge discovery in data, some authors point out that probably the most recognizable is the marker-basket analysis, whose main purpose is for the seller to obtain information about shopping behavior or what things people often buy together (Kaur & Kang, 2016, p. 78). This is compounded by the notion that the discovered relationships bring potential

value to other data mining techniques (Aggarwal, 2014, p. 130), because we already know the relationships between objects in advance. Using association analysis, we can predict a combination of many attributes, which gives freedom compared to prediction, where predictions are limited to a predetermined number of classes (Witten, Hall, & Frank, 2011, p. 72).

The literature emphasizes that the business data of a company is usually private, intended for use only within the organization (Coleman Shirley, 2016, p. 854). In this sense, data confidentiality is defined as data secrecy, which hides a set of attribute values from an unauthorized user. We consider the data of identified persons as personal data. Behavioral data refers to people's behavior in certain circumstances. Data mining includes both personal data and behavioral data. A person who consents to the use of his personal data by business systems must be aware of the purpose of use, confidentiality and integrity protection measures, consequences of non-compliance with agreed frameworks and other rights arising from this relationship (Witten et al., 2011, p.34). In the process of discovering knowledge in data, the quality of business data and information is very important (Denić N. 2016). In the relevant literature, it can be found that the quality of business data means the level to which the data meet the criteria of purity, completeness and sufficiency (Bole et al., 2015, p. 3). Practice shows that business system data is usually collected for immediate needs. In this sense, it is emphasized that satisfactory quality for current activities is not a guarantee that the quality is at a sufficient level for other purposes (Coleman Shirley, 2016, p. 856). Choosing the right data source is essential to the entire project of discovering knowledge in data. Incorrect records, irrelevant or conflicting fields, and outdated data need to be corrected (Verma & Nashine, 2012, p. 607). We also do not want imbalances or

missing values (Cao, 2017, pp. 64-65). Missing categorical values can be replaced by the most common value, and missing numerical values by the inverse value. Discretization is used to convert numerical values into categorical values (Goncalves, Barros, & Vieira, 2012, p. 3). With the mentioned operation, we reduce the number of values of a certain attribute by grouping them into interval values. With the help of normalization, we reduce the differences between data from different sources and enable their comparison (Sullivan, 2012, pp. 200-227).

## 5. Discussion

Although data mining is used in many business activities, research results indicate that it is not suitable for every business model. Then comes the question of where it pays to use. Those activities in which the work with the customer is exclusively electronic and the purchase potentially happens several times are very suitable. As an example of such a business model, I cite an online sports nutrition store. In this case, the human factor in the purchase process itself, which is difficult to include in the model, is minimal or zero. It's also fairly easy to measure user behavior online. In activities where a product or service is sold to a customer only once, the use of data mining does not make the most sense. The time of the company's existence on the market, the level of development and above all the quantity and quality of available data are important. An organization that is only in its first year of operation probably does not have enough data. We can conclude that the volume increases with age, but the quality of the data is questionable. Some customers were already suitable for a novelty such as the introduction of data mining in their business ecosystem at a given moment, some will be in the future. A huge amount of data was available for analysis, so for easier



understanding, a relational model was created that well identified potential problems in data integration and preparation. The understanding of the data is facilitated, among other things, thanks to the precisely given meta-description of the variables.

## 6. Conclusion

Business systems generate huge amounts of data every day that are difficult to analyze. Approaches that have yielded results in the past are no longer sufficient. The research results indicate that business intelligent systems are developed and designed to, among other things, support and facilitate the decision-making process in business systems and companies, which must be able to respond quickly and efficiently to the changing requirements of the business environment. The results of studious research indicate that the biggest contribution to the efficiency of the company is a quick insight into a large amount of data and shortening the time of accessing information. A thorough analysis of reports from business intelligent systems provides the possibility of developing a pattern, improving the company's operations with the possibility of timely influencing and intervening on the business processes of business systems and improving the overall operation. Discovering knowledge in data - Data mining is one of the possible answers to the growing analytical needs. When discovering knowledge in data, there are many opportunities, challenges, limitations and, above all, potential great benefits, which, with adequate effort, are also reflected in the financial sense. Therefore, it is very important that key users in business systems become familiar with the concept and methods of tools and techniques for discovering knowledge in data, because the amount of available data and information will surely increase in the future, and it is evident that it will not become clearer and

easier to understand and make decisions. The key success factors of the data mining implementation project can be identified through case analysis, namely: appropriate approach or selected data mining methodology, clearly defined and measurable goals, developed project plan with deadlines for the completion of each phase, composition of the project group with different knowledge, project sponsor with influence in the company, sufficient quantity and satisfactory quality of available data, provide meta description or meaningful interpretation of data, appropriate knowledge and tools for data preparation and modeling, realistic evaluation and presentation of obtained results. Research in practice shows that, on the other hand, you should not have unrealistic expectations. Data Mining cannot solve all the problems that business systems and their managers are trying to solve. In this sense, it is important to emphasize that DM only determines patterns in the data, new knowledge, which will help managers in the decision-making process, after they determine the problems they want to solve or the opportunities they want to use. On the basis of the above, the obvious conclusion is that Data Mining techniques, methods and tools are not and cannot be a substitute for effective management bodies of business systems. The research results of this work confirm the possibilities of using data mining in business systems, as well as the fact that the acquired knowledge can be applied to similar cases in all business systems in the country and abroad. Due to the combination of the maturity of machine learning algorithms, sufficient capacity and affordability of computers and software, and affordable cloud services, artificial intelligence, including data mining, is expected to be the driving force behind business decisions in the future. In the next few years, it is impossible to imagine a business system that will not use the potential of the data collected so far.

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## IT PROJECT PLANNING PROCESS PARADIGMS

**Abstract:** *By implementing modern IS, companies today implement the best practices in their business processes and provide key users with easy access to business information that they use in the business decision-making process. Previous studies of the IT project planning process in practice indicate that the introduction of these sophisticated systems is not an easy task and in most cases 70% fail and represent a difficulty in business systems that try to implement them. In this direction, this research paper aims to find out whether companies and business systems that plan ERP (ERP-Enterprise Resource Planning) implementation in advance and whether such practice brings a positive contribution to the success of the implementation process. The results of previous research show that companies in the area today implement general practices in project planning, although they do not consider the planning process to be a separate phase in ERP implementation. However, they do not use some commonly known methods, techniques and tools for project planning. It is assumed that this is due to the lack of specific competencies, expertise and skills in the project management process. The research results indicate that experiences based on case studies, project scope and basic plan are mostly applied, while knowledge and risk management skills are applied the least.*

**Keywords:** *project planning, IT projects, ERP systems*

### 1. Introduction

Project management is essentially a rather complex and complex process. In this sense, many organizations decide to purchase software tools for project management purposes, but often without a detailed consideration of their specific needs and requirements. (Crawford, 2011). In this paper, based on relevant literature and experience in practice, an overview of some of the techniques, methods and tools that project managers usually use in project management. The results of the research indicate that project management is a really

complex job and an important matter, in this sense it is necessary to understand the reason and motivation for the application of methods, techniques and tools that can facilitate and speed up some of the stages in the project management process. One of the most widely used definitions is the one by the Project Management Institute (hereinafter: PMI) (2000, p. 4), which gives an idea of what distinguishes a project from other business models of a company. In this regard, PMI defines a project as "a temporary undertaking undertaken to create a unique product or service". Certain authors such as Weaver (2007, p. 16) emphasize that

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project design and management have existed since people began planning to achieve certain goals with limited resources. A closer definition according to PMI (2000, p. 6), is that "Project management is the application of knowledge, skills, tools and techniques to project activities in accordance with project requirements". Based on the above, it can be concluded that project management represents a set of tools and skills that help predict and control the results of efforts undertaken in the organization. In order to successfully manage projects, it is very important that they are completed on time, that they remain within the budget limits, and that the clients are satisfied with the results. The well-known author Schwalbe (2010, p. 63) in his research points out another specific feature of IT projects related to the project life cycle. Also, Schwalbe (2012, p. 8) states the three main limitations of any project, namely: scope, time and budget. In the professional literature of project management, these constraints are commonly called the triple constraint.

It is obvious that three key limitations lead to the success of an IT project: time, scope and costs, i.e. budget, however, in addition to these fundamental limitations, other types also appear in practice. In this sense, Schwalbe (2010) points out that good project management contains more than just taking into account the triple boundary as shown in Figure 1. The life cycle of an IT project can cover or contain several different models (life cycles) of software development (a single component or part software can be developed separately from the whole and with a different methodology), which again differs from specific project to project

There are significant differences between standard types of projects and IT projects, and that it is necessary to apply in these projects some specific techniques and methodologies that are suitable for the particularities of these projects. In this research, the emphasis is on the IT project

management process. This process involves the application of various skills, tools and techniques. By applying these skills, project teams can successfully manage all phases of a project: project initiation, project planning, project execution, and project closure. Managing these phases of an IT project can become even more challenging due to the continuous improvements that technology brings.

## **2. Theoretical background of IT project planning**

IT project management is essential because it should help business systems in their operations, to deal with these issues and overcome difficulties. In this sense, project planning is recognized as one of the most important phases of the project life cycle. The results of the review of the relevant literature indicate that also in the field of information technology, the project way of working is increasingly used and often work is done on complex projects, where, without the use of various methods, techniques and tools that help in risk management, their execution would not be possible.

Some authors in this sense emphasize that careful planning, according to Little (2011, p. 36), is one of the principles that must be followed in order to successfully implement the project. Other authors state that many IT projects fail before they are completed, due to insufficient planning (Phillips, 2011). Thus, in his research, Patrick Meehan, vice president and director of research at Gartner, a research and consulting company in the field of information technologies, points out that from 70% to 80% of failed projects are business intelligence [Meehan, 2011]. Good planning is, in fact, half the way to success. According to Marchewka (2002, p. 13), the project plan should provide answers to certain specific questions that more closely define all the frameworks of IT projects: resources, time frame, work method, job

description, cost price, answers to potential risks, etc. This is followed by authors who point out that the project planning process predetermines the work to be done in order to achieve the project's goal (Haugan, 2002, p. 3). It provides team members with detailed, precise instructions to follow throughout the rest of the project's life cycle and the tools to exercise control. This makes other activities in project management far more efficient and better.

Table 1, according to the well-known authors Brewer and Dittman (2013), presents the observed most significant differences recorded between construction and IT projects

**Table.1.** Comparing the differences between construction and IT projects (Source: J. L. Brewer & K. C. Dittman, *Methods of IT project management*, 2013, p. 1).

Category	Construction projects	IT projects
Change requests	Slow, gradual	Very fast, unplanned
Source of change	Known, predictable	Often unknown
Requests	A clear plan	Often ambiguous
Uniqueness	Often repeated	Rarely recur
Resources	Constant	Hesitating
Use	Structured, under control	Often chaotic
Examination	Defined, measurable	Difficult to verify all options

The results in Table 1 clearly indicate significant differences in these types of projects and that it is necessary to apply a special methodology to IT projects. Certain authors such as Aladwani (2002, p. 223), point out that planning plays a major role in achieving success in IT projects. IT project planning requires an adequate methodology, including various practices, as well as tools

and techniques that facilitate the introduction of such practices, for this purpose some of the most popular are the Gantt diagram, the network diagram and the critical path method (Schwalbe, 2010, p. 12).

### 3. Characteristics of the process of introducing IT projects

Each area of project management has some specific characteristics, and thus differences that distinguish it from other projects, this also applies to IT project management. Many IT projects fail precisely because they fail to deliver an acceptable product on time and within budget. IT project management deals with the management of the application of new modern technologies, and at the same time it includes methods and techniques for leading and motivating project team members. One of the main problems of IT projects lies in predictability itself, that is, there will be unpredictability. The results indicate that this primarily relates to scope and quality, as these projects are difficult to identify at the outset and often change during the project. It is important to note that its goal is not the technology itself, but the achievement of specific business goals, such as improved customer service or increased profitability.

The one who leads the project must take care of the balance of the team, human resources and the technology itself, and that it is precisely this that conditions the increase in productivity and the creation of profits of the business system. In the relevant literature, so-called project information systems are mentioned as a tool for the aforementioned needs. This type of system is characterized by several definitions, one of them is the PMBOK definition (PMI, 2008, p. 443) which points out that a project information system is defined as an information system that consists of tools and techniques for collecting, integrating, combining, searching and disseminating information and

documents that are generated within the project management process. In addition to the known functionalities, Portny (2010, p. 241) adds the analysis of collection and reporting and the storage of information. Building on previous views, some authors (Caniëls in Bakens, 2011; Karim, 2011) emphasize the use of an information system that supports decision-making at all levels of the organization, especially in planning, organizing and project control in independent complex projects as well as in a multi-project environment. Moszkiewicz and Rostek (2011) list other important characteristics of a project information system, especially related to data management, such as knowledge retention, standardized data record, data confidentiality (data access management), data integrity (relevance, completeness, accuracy, timeliness of data), availability of data (data available on request), easier data search, ensuring data durability (storage). Certain authors, such as Raymond and Bergeron (2008), point out that the information system project would contribute to the effectiveness of the project to a certain extent, which, in their opinion, states that the planning, monitoring and control of the project should be improved, as well as the timely making of business decisions and better control over the use of resources.

One of the characteristics of IT projects is that it is difficult to obtain the requirements and wishes of the users, and even more difficult or almost impossible, that the requirements do not change for a long period of time. In addition, such planning is often used in such projects, when a milestone represents the completion of an individual phase of the project's life cycle. All this leads to the conclusion that the IT field is very broad and includes various types of IT projects. Cadle and Yeates (2008, p. 3) group them into nine broad categories: software development, package implementation, system improvement,

sonsalting and business analysis tasks, system migration, infrastructure implementation outsourcing (and insourcing), damage remediation and minor IS projects.

In the relevant literature, certain factors are mentioned for the selection of project management tools. For example, Brandon (2006, p. 344) mentions the following typical elements in selecting the appropriate software package: required performance and functionality, complexity and number of projects, size and complexity of the organization, methods and techniques used, limitations on the platform, locations and types of users and budget constraints. Certain authors such as Young (2007, p. 265) emphasize that even expert and extensive knowledge of the project management process and access to appropriate software tools still do not guarantee a carefree and smooth project flow (if it exists at all). Similarly, Brandon (2006, p. 344), who mentions that modern IT projects are the most suitable web tools, since they use wide relational databases, are very flexible and have a modern graphical user interface.

Many of the selected project management software tools could also be called software packages or even information systems, which is not wrong from a certain point of view because they offer a very wide range of functionality. The results of research in practice say that no tool is perfect, but that it is important to take into account that the decision to choose depends primarily on the nature of the company, needs, types of projects, current processes and tools, and last but not least, the culture and company policy (McCormick, 2012). The tools, techniques and knowledge areas as described in The Guide to the Project Management Body of Knowledge (hereafter: PMBOK) published by PMI have become a widely practiced standard in many branches of business worldwide (Hewagamage and Hewagamage,



2011 , p. 91). The implementation of this standardized practice or the development of an internal methodology is, according to Weaver (2007, p. 6), a key instrument for the successful completion of projects, programs and portfolios. Below are some of the most commonly used project management tools. One of the most famous is certainly the Microsoft Project software tool, which can without a doubt be considered one of the most widely used tools and as much as statistics show that it is the most widely used software tool in this field. In addition to the above, a software tool for project management support - Zoho Projects - is often used in practice. This software tool is used in a wide range of areas, especially in small and medium-sized organizations, for personal use, or even in departments of larger organizations. The following project management software called Celoxis is developed by Celoxis Technologies and has received a lot of attention for its product. It is one of the software tools available in both desktop and web version. Software support for all key areas: planning and monitoring, resource and cost management, error tracking system, portfolio project management, reporting, etc. ProjectManager.com, which is a relatively new player on the market and was developed by Online Manager, is also widely used in practice. The software tool is available only as a cloud-to-cloud service and is intended for individuals or project teams in primarily small, medium and even large enterprises. Also another tool that ranks quite well is OpenProject which has a number of useful features and functionalities, which are welcome in the IT project management process, such as a bug tracking system, document management, reporting and project progress monitoring.

#### 4. Characteristics of the process

Most of the analyzes of unsuccessful introduction of IT projects, which are carried out after their completion, point to the causes and problems that arose during the life cycle of the project, which could have been avoided if they had been identified at an early stage of the project, i.e. if the high-risk elements had been addressed then. .( Denić N, 2020) Some authors sorted and presented the differences between certain types of projects depending on certain categories. In Canada, in 1997, a study was conducted that focused on the problems that arise in the management of IT projects. This survey covered 1,450 organizations from the public and private sectors (Whittacker, 1999, p. 23). Research has shown that the three most common causes of IT project collapse are:

- poor project planning, i.e. poorly prepared project plan and inadequate risk management project,
- bad business example,
- lack of participation and support of the company's top management when establishing the project.

IT projects are proven to be the most difficult projects to implement, the success of which depends on many factors. (Denić N, 2020) Their complexity requires a very high degree of expertise, they contain a large number of interconnected and dependent activities in which a large number of people from different fields with different approaches, motivations and experience participate. The results of the research carried out in 1995 by the Standish Group under the name "CHAOS" in which it was stated that only 16.2% of IT projects were successfully completed. The survey also found that 31% of IT projects were abandoned before completion, costing US companies and government agencies more than \$81 billion. This is followed by later research by the consulting firm McKinsey

from 2012, in which it was found that large IT projects in 45% of cases are not realized within the planned budget, and in 7% of cases they are not realized on time (McKinsey&Company, 2012). Gartner research predicts that by 2025, all industries will be transformed into new digital approaches (Cearley, Burke, & Walker, 2016, p. 2). In order for the IT project to be successfully implemented, it is necessary to adapt the project management, so that it reflects the current business environment. It is also necessary that there are processes and tools adapted to take into account the characteristics of the information technology environment.

Below are the results of the research where some of the most commonly used software packages for project management were investigated and evolved in detail: Microsoft Office Project 2013, Zoho Projects, Celoxis "project2manage" and OpenProject. The results of the research show that the application of the Microsoft Office Project program package in planning, organizing and implementing the information system greatly facilitates the work of the key users who perform these tasks, and above all the immediate implementers, that is, company managers. Namely, this software package can be used to plan needs, as well as keep complete records of cars, customers, transactions, and therefore also of the potential engagement of personnel and equipment, required purchases, time of engagement, cost prices, preparation of reports with various indicators, etc. In addition, the results show that the software application "project2manage" for project management can be very useful, because it facilitates the tasks related to project management, which are listed at the beginning of the paper. But of course it is not a done deal and "project2manage" will not be able to be a substitute for a real engineer and manager at all times. The following table 3 shows the results of the

comparison of the analyzed software tools for project management.

When it comes to the success of IT projects, the authors often mention the so-called Chaos Report, conducted by The Standish Group. The first such survey was conducted in 1995, and the results were surprising, as only 16.2 percent of projects were completed on time, within budget, and within budget. 52.7 percent were only partially successful, meaning that at least one of the above-mentioned limits was exceeded. 31.1 percent of projects were unsuccessful or terminated too late. In the following years, a number of such studies were carried out, where there was a slight trend of increasing successful projects. According to the Standish Group, the latest data for 2012, the article states, 37% of IT projects are successful, 42% are partially successful, and 21% are unsuccessful. Based on the results of this research, the main recommendation would be that although every project planning process is important for the success of the project, as stated in the literature, it is necessary to put more effort into the development of the business case and the basic plan.

## **5. Conclusion**

IT project management is one of the specific areas of project management. The implementation of IT projects today represents a great challenge, primarily due to the increased needs and demands of IT applications and the growing complexity of the development and integration of IT systems with business processes. The test results indicate that virtually no software tool is designed solely to support IT projects, and therefore there are some software tools that offer additional functionality that can provide more efficient project management and project work. There is rapid and continuous development of hardware, software and ICT infrastructure. Also, the

results of the relevant literature research and on the basis of implemented projects in practice, it is evident that a small number of IT projects were completed in the agreed time. Based on the previous research, the conclusion is that IT project management is generally different from any other area of project management. In this research work, based on a comprehensive survey, it was proven that IT projects have their own specifics from company to company, as well as that specific project management activities should be adapted for each type of business, according to the specifics of business processes, for which an analysis of new concepts and management methodology is necessary. projects and determining which one is most suitable for each activity and specific company. The research results of this paper indicate that inadequate project planning, insufficiently prepared project plan and poor risk management project lead to the failure of IT projects. Also in this paper it is shown that no project methodology by itself guarantees the successful completion of the project, but is only a tool that makes the work of project teams, led by the project manager, easier and increases the possibility and probability of success.

It is important to emphasize once again that IT projects often fail, due to non-fulfillment of the agreed time limit and breaking through the budget, and in this sense, the application of software for control, monitoring and cost management of IT projects is needed. jeron provides significant positive results in the business of the company. The research results indicate that it is best and necessary to learn from past mistakes and to improve project management techniques, so as not to endanger the company or organization due to unforeseen costs caused by the failure of IT projects. IT project management is of great importance for the company and it is always possible to further examine and analyze it, because it can still be observed and analyzed

from different perspectives. Each novelty for this is a step forward, a step that can contribute to a better understanding and clearer definition of individual factors that influence the success of an IT project, and thus indirectly increase the probability of success in the implementation of IT solutions or draw attention to aspects that lead to the failure of such projects A better organization of project management in the implementation of strategic projects in IT can improve efficiency and ensure the successful completion of projects. A prerequisite for successful projects is a close connection between strategic business planning and strategic information technology planning. In addition to project management in all phases of IT project management, it is very important that the project manager has knowledge in the field of human resources. IT project management represents the future, which is also the reason why an increasing number of companies are project-oriented when it comes to activities related to modern technologies. The conclusion is that the choice of the right software tool for project management is sensitive and systematic, as well as that in every case, before making a final decision on the choice, the software tool must be tested. MS Project has proven to be one of the tools without which no serious IT project can be managed today. The program itself covers all the options required for successful project management. The results of the study show that SMEs implement general practices in project planning, although they do not consider the planning process to be a separate phase in the implementation of IT projects. However, they do not use any special project planning tools, such as a Gantt chart or WBS. It is assumed that this is due to a lack of project management skills within the surveyed companies. From the project planning practices that have been observed, the most practiced are those involved in the

development of the business case, the scope of the project and the basic plan. Practices for risk planning were practiced the least, which is in accordance with the results of the relevant literature research.

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## SOFTWARE IMPLEMENTATION OF IC TOPOLOGY TRANSFORMATIONS FOR PROTECTION AGAINST HARDWARE TROJANS

**Abstract:** *This article focuses on software methods for detecting and preventing the introduction of hardware trojans into the topology of integrated circuits at the design stage. An additional recommendation for typical procedures of receiving GDSII files that significantly complicates the introduction of HTs into the topology is to facilitate detection methods by including special self-test structures created after performing transformations of the initial topology and ensuring the effective examination of ICs at the post-manufacture test stage. The proposed method is based on the analysis of synthesis results at the level of netlist description, its subsequent software conversion into a topological drawing, shifting standard cells and filling created voids with special self-test cells. The method is simple to implement during the topology design stage and can be recommended for use in design centres for machine learning of computer-aided design systems.*

**Keywords:** *Hardware Trojans; Topology Transformation; Built-In Self-Authentication Scheme*

### 1. Introduction

Intentional and malicious modifications of integrated circuits designed to change the behaviour of a circuit and achieve a certain goal are called hardware trojans (HTs) (Bhunja & Tehranipoor, 2018; Kuznetsov & Saurov, 2016a). Trojan attacks can be carried out by changing a technology (for example, by replacing the doping type), introducing analog and digital components (for example, by switching on an external chain when charging a parasitic capacitor or adding functions of a finite-state machine that are actuated from unused conditions). The article (Chaduvula et al., 2018) discusses different security techniques in the field of digital technologies, such as

encryption and shared use of know-how, as well as in areas related to design and manufacture, such as physically unclonable functions (PUFs) and watermarks attached to a physical part to protect it against counterfeiting and unauthorised access. It is proposed to classify these methods depending on their effectiveness for various competition models at different stages of product development. This classification can help developers make reasoned decisions on security practices during product development.

One of the first methods of synthesising reliable microchips using unreliable CAD tools is proposed in the work (Knechtel et al., 2020). This approach allows us to use CAD tools for complex synthesis tasks and

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very simple reliable tools that can be used by designers to verify results and change specifications. The main idea is to limit the design tools used so that an unreliable tool has no room to add any malicious changes to the design.

Short-term and medium-term possibilities for integrating design methods based on the safety of EDA tools are presented in the work (Potkonjak, 2010). The article considers conceptual problems for the safe organisation of countermeasures against different threat vectors and security indicators.

Since there are different types and size of hardware trojans, a combination of protection methods is required to ensure an acceptable level of security, both in design at different levels of abstraction and in IC testing after manufacture. In the latter case, verification will require a combination of operation logic verification and side channel analysis to cover trojans of different types and sizes with large variations in parameters. The main development problems in this area include: mechanisms for detecting analog trojans that can carry out numerous types of activation and observation conditions, as well as a comprehensive metrics for quantifying the level of confidence that combines the analysis of design and testing methods.

In recent years, trends have included more advanced functions, such as temperature activation, radio channel and power activation, optical side channel reading, accelerated chip aging, and denial of service (DoS). According to the currently established classification (Chakraborty et al., 2009; Pevtsov et al., 2019), it is customary to distinguish hardware trojans by introduction phases, abstraction levels, activation methods, effects and locations. This classification implies that each of the above categories contains several attributes and is based on the fact that a classification should cover all trojans and should describe all

methods of how they cause harm.

The classification by introduction method describes the stages of the design route where a project is vulnerable to malicious modifications.

The classification by abstraction level describes the different stages of IC development, including IC introduction before their manufacture. This level covers both the design of topology (i.e. at the physical level) and the determination of a netlist and communication protocols used in an IC (i.e. at the system level).

The activation method describes the means by which an undeclared function is activated. This includes permanently active backdoors, as well as trojans that require certain triggers to be activated, such as internal sequential counters or external triggers from input data flows.

The category of harmful effects describes the undesirable result of a malicious change, which can manifest itself as a change in functions or even a complete failure of a microchip.

The location category describes where a change in the initial design can be physically implemented within a microchip or equipment. In this case, the target of an attack may be either one component, for example, a system clock with introduced timing errors, or several complex components, for example, processors for changing the order of command execution.

A new classification is also proposed, based on the location of IC protection means (the chip itself or its packaging) and the type of protection: protection against unauthorised access or authentication (Fievrea et al., 2015). It is concluded that security methods should be aimed at meeting the requirements of new technologies, such as 3-D systems-on-chip and wearable devices. It is noted that it is promising to use new optical means, such as arrays of nanowires or a method where technical defects are used to create



“fingerprints” as information encoded in the form of electromagnetic radiation from a working circuit.

## 2. Previous work

Since all modern VLIC developments are carried out with a certain degree of participation of other companies, a prerequisite for ensuring the reliable operation of these products is to develop and perform special organisational and technical activities to analyse, identify and eliminate possible design distortions in the form of software and/or hard-ware backdoors directly during the design or manufacture stages.

The website <https://www.trust-hub.org> regularly updates a collection of hardware trojan tests that have been developed and updated by researchers in the hardware security and trusted design community.

The works regarding IC countermeasures consider the issues of both detecting (Huang & Wang, 2020; Khairallah et al., 2018; Kuznetsov Saurov, 2016b; Kuznetsov Saurov, 2017a; Moein et al., 2017; Yuan et al., 2021) and preventing hardware backdoors to protect ICs (Chakraborty & Bhunia, 2009; Herder et al., 2014; Kulkarni et al., 2016; Kuznetsov & Saurov, 2017b; Shekarian et al., 2013).

The authors of the publication (Moein et al., 2017) note that hardware trojans have a number of properties that can be used to systematically develop detection methods. Based on this concept, they present a detailed overview of modern methods for detecting trojans and the characteristics of existing hardware trojans, and also propose a new approach to identifying and classifying hardware trojans. This identification can be used to compare the risk or seriousness of trojan programmes with the effectiveness of trojan detection. Identification vectors are generated for each hardware trojan and

trojan detection method based on corresponding attributes: insertion methods, abstraction levels, influence effectiveness, type of logic, influence method, activation method, physical implementation at the topology level, location within the IC, etc. Based on the system of quantitative assessment of these attributes, vectors that reflect the risk or seriousness of trojan attacks and the effectiveness of their detection are determined.

Another method of detecting hardware backdoors is proposed in the work (Khairallah et al., 2018). For hardware encryption systems, there is a design method based on the integration of a specially developed sensor circuit based on a ring oscillator located around potential targets of a trojan attack without any loss of circuit performance.

Unlike the existing solutions at the IP core level, solutions presented in the work (Huang & Wang, 2020) also take into account architecture-level security threats and use a strategy of introducing distributed IP security units to ensure reliable SoC operations with unreliable IP units. Special side channel attack protection modules built into the IC, physically unclonable modules and circuit abnormal behaviour monitoring modules were installed on a FPGA platform. The experimental results show the effectiveness of the proposed approach for ensuring that a system is protected against various attacks. Built-in IP units bring low overhead expenses, do not affect main IP units and have such characteristics as flexibility, scalability and diversity.

In the context of HT detection measures, works aimed at ensuring the security of built-in processor cores deserve special attention. In particular, the work (Yuan et al., 2021) notes that hardware trojans are one of the main hardware security threats for general-purpose registers (GPRs) of processors. This article presents a new method for detecting HT attacks by

comparing the conditions of GPRs with a built-in reference model in real time. The authors used this method in the design of a RISC-V core and studied its effectiveness. The experimental results show that all accidentally inserted HT attacks can be detected in real time with a delay of two cycles.

The article (Kulkarni et al., 2016) presents a method for detecting hardware trojans during the operation of a multi-core processor using machine learning. The support-vector method (SVM) is used for machine learning. A data set is generated based on the behaviour of a multi-core router in a normal mode and when a hardware trojan is activated. The article discusses various communication attacks initiated by hardware trojans, namely: spoofing, redirection of one traffic packet to a random core, routing loops. An algorithm based on the support-vector method has the detection accuracy of 94% ÷ 97%. The implemented structure for detecting trojan attacks increases the chip area by 2%.

Software and hardware methods for counteracting HT introduction are considered in the work (Kuznetsov & Saurov, 2017b). In one option in the article (Herder et al., 2014), it is suggested to use physical unclonable functions (PUFs) in low-cost applications for the authentication and generation of encryption keys. It discusses the weaknesses of PUF implementations and their use in key generation applications associated with constructing error correction schemes based on sample matching and index-based coding.

Another protection option is to use a key-based obfuscation method to ensure protection against hardware trojans (Chakraborty & Bhunia, 2009). The obfuscation method is based on changing the state transition function of this scheme by extending its reachable state space, allowing it to operate in two different modes—normal mode and obfuscated mode. This

modification makes it difficult to insert difficult-to-detect trojan backdoors into the design at both the software and hardware levels. The authors presented a functional OBISA circuit (obfuscated built-in self-authentication). This circuit is connected to the initial design circuit and achieves the goal of deceiving the attacker by reducing the empty chip space and making it difficult to interpret the functional purpose of a particular circuit element. The mechanism for selectively disabling various circuit sections and the method for selecting the path of a useful signal proposed in this article reduce resources potentially expended for filling.

The work (Shekarian et al., 2013) suggests a method called DfHT (Design-for-Hardware-Trust). The purpose of this method is to construct a scheme with maximum density. Instead of non-functional filling cells, it uses functional testing ones. However, functional cells can greatly limit design traceability. This paper also presents an improvement algorithm to minimise limitations imposed on tracing.

This method, in particular, was developed in the works (Xiao & Tehranipoor, 2013; Shiet al., 2019). The work (Xiao & Tehranipoor, 2013) suggests to include built-in self-authentication (BISA) circuits in the design for protection against HT introduction. The idea of this method is to fill unused spaces in a chip with functional cells—fillers that form logic devices of combinational or sequential logic, the correctness of which is checked by the BISA device itself, as a result of which a digital signature is formed. Any change in BISA chains will result in a different signature. Thus, BISA can be used to prevent or extremely obstruct the introduction of trojan programmes. BISA is applicable to any single-module or hierarchical design.

The work (Shi et al., 2019) suggests the joint use of the BISA concept and split manufacturing. It is noted that split manufacturing is designed to prevent IP

piracy and IC cloning, but it does not prevent the untargeted introduction of hardware trojans and results in considerable overhead expenses when a high level of security is required. Built-in self-authentication (BISA) is an inexpensive method of preventing and detecting the introduction of hardware trojans, but it is vulnerable to IP piracy, microchip cloning or attempts to hack original circuit features. This article suggests an obfuscated BISA method that combines and optimises both methods so that they complement and enhance protection against both vulnerabilities, while minimising design overhead expenses to such an extent that the proposed method does not require excessive expenses for industrial-level designs. According to the authors' estimate, the proposed method more than doubles the level of security, while reducing overhead expenses from hundreds of percent to less than 13% in capacity, 5% in delay and zero percent in area compared to the best declared performance in the existing technologies.

A number of publications address the application of symmetry principles for detecting and preventing HTs.

The article (Vaikuntapu et al., 2016) suggests a method for detecting trojans inserted after the completion of development, i.e. a trojan is inserted at the topology level. Since golden ICs, guaranteed to be free of trojans, are not always available in all cases, it is relevant to develop a detection methodology that does not require any gold microchips. This work uses the concept of asymmetric path delays to detect trojans, taking into account changes in delays of symmetric pairs due to the insertion of a trojan. Proposals are formulated on the methods of detecting suspicious ICs by comparing the metrics of two symmetric signal propagation paths. It has been shown that the proposed method is quite resistant to the influence of changes in the manufacturing process. In particular, the modelling results show that the total

probability of trojan detection is close to 100% with a maximum change in threshold voltage and gate length of 8% in one chip and with a variation of 10% between batch chips.

The article (Xue & Ren, 2018) suggests a novel microelectronic HT detection circuit based on timing analysis. This detection method can be applied in both combinational and sequential circuits. The proposed technique is implemented in the IBM 90 nm CMOS processor and Xilinx ISE PLD. Experiments have shown that one detection circuit embedded in the test-path can detect a HT with a size that is 2.81% of the host-circuit size with a detection probability of 90%. The probability of false positives is controlled effectively by the testing clock frequency. For 90nm CMOS ASIC tests, the ratio of the detectable HT size to the host-circuit size ranged from 2.81% to 3.37% with a detection probability of 90% at 10% FP. For PLD implementation, the ratio of the detectable HT size to the host-circuit size ranged from approximated 0.5% to 0.9% with a detection probability of 90%. The detection probability decreases with a decrease in the HT size, but can be additionally improved by applying a larger number of detection circuits on a test-path. Moreover, a ring oscillator can be introduced to estimate operating temperature and changes in the test-path process for calibrating detection parameters, which eventually increases detection probability.

A similar method based on delay analysis is proposed in the work (Jin & Makris, 2008). To reduce the overhead expenses of analysis, the authors proposed to divide the design into separate sections, each of which has much smaller dimensions than the initial dataset, but reflects the main characteristics in the initial datasets. The results of experiments with circuit sections with comparators and counters show that the detection rate of payload trojans is 100%. However, the authors note that this method

does not work well in the case of trojans, the effect of which is activated only after the occurrence of their activation event.

The articles (Cui et al., 2018; Yoshimizu, 2014) suggest a two-phase technique based on signal symmetry analysis that determines delays in path pairs for HT detection. At the design stage, a full-cover path set that covers all the nets of the design is created. At the test stage, the actual path delay in the full-cover set is extracted from manufactured circuits, and the travel of signals in path pairs is compared to a reference order generated at the design stage. A mismatch between them indicates the existence of HTs. Both process changes and measurement noise are taken into account. The efficiency and accuracy of the proposed technique are confirmed by a series of experiments, including the examination of both violated path pairs caused by HTs and their false activation rate.

Therefore, currently there is no clear trend in the development of HT detection methods. The variety of detection and anti-implementation techniques proposed so far provide the opportunity to combat various types of HTs in various hardware platforms. An obvious condition for IC design for trust (DfT or DfS—Design for Security) is the preliminary analysis of possible trojan attack models and the development of appropriate detection and/or prevention measures.

Such measures, in particular, are:

- Analysis of standard element libraries used in the design, with a full disclosure of their specifications, i.e. descriptions at the level of topology, circuit diagrams and methods for checking design and verification rules.
- Application of trusted complex functional units, control of the design route, introduction of the designed node circuit into the topology, which perform the functions of obfuscation,

camouflaging, filling of the topology free spaces. Obfuscation is a method of hiding circuit functionality by inserting an additional logic-locking circuit into the design in order to conceal its functions and intended topology. Camouflaging is a method of creating indistinguishable layouts of gates using additional dummy contacts and fake connections between layers, which prevents the attacker from re-designing the circuit's netlist. When filling empty topology spaces, additional functional elements are intentionally added to the design, which form combinational logic that can be tested during the design process and whose mal-function can serve as evidence that the topology has been distorted during manufacture.

- Implementation of split manufacturing where the factory with design rates of 40...7 nm produces the main part of a circuit without revealing its functions, and the final stage of IC manufacture is carried out at a trusted factory.
- Creation of VLIC nodes based on new principles of digital electronics, in particular, based on quantum effects and microelectromechanical nodes.

Development of special hardware measurement methods and analysis of their results for monitoring the functioning of manufactured circuits and their parameters.

### 3. Problem statement

Depending on the attacker's potential possibilities, a HT can be introduced, in one way or another, at any stage of IC creation, however, this action can be relatively easily carried out and relatively easily detected or

prevented during the design stage. At the same time, the cost of localisation and control of the development and design process is millions of times lower than the cost of localisation and control of the IC manufacture process, which makes the task of counteracting the introduction of HTs at the manufacture stage a high priority.

In order to choose the optimal method of counteracting the introduction of hardware backdoors, it is necessary to separately consider the characteristic advantages and existing disadvantages of the above methods. We can divide the methods of counteracting the introduction of hardware backdoors into two groups: DfT (design for trust) and SMfT (split manufacturing for trust).

The methods of the DfT group usually involve inserting additional circuit components, obfuscation functions into the design or reducing the empty space of a chip. This also results in additional overhead expenses in the form of increased chip area, increased dissipated power and signal propagation delays, which is a major limitation of the DfT approach. However, for some specialised mission-critical ICs produced in small batches, this method is an excellent protection option. The method can significantly improve the security of ICs.

The main idea of the SMfT methods is to share out the stages of IC manufacture among several factories. These methods allow to effectively implement mutual physical isolation of untrusted and trusted manufacturers, thereby minimising the probability of HT introduction. At the same time, the SMfT methods have a long production cycle and higher production costs than the DfT methods, and cannot be used for large-scale production. It is necessary to separately consider the logistics problems during the movement of plates between factories, and the issues of economic efficiency in case of a sharp drop in the release of suitable products in case of violating the standard technological process.

In the current conditions of extreme technological dependence in the field of semiconductor production with nanometre topological norms and the absence of appropriate trusted manufacturers in the country, technological methods of counteracting the introduction of hardware backdoors are still not applicable.

Based on the assessment of the attacker's high potential (capabilities of the enterprise/group of enterprises/state's level to develop and use special means of exploiting vulnerabilities), measures to counteract the introduction of hardware backdoors that make it difficult to analyse initial circuits and topological drawings may be ineffective due to the potential attacker's ability to extract initial design documents.

Therefore, the only group of methods applicable in this situation are methods of increasing testability and filling the area of a topological drawing. Testable design and testability improvement are currently a standard approach to VLIC design, are well studied and will not be discussed in this work.

A universal approach to counteracting the introduction of HTs into a topological drawing is to limit the free area on the chip (filling the empty space of the chip): the filling is associated with minimising the use of non-functional cells in the circuit, inserting a specially designed detection circuit (BISA) or removing the empty space, in order to limit the space where HTs can be inserted.

Summarising the known approaches to counteracting the introduction of HTs into IC topological drawings after obtaining a final design solution in the form of a topological drawing, we have formulated the following main requirements for solving the problem of ensuring protection against hardware backdoors in the IC design:

- filling the entire area of an IC digital core with standard library

elements that are part of the circuit suitable for functional testing (the main functional diagram of the design and the BISA scheme);

- fully controlling the integrity of the protection circuit using functional testing methods;
- minimising the effect of the protection circuit on the functional characteristics of the main device circuit;
- implementation of the protection circuit within the standard IC design route.

The above procedures are universal and can be effectively used in existing design centres to train and instruct staff in basic HT countermeasures during the design phase.

### 3.1 Implementing the self-testing circuit of an IC digital core

The idea of the BISA circuit implementation proposed in this work is to perform symmetric topology transformations in the obtained design solution of the IC topology that provides all the required functions in accordance with the technical specifications. Moreover, these symmetric topology transformations should not impair the circuit functionality, but allow the installation of additional BISA cells. This intermediate topological solution is then symmetrically displayed in a new drawing where empty spaces are filled with standard cells that form BISA circuits. The empty spaces should be filled with BISA cells in such a way that it is impossible to add a cell to any part of the topology that has the smallest size of all standard cells in the design library. The symmetry of the topology display ensures that all required functions of the main circuit are maintained in accordance with the specifications.

Assuming that the functionality of a HT circuit should not be less than a logic

function with three inputs, the equivalent area occupied by a HT circuit in the topological drawing should not be less than the area of four inverters in this process. Therefore, the total area available for locating active semiconductor devices within the boundaries of a digital core should not exceed this value. Despite the fact that in the process of locating standard library elements within the boundaries of the digital core, the location pitch can be several times less than the width of the smallest inverter, we assume that an attacker can change the topological drawing in such a way as to combine unoccupied areas, as well as locate HT parts (up to one transistor) in unoccupied areas in different parts of the digital core.

Simply eliminating the free area by compacting the topological drawing of the main IC may lead to a fatal violation of design rules and design limitations:

- A violation of topological design rules, namely the inability to provide the required minimum distances between metallisation buses with a high-density location of input and output ports of library elements.
- A violation of electrical design rules, namely exceeding the permissible dissipated power per area unit in highly loaded parts of the circuit.
- A violation of design time limits, namely increasing parasitic capacities of metallisation buses with an increase of their location density.

Based on this, additional elements that are not part of the main circuit and do not have dynamic consumption during its operation should be used to fill the unused space, while the ratio of the area of these elements to the area of the required metal layout should be maximum.

Free space can be filled by various circuits, if only they can be controlled by non-invasive methods. In general, they can be divided into two types:

- digital ones (based on logic gates and memory circuits), during the control of which their logical function is checked;
- analog ones (based on passive and active elements), during the control of which their electrical and time parameters are checked.

At the same time, the protection circuit should not have a destructive effect on the main circuit. For example, it is permissible to increase the static current consumption of the circuit, but it is not permissible to reduce the maximum clock frequency of the main circuit or limit its any other functions.

This work uses GSCL (general standard cell library) as an example. It is a library of standard 150 nm process cells containing 42 elements of different widths that implement basic logical operations and auxiliary functions.

Names and types of the library cells are shown in Table 1.

To meet all requirements, we analysed the composition of the GSCL standard cell library to assess the effect of each of its functional elements (except for buffers and inverters) on the traceability of the main digital core circuit. Elements with the same functional purpose and different output stage power were also excluded from the analysis (only single-power elements were assessed). The assessment results are presented in Table 2.

Based on this assessment, a D-trigger named DFFX1 is selected as the main element of the integrity control circuit of the topological drawing of the IC digital core. This element is the simplest one, so its circuit cannot be optimised to reduce the area of its topological drawing, while the minimum number of involved ports without loss of control can be reduced to 3, which allows to achieve the best ratio of the controlled area and the spent tracing resources.

The proposed circuitry and algorithmic solutions were tested in this work using the example of the core of the RISC-V Steel Core RTL microprocessor whose code is open for free use.

**Table 1.** Elements of the GSCL standard cell library

Cell type	Cell name
Inversion	INVX8, INVX4, INVX2, INVX1
“AND”	AND2X1
“OR”	OR4X1, OR2X1
“AND-NO”	NAND4X1, NAND3X1, NAND2X2, NAND2X1
“OR-NO”	NOR4X1, NOR3X1, NOR2X1
“EXCLUSIVE OR”	XOR2X1
Two-level logic	OAI33X1, OAI22X1, OAI21X1, AOI22X1, AOI21X1
Multiplexer	MX2X1
D-triggers	DFFX1, DFFSRX1, SDFFSRX1
Clock buffers	CLKBUF1, CLKBUF3, CLKBUF2
Three-state buffers	TBUF1, TBUF2, TBUF4, TBUF8
Adders	ADDHX1, ADDFX1
Buffers	BUF1, BUF3
Filling cells	FILL1, FILL2, FILL4

**Table 2.** Analysis of the GSCL library topological parameters

Element	Linear size, $\mu\text{m}$	Number of vertical tracks (pitch of $0.6 \mu\text{m}$ )	Number of ports	Number of effective vertical tracks
NAND2X1	3.3	5.5	3	2.5
NOR2X1	3.3	5.5	3	2.5
AOI21X1	3.96	6.6	4	2.6
AND2X1	3.96	6.6	3	3.6
OR2X1	3.96	6.6	3	3.6
NAND3X1	4.62	7.7	4	3.7
AOI22X1	5.28	8.8	5	3.8
NAND4X1	5.28	8.8	5	3.8
OAI21X1	5.28	8.8	4	4.8
XOR2X1	7.26	12.1	3	9.1
MX2X1	7.92	13.2	4	9.2
NOR3X1	7.92	13.2	4	9.2
OAI22X1	8.58	14.3	5	9.3
OR4X1	9.24	15.4	5	10.4
OAI33X1	11.22	18.7	7	11.7
TLATX1	11.22	18.7	4	14.7
NOR4X1	12.54	20.9	5	15.9
DFFX1	18.48	30.8	4	26.8
DFFSRX1	20.46	34.1	6	28.1
TLATSRX1	21.12	35.2	6	29.2
ADDFX1	24.42	40.7	5	35.7
SDFFSRX1	35.64	59.4	8	51.4

This core contains three pipelining stages: extracting instructions, decoding instructions, executing instructions. The small number of pipelining stages eliminates the need to implement conflict resolution units and other complex microarchitectural solutions. Figure 1 presents a microarchitecture diagram of this processor at the level of register transmissions.

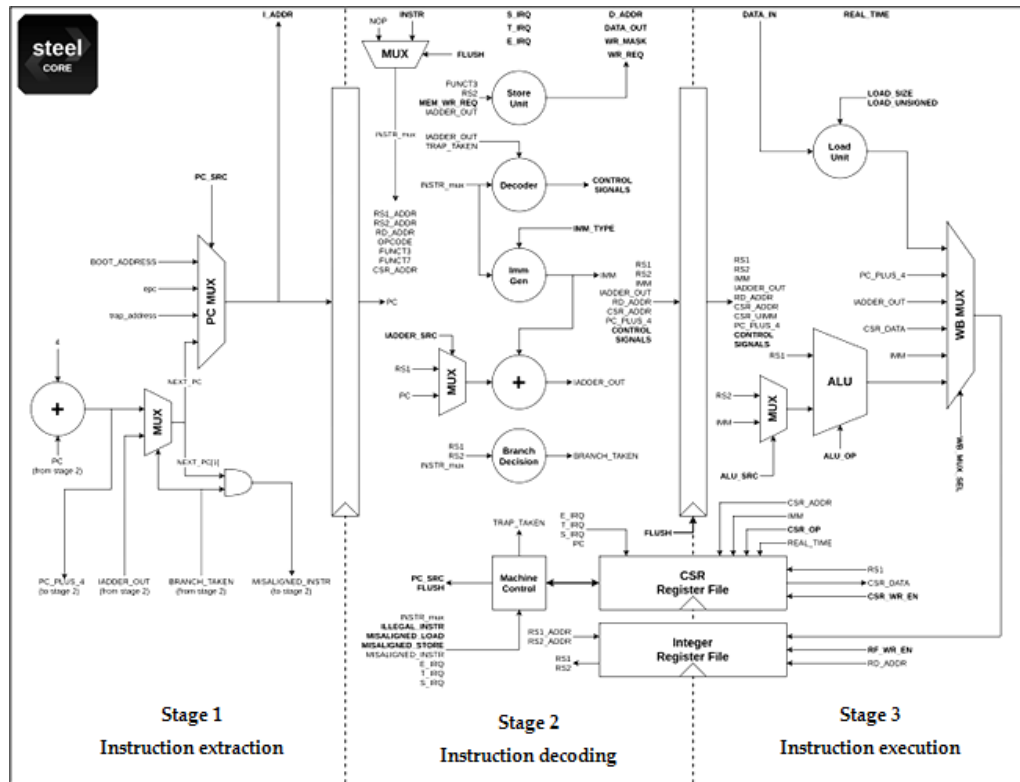
The main functional units of this processor are as follows:

- A decoder that decrypts instructions and generates signals to monitor the processor data path.
- An arithmetic-logic unit (ALU) that implements 10 logical and arithmetic operations on two 32-bit operands.
- Register files (IRF, CSR) that contain 32 general-purpose registers and support writing and reading operations.

- A branch unit that predicts when to perform the operation of moving to another address in the executed programme.
- A load unit that is required to load data into a register file.
- A store unit that controls signals of the memory interface.
- An immediate generator that expands immediate operands to 32 bits if necessary.
- A special machine control that controls the processor instruction counter.

In general, the design route is shown in Figure 6. Parallel branches of the circuit show that the design of analog and digital parts can be carried out parallelly and independently.





**Figure 1.** The RISC-V Steel microprocessor core at the level of register transmissions

The entire design route can be nominally divided into 5 stages: architecture development, development of non-standard library elements (analog components and SF units), logical synthesis (digital components), chip planning and physical synthesis (combining all parts of the design), mixed modelling and verification. At the same time, the introduction of BISA elements is a separate stage, the role and place of which in the design route are given in Figure 2.

At this stage, DEF (design exchange format) files that contain information about cell coordinates, chip sizes, power lines, etc., and LEF (library exchange format) files that contain data about the size of standard cells, the location of their ports and the metallisation paths within a cell should

already be retrieved from the design database. These files are required to implement the BISA filling cell location algorithm.

Based on D-triggers, when they are switched on sequentially, a shift register circuit can be implemented (trigger chains, Figure 3), which allows to monitor the presence of all its elements (links), for which it is enough to use only three additional ports (Si, So, Clock).

By replacing all the free areas of the IC digital core with D-trigger cells and then combining them into a shift register of any length, the location density of standard cells approaching 100% can be achieved, while the integrity control of the chain itself, which is performed once, can be carried out in a number of cycles equal to twice the number

of triggers in the chain. By supplying an arbitrary, unknown binary sequence to the input of the shift register and reading it from the output of the shift register through the number of cycles equal to that of triggers in

the circuit, the integrity of the proposed integrity control circuit of the topological drawing of the IC digital core can be precisely estimated.

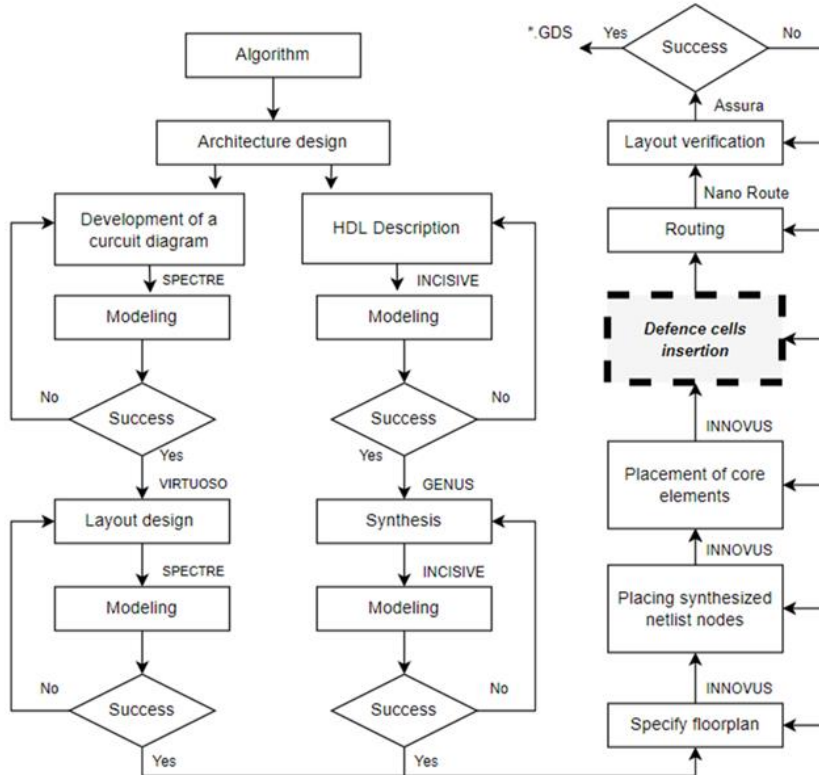


Figure 2. The design route of the topology of trusted ICs

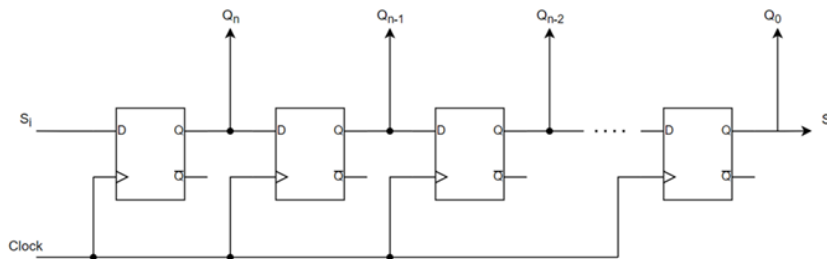


Figure 3. The diagram of a shift register

One of the disadvantages of the previous methods is the inability to achieve 100% use of the free circuit space, since possible voids

may be smaller or be not a multiple of the dimensions of the test circuit elements inserted into them. The remaining voids can

be smaller in size than the NAND gate. But the total area of all such voids may be critical. And when a HT is introduced, this space can be used, for example, by combining individual voids into one due to small movements of the main circuit elements (displays symmetrical with respect to the main functions of the circuit). Insignificant movements (comparable to the size of the simplest gate), for the most part, have a minimal effect on the main circuit, since the average location density of the elements does not change. Therefore, if an additional location optimisation cycle is performed prior to the introduction of the protection circuit, which provides voids equal to or being a multiple of the dimensions of the filling elements of the protection circuit, 100% use of the free area can be achieved. After such optimisation, re-checking the time characteristics of the main circuit allows to verify that its parameters meet the requirements. If the requirements are not met, several optimisation stages can be performed to achieve the required results. After the voids are compensated through optimisation, the previously described integrity control circuit can be implemented.

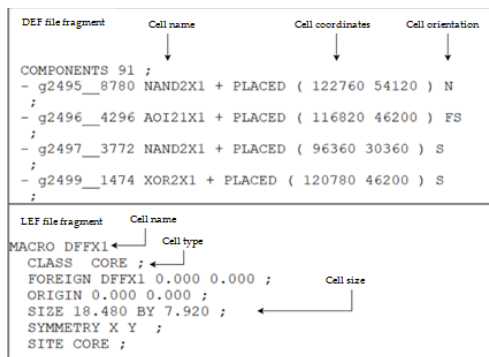
To ensure 100% filling of the free space inside the digital part of the design, it is necessary to set the dimensions of the voids to multiple sizes of the filling elements. Initially, the dimensions of the voids are arbitrary and are chosen by means of locating the main circuit, based on the requirements of the optimal design tracing. Setting the voids to multiple dimensions results in the movement of the main circuit elements, while their significant movement may negatively affect the parameters of the main circuit. Therefore, setting the voids to multiple dimensions should be carried out while maintaining the average density of the design. To construct a clock tree for the shift register, the circuit should have room for clock signal buffers. The location of these

buffers should be strictly consistent with the direction of signal propagation (towards the data flow) and meet a number of requirements for the maximum distance between the buffers and the maximum number of the triggers per buffer. Since the operation is carried out with the digital circuit elements, only the width of the elements is taken into account, since the height of all elements is the same. When levelling the voids, the following actions can be carried out:

- decreasing the size to a multiple size
- increasing the size to a multiple size
- combining adjacent voids up to a multiple size
- creating voids of specified size in places required for setting clock buffers

The cell location programme is implemented in the Python programming language and contains three main stages: reading data from .def, .v and .lef files; an algorithm for optimising and locating cells; recording data to new files with the same extensions.

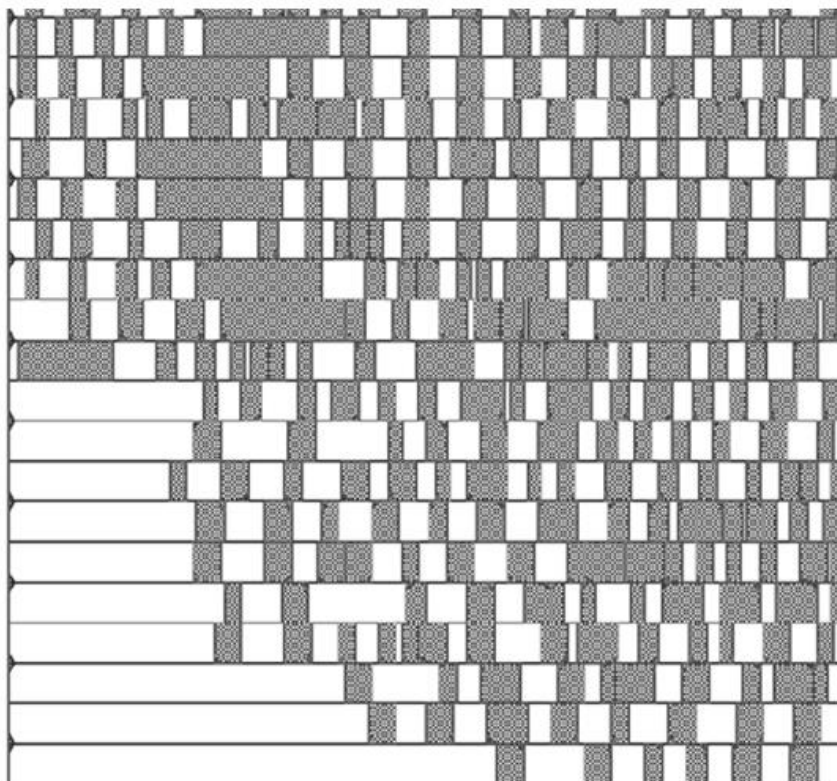
An example of text data contained in the LEF and DEF files is shown in Figure 4.



**Figure 4.** The fragments of LEF and DEF files describing the parameters and coordinates of the location of the standard cells used in the design



**Figure 5.** The IC core topology drawing after converting DEF file data



**Figure 6.** The fragment of the IC digital core after locating elements of the synthesised netlist (the initial back end)

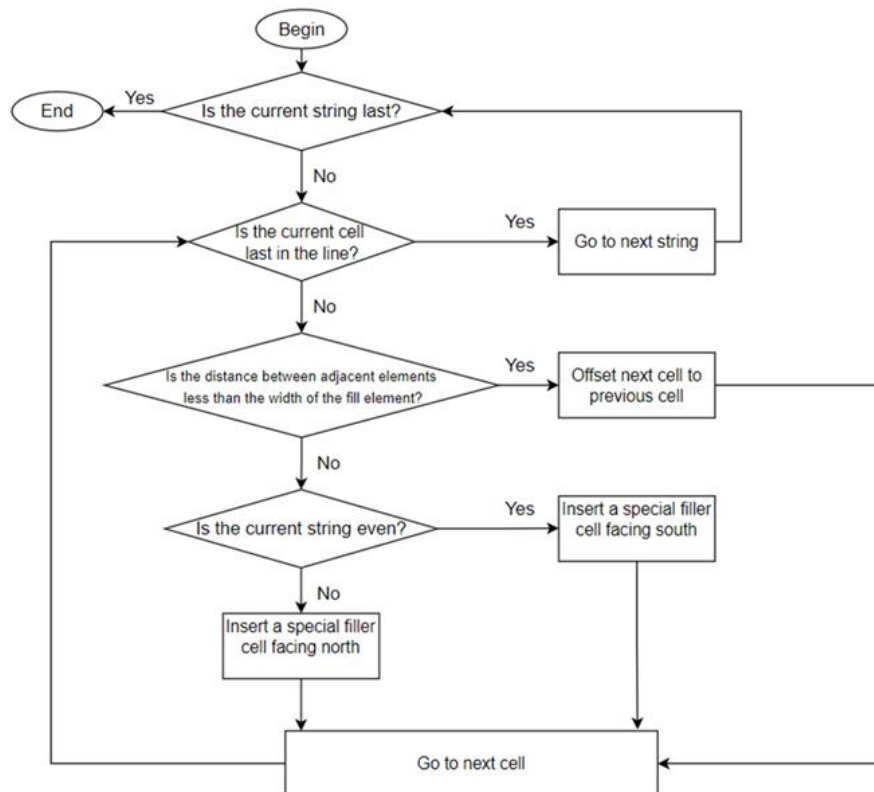
All stages of the unit design route, including the location of specialised elements of the digital core, are carried out in the standard route using standard tools. At the preparatory stage, a special Python programme converted data from a DEF file format into a cell topology drawing. The result of the conversion programme is shown in Figure 5.

An enlarged fragment of the digital core drawing highlighted in the lower left corner of Figure 5 is presented in Figure 6.

This topology is initial for subsequent symmetric transformation in order to introduce BISA cells, which is performed in two stages: 1) analysis of free areas and symmetric shift of standard cells, 2) location of BISA cells. This optimisation algorithm can be implemented as follows. Since all

logical elements of the digital core are located sequentially in strings, optimisation should also be carried out string by string. At the first step, the string start and end coordinates should be obtained. Next, the centre of the string is determined, relative to which the cell shift algorithm will be implemented. After marking all reference points, the optimisation of cell space in strings is carried out by shifting them and filling the freed space with filling elements, in our case with D-triggers. In this case, it is necessary to take into account the orientation of the filling cell in space, since the orientation of the power lines alternates in each string.

A block diagram of the location algorithm is shown in Figure 7.



**Figure 7.** Block diagram of the location algorithm for filling cells

The programme that implements this algorithm is also written in Python. An example that illustrates the operation of the standard cell symmetric shift programme is shown in Figure 8. The filling cell is marked as DFFX1. At the first step, the distance between adjacent elements is checked, including the line start coordinate. If the  $D_0$  distance is less than the width of the filling cell, the right cell is shifted to the left one; in this case, the cell with coordinates  $(X_1, Y_0)$  to

that with coordinates  $(X_0, Y_0)$ . At the next step, the distance between the next two elements is checked; if it is larger than the width of the filling element, it is located in this place, otherwise a verification similar to the first step is carried out. At the last step, the filling cell extends the array of the string, then the same conditions are checked on the string as in the previous two steps.

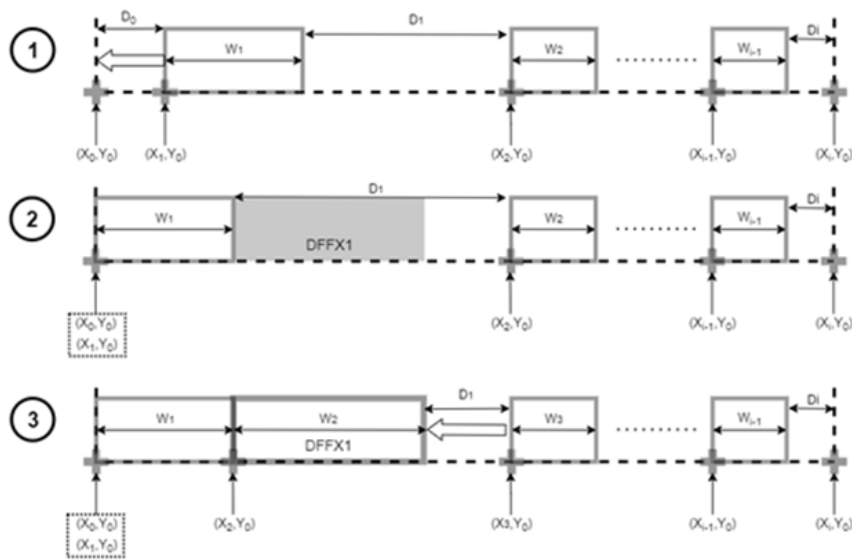


Figure 8. Visualisation of the filling cell location algorithm

At the stage of introducing protection elements for the IC digital core into the design, the following sequence of actions is performed:

- 1) Uploading information on the location of library cells of standard digital elements of the synthesised netlist and specialised elements.
- 2) Optimising the location of library cells of standard digital elements of the synthesised netlist, taking into account the requirements for free areas.
- 3) Locating the triggers of the specialised scan chain in the voids

of the optimised digital core.

- 4) Finding the best way to connect the triggers of the specialised scan chain.
- 5) Downloading information on the location of library cells of standard digital elements of the synthesised netlist and triggers of the specialised scan chain.
- 6) Downloading information on the interconnections of triggers of the specialised scan chain in the format of a synthesised netlist for

subsequent tracing.

The algorithm for optimising the location of library cells consists in shifting elements within strings so that, after displacement, the voids or free areas between adjacent elements have certain width.

Elements in a string can move in an arbitrary order to the left or right, but the elements cannot swap places.

After optimising all free areas in a string, one can proceed to the next string and so on until the strings are complete. After all strings have been optimised, new element coordinates are recorded, their dimensions and the list of elements are downloaded in an input format. At this stage, the percentage of the occupied core area is 69.99%.

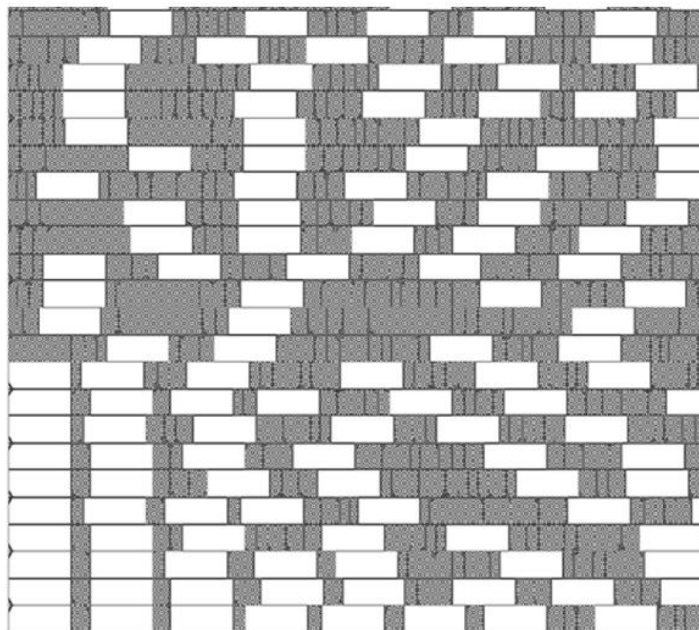
As a result of changing the input data, only the coordinates of the logical cells change, the remaining input data do not change,

namely, the size of the cells, their names and the dimensions of the workspace should remain in their original form. As a result, the digital core takes the form shown in Figure 9.

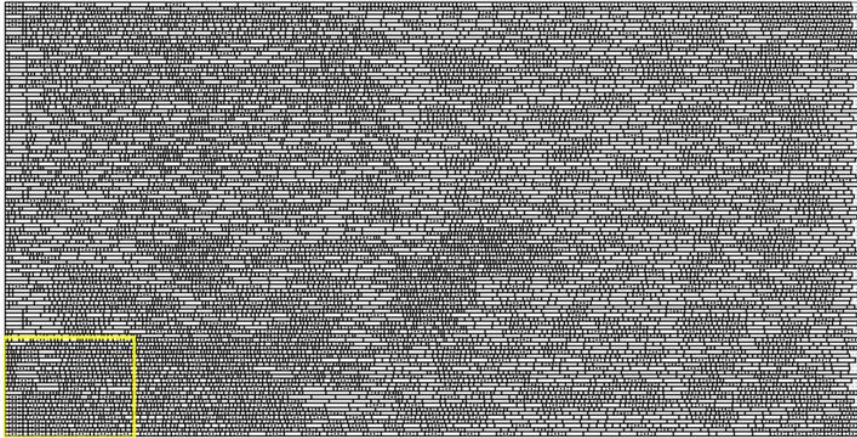
As a result of locating the triggers of the specialised scan chain in the free areas of the design strings, the location of library cells of standard digital elements of the synthesised netlist and specialised elements is optimised so that the voids between the elements in the string are multiple of the size of the trigger of the specialised scanning chain.

After replacing all voids with the cells of the trigger of the specialised scan chain, new element coordinates are recorded, as well as their dimensions and the supplemented list of elements are downloaded in an input format.

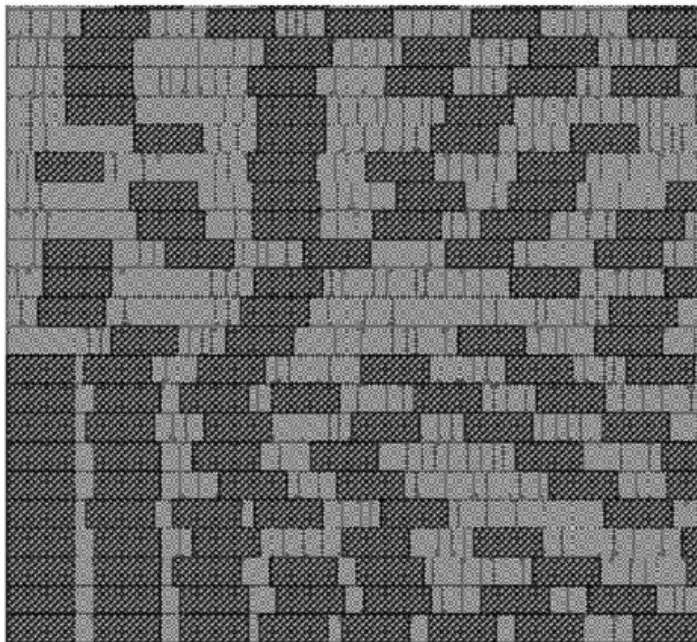
As a result, the digital core takes the form shown in Figures 10 and 11 (a highlighted fragment).



**Figure 9.** A fragment of the IC digital core after the stage of locating the elements of the synthesised netlist



**Figure 10.** The IC digital core with located protection elements



**Figure 11.** A fragment of the IC digital core with located protection elements (inserted standard elements are highlighted in dark grey)

In this case, the percentage of the occupied chip area is 98.95%.

At the next design stage, the process of sequentially forming logical interconnections

between the nearest triggers of the specialised scan chain takes place, as a result of which the input of each subsequent trigger is connected to the output of the previous one independently of the location string. The



result is a netlist file for the triggers of the specialised scan chain in the Verilog hardware description language. The resulting netlist is included in the main netlist file of the design, and then we return to the stage of tracing the standard design route.

## 4. Conclusion

Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions. Research has been carried out on software methods for detecting and preventing the introduction of hardware Trojans into the topology of integrated circuits at the stage of their design. An additional recommendation for typical design procedures for obtaining GDSII files, which significantly complicates the introduction of hardware Trojans into the topology, is to facilitate detection methods by including special self-testing structures in the project, formed after performing symmetrical transformations of the original topology and providing effective verification of integrated circuits at the testing stage after manufacturing. A method is proposed for introducing BISA self-testing cells into the project, which is based on the analysis of the results of synthesis at the level of description of the list of circuits, its subsequent program transformation into a topology drawing, symmetrical shift of standard cells and filling the voids formed in this way with

special self-testing cells. The result is a netlist file for custom scan chain flip-flops in the Verilog hardware description language. The resulting netlist is included in the project's main netlist file, after which it returns to the tracing phase of the standard design route.

The proposed method makes it possible to build a very simple and efficient protection scheme based on the operation of symmetrical transformation of the topology drawing and shift of standard design elements.

Advantages of the method:

- the simplicity of the scheme and its strict determinism, when controlling the scheme, you can accurately determine the number of protection triggers and, if they are absent, you can talk about possible changes to the scheme
- the minimum necessary amount of required additional tracing resources.

The method is simple to implement at the topology design stage and can be recommended for use in design centers for machine learning of computer-aided design systems.

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## OBJECT-ORIENTED METRICS PREDICTION AS A TOOL FOR SOFTWARE QUALITY EVALUATION

**Abstract:** *Chidamber & Kemerer metrics as a set of six basic metrics, in combination with Lines of Code, is used as a quantitative measure of object-oriented software characteristics. Guided by the fact that these measurements are not an easy task and time consuming, we propose an artificial neural network with optimal three-layer back-propagation for quick object-oriented metrics' prediction, based on measured values of Weighted Methods per Class and Lines of Code. The study is conducted at the sample of 367 cases of metrics' values taken for jedi 4.2. Performances in the form of correlation coefficient and mean square error are measured, as well as the performance during the learning process in terms of gradient, momentum and validation checks with respect to number of epochs. Obtained values indicate a significant and almost perfect adaption of outputs to the targets, creating an opportunity get all the values for basic metrics, with proper accuracy.*

**Keywords:** *Chidamber & Kemerer metrics, software assessment, artificial neural network*

### 1. Introduction

Quality attainment is the most critical issue in software development, especially in today's dynamic environment. Therefore, ensuring the software's commercial success implies conforming to a number of client requirements with zero error, under specified conditions. Meeting the internal and external set of features and characteristics should be achieved through continuous monitoring and software quality evaluation (Arvanitou et al., 2016). The most common way to do this is to conduct different software measurements with the aim to obtain numeric data related to software projects, and to determine factors such as project size, time spent, cost, etc. (Yücalar & Boranda, 2016). These measurement are useful in assessing

software quality attributes and could be used in predicting software testability (Badri & Toure, 2012; Juliano et al., 2014), as well as evaluating maintainability, understandability, and reliability (Desai, 2014; Juliano et al., 2014).

Series of International standards ISO/IEC 25000 SQuaRE (Software Product Quality Requirement and Evaluation) has been developed with the aim to provide proper framework for evaluating software quality. Due the fact that SQuaRE is the result of evolution of several standards, it consists of five divisions: Quality Management (2500x), Quality Model (2501x), Quality Measurement (2502x), Quality Requirements (2503x) and Quality Evaluation (2504x). According to ISO/IEC 25000, evaluation could be done by

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measuring internal or external properties, such as static measures or by measuring code's behavior during execution (Perdomo & Zapata, 2021; Norbert & András, 2021).

Different aspects of quality require different software metrics that are used to provide a quantitative way to assess the quality, through objective reproducible measurements (Dubey et al., 2012). This resulted in development of a large number of metrics, as well as many tools for collecting metrics from software (Singla & Singh, 2014). These tools can be general or dependent on programming language, provided as stand-alone software or integrated, in the form of plugin (Molnar et al., 2019). Thereby, regardless of the type or form of these tools, it is necessary to know the context of the measured object for software evaluation (Dahab & Maag, 2019).

Object-oriented approach to software development, as an expansion of procedural approaches, separates data and control. Due to the fact that the system is viewed as a collection of objects, object-oriented metrics must provide measurements that can be applied on classes and characteristics such as object abstraction techniques, encapsulation, inheritance, polymorphism, and information hiding. There are three categories of this metric, namely process metric, product metric, and project metric (Kumar & Vijayaraghavulu, 2021; Shaik et al., 2010). Different sets of object-oriented metrics are proposed: Chen metrics, Chidamber & Kemerer (CK) metrics, Martin metrics, Lorenz and Kidd metrics, MOOSE (Metrics for Object-Oriented Software Engineering) metrics, MODD (Metrics for Object Oriented Design) metrics, Goal Question metrics, QMOOD (Quality Model for Object Oriented Design) metrics, Li and Henry metrics, and SATC (Software Assurance Technology Center) for object-oriented metrics (Desai, 2014; Dubey et al., 2012; Yücalar & Boranda, 2016). CK recommends six basic metrics: Weighted Methods per

Class (WMC), Depth of Inheritance Tree (DIT), Number of Children (NOC), Coupling Between Object Classes (CBO), Response for a Class (RFC), and Lack of Cohesion in Methods (LCOM) (Chidamber & Kemerer, 1994; Desai, 2014; Juliano et al., 2014; Dubey et al., 2012; Molnar et al., 2019; Padhy et al., 2017; Sabhat et al., 2017; Tirban, 2018; Yücalar & Boranda, 2016). Li and Henry took five metrics from CK (WMC, DIT, NOC, RFC, and LCOM), and added five more metrics: Message Passing Coupling (MPC), Data Abstraction Coupling (DAC), Number of Methods (NOM), Number of Semicolons (SIZE1), and Number of Properties (SIZE2) (Desai, 2014). Martin focuses on architectural design issues, defining six metrics (Relational cohesion (H), Afferent coupling (CA), Efferent coupling (CE), Abstractness (A), Instability (I), and Distance from main sequence (D)), with the aim to reduce dependencies between classes (Desai, 2014). MOOD metrics deal with basic object-oriented paradigms, covering six metrics, namely Method Hiding Factor (MHF), Attribute Hiding Factor (AHF), Method Inheritance Factor (MIF), Attribute Inheritance Factor (AIF), Polymorphism Factor (POF), and Coupling Factor (COF). MHF and AHF cover encapsulation, MIF and AIF cover inheritance, POF covers polymorphism, while COF deals with message passing (Desai, 2014; Yücalar & Boranda, 2016). QMOOD set of metrics allows total quality index of the software calculation based on seven metrics (Lines of Code (LOC), Average Complexity (AC), Number of Instance Variables (NIV), WMC, DIT, RFC, LCOM) (Dubey et al., 2012; Yücalar & Boranda, 2016). Some traditional metrics include Cyclomatic Complexity (CC) to measure algorithm complexity in the class method, and LOC (Dubey et al., 2012).

Different values for metric numbers have been proposed for requirement, design, and testing phases of software development

lifecycle, such are 27, 42, and 46 metrics, respectively (Singla & Singh, 2014). The fluctuation analysis of 19 object-oriented metrics, conducted at 20 open-source software projects shows that the source code metrics are more sensitive, compared to design metrics (Arvanitou et al., 2016). Object-oriented metric has proved to be successful with identifying classes that should be tested first (Yücalar & Boranda, 2016). Basic six CK metrics were combined into three metrics for software quality assessment: WMPRC (WMC + RFC), DITNC (DIT + NOC), and CBLCM (CBO + LCOM) (Padhy et al., 2017). Software CK metrics for Java and C++ projects that can indicate possible failures with high probability were analyzed (Juliano et al., 2014). Some automated tool for software code quality assessment based on inheritance, encapsulation, and polymorphism, was considered (Mwangi et al., 2014). WMC and LOC were considered as the class size factors with the aim to develop models for software defects prediction (Jureczko & Spinellis, 2010). There is a possibility to predict class fault-proneness using five out of six CK metrics (Basili et al., 1996).

Different open source and licensed tools were used for Geant4 software metrics. Some examples include CCCC (C and C++ Code Counter), CLOC (Count Lines of Code), Pmccabe, SLOCCount (Source Lines of Code Count), Unified Code Count, and DiffTool (Ronchieri et al., 2016; Vijay, 2016). The metrics were aggregated in categories like Program Size, Code Distribution, Control Flow Complexity, and Object-Orientation (Ronchieri et al., 2016). Coupling, inheritance, cohesion, and structural complexity as internal characteristics were computed using VizzAnalyzer tool. The metrics used for coupling are extracted with CBO, DAC, and Message Pass Coupling (MPC). The inheritance is measured via DIT, NOC,

LCOM, Improvement to Lack of Cohesion in Methods (ILCOM), and Tight Class Cohesion (TCC), while the metrics related to the structural complexity of classes is derived using Locality of Data (LD), Number of Attributes and Methods (NAM), NOM, RFC, and WMC. The metric related to code documentation include Length of Class Name (LEN) and Lack of Documentation (LOD), as well as LOC. The measurements were done at three open-source applications developed in Java, and the obtained values were analyzed using statistical tools, followed by establishing proper correlations between pairs of metrics (Molnar et al., 2019).

Ten different metrics were used for: complexity (WMC, DIT, RFC, and Average Method Complexity (AMC)), coupling (CBO, CA, and CE), and cohesion (two versions of LCOM and Cohesion Among Methods of a Class (CAM)) (Bos, 2019). System which calculates CK metrics, as well as hierarchical metrics, and project and module metrics, was deployed and used for Java application (Thirugnanam & Swathi, 2010). Web-based tool that enables standard software metrics and statistic calculations was developed (Vijay, 2016). Model for predicting bugs in object-oriented software using metrics was established (Kumar & Vijayaraghavulu, 2021). CK metrics related to the JUnit test cases, together with LOC, was used to evaluate the relationship between object-oriented metrics and unit testing effort, with the aid of multivariate logistic regression models (Badri & Toure, 2012). Statistical analysis was used for establishing correlation between reliability and object-oriented metrics. WMC, RFC and LOC show strong correlations with reliability, while CBO and LCOM have moderate correlations. NOC has weak correlation (Tirban, 2018). The results of the study conducted at 10 software modules indicate that optimal metrics for object-oriented software are RFC, LOC and WMC,

while NOC and DIT are less important (Lamba et al., 2017).

Improving the software measurement process was done using unsupervised learning algorithm X-MEANS, with the aim to generate a reliable analysis model from a historical database (Dahab & Maag, 2019). The possibilities for the application of machine learning techniques for software quality assurance and automatic testing, such as Neural networks (NNs), Support Vector Machine, Clustering, Decision Tree, Grammar Induction, Bayesian Based Method, Random Forest, Generic ML Techniques, have been studied (Chen & Hossain, 2022). Board-based software games, written in object-oriented programming languages, were used for obtaining a regression-based size estimation model for software metrics. The results of the study indicate that forward stepwise multiple linear regression has acceptable accuracy with the value for coefficient of determination (R) of 0.756 (Sabhat et al., 2017).

This study is guided by the idea to use artificial neural networks (ANN) with optimal three-layer back-propagation architecture to identify and find patterns between CK six basic metrics (plus LOC), with the aim to obtain optimal number of input metrics, which will be sufficient to get all the values for basic metrics, with proper accuracy. This approach represents the base for further expansion of metrics sets and model propagation in the cases of object-oriented metrics.

## 2. Methodology

Study is conducted through following steps:

- determining the set of metrics,
- data normalization,
- determining sets of input, output and hidden layers,
- testing neural networks, and

- choosing the most appropriate set of input variables.

The sample consists from 367 cases of object-oriented metrics taken for programmer's text editor written in Java, jedit 4.2 (Deepti, 2021). These metrics, among the others, include WMC, DIT, NOC, CBO, RFC, LCOM, CA, CE, LOC, CC (with values of max\_cc and avg\_cc), number of bugs, etc. For the purpose of this study, we have chosen six basic CK metrics, as well as LOC. WMC represents the sum of all complexities for all methods in the given class (Dubey et al., 2012; Țirban, 2018; Yücalar & Boranda, 2016). DIT measures the length of the path from derived class to its root in the inheritance tree. This value is equal to zero in the case of underived class, while in the case of multiple inheritances DIT represents the distance to the farthest root (Dubey et al., 2012; Molnar et al., 2019; Țirban, 2018; Yücalar & Boranda, 2016). NOC counts the number of subclasses in the inheritance tree that are directly derived from a given class. It should be used for determining the amount of time that would be spent on class testing (Chidamber & Kemerer, 1994; Dubey et al., 2012; Molnar et al., 2019; Țirban, 2018; Yücalar & Boranda, 2016;). CBO counts the number of classes from which the observed class depends on (Chidamber & Kemerer, 1994; Dubey et al., 2012; Țirban, 2018). Number of all methods that might be invoked when calling the methods of an object in the class represents RFC (Chidamber & Kemerer, 1994; Dubey et al., 2012; Molnar et al., 2019; Țirban, 2018; Yücalar & Boranda, 2016). Compatibility between the methods in the class is expressed with LCOM (Țirban, 2018; Yücalar & Boranda, 2016). LOC, as a universal software metric, counts the total number of lines (excluding blank lines or comments) in the class, giving the basic information about the project size (Chidamber & Kemerer, 1994; Molnar et al., 2019; Yücalar & Boranda, 2016).

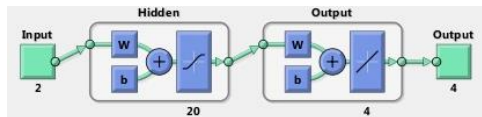


Data about measured values is analyzed using statistical tools and appropriate correlations between them are established. Based on the correlation values WMC, DIT, NOC, CBO, RFC, LCOM, and LOC are separated. WMC and LOC are easily measurable and therefore are taken as input variables, while all other metrics are used as output variables. The values of WMC, DIT, NOC, CBO, RFC, LCOM, and LOC are normalized using robust scaling and used as initial dataset for ANN modeling. These inputs are taken individually or in combination as neurons for the input layer in the ANN. For input layer with 1 neuron WMC metrics or LOC metrics are taken separately, but the results were not satisfactory. Best results are in the case when the input layer has two neurons as their combination. NOC is excluded from the study due to the fact that the measured values after robust scaling don't have proper values, so the output layer consists of 4 neurons (DIT, CBO, RFC, and LCOM). Trial-and-error method is used to determine the number of hidden neurons. Proposed NNs are trained with 10 and 20 neurons in hidden layer via back-propagation Levenberg - Marquardt (LM) algorithm, with the aid of nntaintool in Matlab 2018R. LM algorithm proved to be fastest method for training moderate-sized feed forward neural networks. Initial dataset is divided into three parts in relation 257:55:55, respectively for training, validation and testing set, with the aid of function divider. Performances for different numbers of hidden neurons are expressed in the form of correlation coefficient (R) and Mean Square Error (MSE).

### 3. Results and discussion

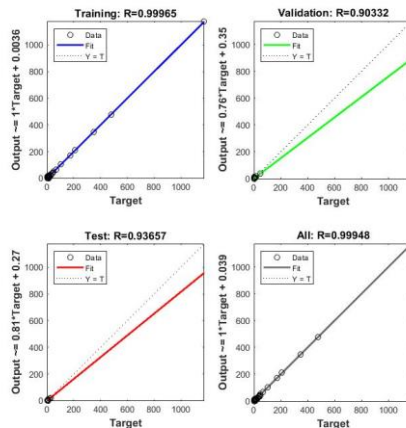
The best results are in the case of neural network with 2 neurons in input layer, 20 neurons in hidden layer with sigmoid activation function, and 4 neurons in output

layer with linear activation function. The values of WMC and LOC metrics represent the inputs' data in the form of 367x2 matrix, while the values of DIT, CBO, RFC, and LCOM metrics represent the target's data in the form of 367x4 matrix. Proposed ANN architecture is presented in Figure 1.



**Figure 1.** ANN architecture for object-oriented metrics' prediction

Values of R for training is 0.99965, for testing 0.93657, for validation 0.90332, and for all 0.99948 for proposed ANN architecture (Figure 2).



**Figure 2.** Linear regression between target and predicted values

Based on these values, it can be concluded that the network has been accurately trained, and there is a close relationship between the outputs and the targets. These values for the NN architecture with 10 neurons in hidden layer are 0.99953, 0.93811, 0.84997 and

0.9993. The values for MSE are 1.22988, 2.30203 and 0.629841 for training, testing and validation, while in case of NN architecture with 10 neurons in the hidden layer these values are higher (1.65175, 2.80312, and 1.02848 for training, testing and validation, respectively).

The best validation performance is 2.302 at epoch 11 (Figure 3). The plot shows the L-shaped distribution and follows the horizontal line trends for trained, validation and test data, with negligibly small differences in slope, indicating that there is no overfitting.

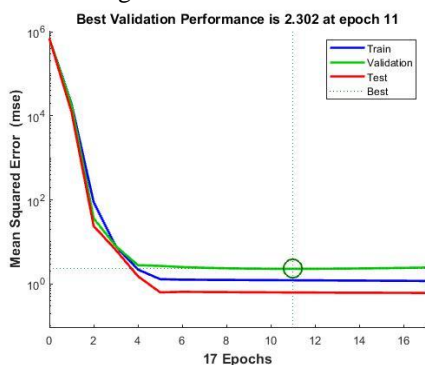


Figure 3. Performance plot

The performance during the learning process in terms of gradient, momentum gain (Mu) and validation checks with respect to number of epochs is shown in Fig. 4. It should be noticed that during the learning process, the gradient from around epoch 7 was near zero, indicating on the fact that there are slight changes in bias and weights which will improve the learning process for the validation. Convergence in ANN training model is achieved after 17 epochs (iterations) with a gradient value of 3.299. Value's changes in Mu, which is used to control weight updating process, are presented for each successive learning epoch. Its value reaches 0.1 at epoch 17, showing that chosen ANN has sufficiently large capacity to predict CK metrics. According to “validation checks” chart

(Figure 4), zero values indicate that the learning process was carried out without increasing the values of MSE in the validation phase. Some non-zero values with an upward trend are noticed after 11th epoch, which could be the consequence of the outlier's presence in the sample.

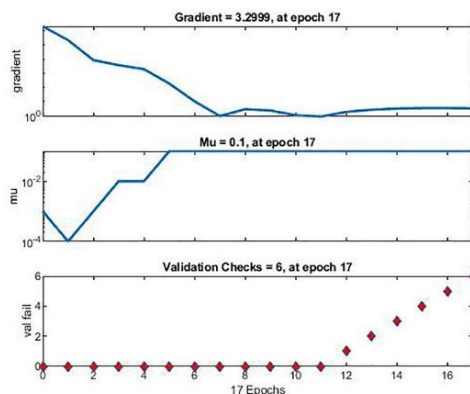


Figure 4. Gradient, momentum, and validation check values during the learning process

#### 4. Conclusion

Proposed ANN model allows quick basic object-oriented metrics' prediction and is valid enough to estimate CK metrics. Taking into account that the values for R indicate a significant and almost perfect adaption of outputs to the targets, some improvements should be made with increasing the number of input/output data, in order to reduce the value of MSE.

Another issue that should be taken into consideration is the fact that it is enough to measure only the values of WMC and LOC metrics, while DIT, CBO, RFC, and LCOM metrics could be predicted. This plays a role in reducing time and effort for obtaining numeric data related to the software projects, which leads to better and faster software quality attributes' assessment, evaluation, and above all, improves the software quality.

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## MODERN TECHNOLOGY FOR OLD-FASHIONED USERS: THE POWER OF E-WOM (ELECTRONIC WORD OF MOUTH) ON MOBILE PHONES PURCHASE AMONG OLDER GENERATIONS

**Abstract:** *The intention to purchase a mobile phone can be influenced either internally or externally. This study investigates the influence of electronic word of mouth (eWOM) particularly the source's expertise, the source's trustworthiness, the richness of message content, strength of advocacy, and tie strength towards such intention among consumers from the older generation. Compared to the younger generation, the possibility of older consumers having higher purchasing power is likely and without many people being aware of it. Some of them are interested in new technologies that will not want to be left behind. They are willing to learn and know more. Empirical data analysis involving 180 respondents aged more than 50 years old showed that the hypothesized relationships were all supported. Findings suggested that older consumers were more prone to act on their purchasing intent with credible eWOM recommended by others whom they trust. They are also attracted by strong emotional appeal from highly informative messages delivered through eWOM.*

**Keywords:** *Electronic Word Of Mouth, Purchase Intention, Mobile Phone, Older Consumers*

### 1. Introduction

Nowadays cell phones are more than a curiosity but a requirement to be up-to-date with the latest developments. As a result, market demand for mobile phones continues to grow and potential buyers are being faced with a wide variety of product choices that they can choose from to cope with this demand. Epstein (2016) describes the propensity of mobile phone firms to use new marketing approaches as an attempt to achieve a competitive advantage in their crowded market. Nonetheless, the proliferation of different product choices could become overwhelming for some

(Bughin et al., 2010), as customers are exposed to numerous marketing tactics used by cell phone companies. It is even more so since researchers such as Chung et al. (2018), Fung and Carstensen (2003), Wolfe (2005), and Tongren (1988) concluded that younger generation and older generation customers have different marketing preferences.

In this study, the focus is on the older generation customers as their number especially those aged 60 years and above is growing whereby by the year 2050, it could reach 2 trillion (UN, 2015). They thus would probably possess higher purchasing power in the years to come. Such probability is

statistically reinforced through a survey conducted in the United States by Pew Research Center that found approximately 77% of senior citizens bought cell phones in 2014 compared to 69% in 2012 (Smith, 2014). Wong (2011) considered the Asian region to have the most aging population due to statistics showing longer life expectancies and low birth rates. Malaysia is projected to be similarly populated at least 12% in the year 2030 (Wong, 2011). Cell phones here are more commonly called mobile phones for their mobility. Locals especially those having reached the age of 60 years old, use their mobile phones to communicate with loved ones or for emergencies. Such usage aid in sustaining older generation's social relationships as well as provide them with an added sense of security and safety (Hassan & Nasir, 2008). Complex features of mobile phones nevertheless might become a hindrance to older users as they are known to be less fond of innovative addition compared to their younger counterparts (Malik & Azuddin, 2013). Yet, Malik and Azuddin (2013) discovered that some older users of mobile phones are open to innovation if the outcome gained will outweigh the complexity and cost of the device. It is thus unwise to not tap into this potentially lucrative market segment since the older generation will keep on growing and the trend of mobile ubiquitous technologies will keep on being in our daily life actions.

As older consumers' purchase intention is focused on, the theoretical framework in this study is supported by Aristotle's rhetorical theory of reasoned action as well as Selective Optimization with Compensation (SOC). Kennedy (1991) explained that rational action theory concerns the resultant effect of subjective standards towards the buying intent. Concerning eWOM, older consumers' intention to buy can be affected but the degree of such impact (resultant effect) is dependent on how well the opinion of others is valued by the customer

(subjective standard). Similarly, Johnson and Mutchler (2013) explained that SOC concerns life choices made by strategizing to pick possible outcomes in their chronological age and thereby maximizing personal satisfaction while at the same time compensating for the conditions resulting from old age. Concerning eWOM, older consumers tend to deliberate their purchasing intent (strategizing) based on available options that best suit them under current circumstances (maximizing and compensating).

### **Older generation's intention to purchase**

Intention to buy is the propensity of personal behavior against a specific brand (Spears & Singh, 2004; Chang & Wildt, 1994). Such a propensity can be intentionally or unconsciously influenced by others, particularly when those important to consumers are involved (Tsai et al., 2010). This echoes previous studies (e.g. Ajzen & Fishbein, 1977; Cialdini & Goldstein, 2004; Tsai et al., 2010) that support the importance of social influence in consumer behavior. Tsai et al. (2010) however emphasized that intention would always affect individual action in a positive light. Studies by Carrington et al. (2010), Chang and Wildt (1994), and Middleton and Smith (2011) also noted similar findings that significantly associate purchase intention with brand consumption. This study deemed the driving force behind a purchasing action to be purchase intention. In a survey involving American consumers, Kitterman (2018) found those aging up to 40 years old tend to trust others that are around their parents' age and older. The trust will prevail until they reach the age of 60 years old which they then would also start to trust others that are similar in age to their children. Akhter (2003) reasoned consumers become more discerning with age as they tend to be more vigilant in decision making when they grow

older. Such behavior is apparent when the current older generation of consumers frequently act upon their buying intent if the purchase results in a beneficial outcome (Szimigin & Carrigan, 2001). However, their deteriorating cognitive abilities make it harder for them to fully appreciate items that are technologically advanced than the standard. Older consumers compared to younger ones who take advantage of the development of today's technology daily thus favor technological innovation that eases the daily routine (i.e. electronic fund transaction). Older people often act upon their buying intent until their ulterior motives, cognitive ability, and financial benefits are aligned for the purchase. In terms of commercial appeal, Williams and Drolet (2005) projected that the risk of drawing older audiences to the emotional appeal of adverts rather than reasonable ones is greater. This is because they are more inspired by emotionally stimulating, advertising messages. Henceforth, purchase intention in this study looks at the actual behavior of older consumers towards purchasing mobile phones as their intent can be influenced by the source's characteristics (i.e. expertise and trustworthiness) and message characteristics of eWOM (i.e. richness of message content and strength of advocacy).

### **The electronic word of mouth**

Cooke and Buckley (2008) noticed the popularization of adverts through social media means whilst Friebe and Campbell (2010) crowned Facebook and Twitter as the most used social media platforms for marketing purposes in the hospitality industry. Such literature suggests that online advertising is the future direction of marketing. Moreover, it is favored by companies with a limited budget for advertising as it is deemed more cost-efficient to communicate their product

online. Küster and Vila (2011) adds that the chances of achieving global recognition are also rather high than the previous offline advertisement. As a result, businesses can expand their product advertising outside of the regional market and attained prospective consumers worldwide. Further understanding of consumer behavior is thus necessary to stay competitive on the global scale (Teo & Yeonh, 2003) as business expansion necessitates changes in complementing 'global' consumers. Consumers nevertheless remain vigilant in deliberating any purchasing related decision. At times, consumers deliberate their purchase intention by considering what was mentioned online on social media as well as search engines (Ghose & Han, 2011; Geissler et al., 2006). Dellarocas (2003) views consumers nowadays as tech-savvy hence they can know what others are mentioning and even express themselves online by using the internet. Consumers might even find this sort of eWOM to be useful in aiding their purchasing deliberation. It is evident as consumers actively read various reviews and opinions posted online (Gretzel & Yoo, 2008) that are a representation of actual consumers' views in writing (Bhatnagar & Ghose, 2004). The same can be said in regards to Malaysian consumers. In the past years, reliance on online comments and reviews about certain products or services has become more prominent among conscious-minded locals. Some even considered it to be a wise choice in searching for such electronic postings as they could save on valuable time plus avoid any further hassle. Nonetheless, consumers, particularly from the older generation, may opt to not make such a choice as they might be limited by their physical and non-physical changes that come with age (Malik & Azuddin, 2013). Wong (2011) reassured that older users require more time to fully adopt the available mobile technologies hence those opting otherwise would surely rise in

numbers. Reasons for triggering their intent to purchase mobile phones includes staying in touch with acquaintances, fostering closer familial relationship through sharing emotions, aiding tool for health deterioration and personal guide for directions or places (Wong, 2011). Some of the reasons can be done remotely via social media platforms such as Facebook and Instagram as well as through communication apps such as WhatsApp and Twitter.

The purchasing intention of older users though is susceptible to likely being influenced by eWOM. This is because online eWOM might provide a more detailed and durable source of information for consumers (Banarjee & Chai, 2019). Some have even treated eWOM as a countermeasure for quality assurance (Blal & Sturman, 2014; Vermeulan & Seegers, 2009). Consumers for instance would often rely on online reviews of hotels when they intend to book for their next holiday accommodation. Such reliance affects consumers' perception and in turn their consideration when booking. A study by ComScore and the Kelsey Group (2007) gives support whereby they concluded that consumers are willing to spend more for a service that is rated higher online in exchange for higher quality service.

## **2. Hypotheses**

Consumers think eWOM message material is more trustworthy if it comes from an expert. Determining if someone possessed the expertise is a subjective matter yet, anyone who can make valid statements (Yoon et al., 1998) based on their own experience and abilities (Gotlieb & Sarel, 1991; Sweeney et al., 2014) can be called an expert. So experts are considered to have a stronger understanding of the commodity. Schiffman et al. (2013) added that the personal perception of an expert could be affected by his or her related work position, social training, or experience. Therefore,

consumers often counseled someone who possessed perceived higher expertise as the probability that they have more product insights is likely. Information received from experts has more persuasive power as their opinions are higher in value (Gilly et al., 1998; Jun et al., 2011). Ohanian (1990b), Pornpitakpan (2004), and Sternthal et al. (1978) collectively indicated that there is a positive relationship between source expertise and persuasiveness. As a result, it plays a substantial role in the consumer's purchasing deliberation (Bansal & Voyer, 2000; Money, Gilly, & Graham, 1998). Lim and Chung (2014) relate an individual's information acceptance with the source's degree of expertise, credibility, and risk. A higher degree of expertise, credibility, and lower risk increases the likelihood of affecting consumer's intentions particularly the older generation without further pondering (Bohner, Ruder, & Erb, 2002; Jun et al., 2011; Strutton & Tanner, 1994). How well older consumers perceived the information source either positively or negatively, therefore, would affect their information-seeking behavior. Strutton and Tanner (1994) discovered that such perception could result in a lower or higher affinity towards relying on a particular source. Consumers should also trust their eWOM more as the intention to buy entails unknown risks (Lim & Chung, 2014). The interest entrusted to the message content represents the faith of the receiver in the sender otherwise known as trustworthiness (Ohanian, 1990a). Chu and Kamal (2008), Priester and Petty (2003), and Ohanian (1990b) collectively described confidentiality as the degree of customer trust that knowledge derived from the content of the message is truthful, genuine, reasonable, and honorable. The following are the hypothesized relationships between eWOM source reputation and older customer buying intent:



*H1a: The expertise of eWOM sources is positively related to older consumers' purchase intention towards the mobile phone.*

*H1b: The trustworthiness of the eWOM source is positively related to the older consumers' purchase intention towards the mobile phone.*

Collectively, Chu and Kamal (2008), Priester and Petty (2003), and Ohanian (1990b) defined confidentiality as the degree of customer confidence that information derived from the message content is authentic, real, fair, and honorable. The following are the hypothesized relationships between the credibility of eWOM sources and the buying intent of older customers. The quality of message content is measured by how much the recipient values the information obtained while the strength of the advocacy is determined by how well the message delivery result is perceived (Sweeney et al., 2012). In terms of advertisement, marketing information transmitted by a narrative message is considered by Phillips and McQuarrie (2010), Adaval and Wyerjr (1998), and Padgett and Allen (1997) to be the best choice as such eWOM is more convincing because of its factual basis and not produced by the sender. In turn, both the sender and the receiver interpret the eWOM message which is transmitted with intensity and excitement more significantly. This is more evident among older generation users, as their declining cognitive capacities and perceived restricted time forced them to prioritize emotional social goals fulfillment. The following are the hypothesized relationship between eWOM message and purchase intention of older consumers:

*H2a: The richness of eWOM message content is positively related to older consumers' purchase intention toward the mobile phone.*

*H2b: The strength of advocacy of eWOM is positively related to older consumers' purchase intention on the mobile phone.*

This research contains a moderating variable, i.e. the tie intensity between eWOM sender and recipient to further shed light on customer behavior in such a relationship (Baker et al., 2016; Wang et al., 2012). Money et al. (1998) defined tie strength as a "multidimensional construct that in the context of social networks represents the strength of dyadic interpersonal relationship" (p.79). Those who received eWOM are most likely to react if the message delivered is from strong ties. It is deemed more trustworthy thus reliable compared to weak ties (Baker et al., 2016 and Wen et al., 2009). Koo (2016) reasoned that individuals involved in a strong tie often have a greater understanding of each other and in turn, they can offer suitable information that aids the other's information-seeking process. A strong tie nonetheless could bring either a positive or negative eWOM effect on branding. This is evident as a positive eWOM about a brand entices consumer's intent to buy far better than a negative eWOM would despite both having strong ties (Baker et al., 2016; Chu & Kim, 2011; East et al., 2008). Jun et al. (2011) and Wangenheim and Bayon (2004) considered tie strength as a significant moderator of interpersonal influence. It is so as older consumers have a profound appreciation towards their social relations with others. Moschis (2003) clarified that personal relationships are valued once they come into a realization of the other's affectionate feelings for them. As consequence, older consumers tend to act based on suggestions made by those who have demonstrated their affection. Fall and Knutson (2001) exemplified that the tendency often originates from friends and family. They also would probably make changes in terms of values, beliefs, and decisions to avoid being excluded from their circle of friends.

Trocchia and Janda (2000) attribute the change possibility to the older generation's desire of staying connected with cherished individuals. In this analysis, the strength of the relationship between the message sender and the receiver of the information is calculated according to the classification of strong links and weak links by Baker et al. (2016). Strong links indicate a significant relationship involving regular contact with those close to the receiver of the message while weak connections indicate a non-significant relationship involving casual contact with acquaintances or strangers. Baker et al. (2016) found close links to be reflective of a greater degree of confidence in the relationship as the message originates from a reliable source. This is therefore more effective towards recipient actions which include their intention to purchase. On the other hand, weak links suggest that even though it is distributed infrequently and originates from an untrusted source, the message has potential novel content. The hypothesized relationships between tie strength and buying intention are as follows:

*H3a: Tie strength positively moderate the relationship between the expertise of eWOM source and older consumers' purchase intention.*

*H3b: Tie strength positively moderate the relationship between the trustworthiness of eWOM source and older consumers' purchase intention.*

*H3c: Tie strength positively moderate the relationship between richness of message content of eWOM and older consumers' purchase intention.*

*H3d: Tie strength positively moderate the relationship between the strength of advocacy of eWOM and older consumers' purchase intention.*

### 3. Method

#### 3.1 Respondents

This study gathers empirical data from older consumers. Yoon et al. (2005) grouped the older generation as those aged 50 years and above. In general, older people are expected to experience deteriorating physical, motor, cognitive and memory abilities. Despite that, they possessed invaluable life experiences, accumulated knowledge, and practical skills compared to the younger generation in their respective field (Wong, 2011). They were chosen due to the increasing size of the market for older consumers. The market increase is considered a tempting business venture to marketers as it is a rapidly growing population that possesses higher disposable income and purchasing power (Eastman & Iyer, 2004). Specifically, in this study, the targeted respondents are older customers with their age varying from 50 years of age who buy cell phones or plan to do so. Wong (2011) discovered that local historical instability contributed towards Malaysians born earlier than 1953 to have undergone less formal education. The diversity of culture and ethnicity nevertheless enable locals to have a good command of different languages though most can master the country's mother tongue. Today's older generation is said to have experienced changes in their behavior as current older people achieve higher education and income leading to different lifestyles from their predecessors (Ong et al., 2008). Also said to be more insightful about what they perceive and more innovative than the previous generation (Szmigin & Carrigan, 2001).

Hence, the perceived technophobia among older people may not be relevant anymore in modern times. Wagner, Hassanein, and Head (2010) shed light on the increasing number of older consumers using online services such as surfing the internet and emailing

which contradicts the belief that older consumers are not too keen on new technology. Therefore, it is considered appropriate for this study to target older people to investigate the influence of eWOM on the purchase intention among older consumers towards mobile phones. A total of 180 questionnaires were distributed to selected representative respondents, which included 91 women and 89 males. They were chosen based on simple random sampling that allows the sample to be taken from the target population in a manner that mitigates any bias and prejudice (Kumar et al., 2013).

### 3.2 Data collection

A survey approach is applied in this study to gather equal and detailed data from respondents. Kumar et al. (2013) explained that a survey includes gathering data from a selection of respondents by using a pre-designed questionnaire. The selected respondents, therefore, are considered as representative of consumers from the older generation. This research also collected offline data, as it was proposed by Gunter et al. (2002) that better respondent control and higher response levels could be feasible if data collection were carried out offline. The overall data collection covers Klang Valley, where about 7.2 million reside in one of the rapidly growing metropolitan cities in Malaysia (Sumarjan et al., 2013). It is thus an ideal scope of the area to investigate the influence of eWOM on older consumers' purchase intention towards mobile phones. Data collected were measured against a Likert scale of 7 points and all of the variables used in the questionnaire were built based on previous studies. However, each of the variables has been changed to fit this study's context. A total of 25 questions were posed in six parts; purchase intention, source expertise, source trustworthiness, the richness of message, the strength of

advocacy, and tie strength. The completed questionnaire as per the Appendix was pilot tested beforehand to ensure the reliability and validity of data collection. Bryman and Bell (2015) asserted the importance of piloting especially when the questionnaire is self-administered as the presence of an interviewer to clarify any uncertainty would be absent. It also gives assurance that the intended survey purpose would be addressed. The test was conducted among a small group of 30 people with criteria similar to those in the sample population. Muijs (2011) recommends doing so would determine the need for further amendment to ensure that the posed questions are wholly understood by respondents.

### 3.3 Statistical procedure

Babbie (2010) emphasized that an analysis of the association between an independent variable and a dependent variable will determine the hypothesized relationship. Such an experiment is carried out in this study using the program IBM Statistical System for Social Science (SPSS). The software provides results through descriptive statistics, reliability analysis, bivariate correlation analysis, multiple regression analysis, and moderation tests based on data collected from the survey. Data collected from respondents were filtered based on their demographic differences such as age, race, gender, and level of education. The data filtering was done through descriptive analysis. O'leary (2004) explained that descriptive statistics facilitate a better understanding of the respondent's criteria through its measurement of dispersion, central tendency, and distribution shape. Such statistics permit better control of respondent selection hence allowing exclusion of data from respondents that did not meet the required criteria before further analysis is made.

**4. Results**

**4.1. Reliability analysis**

Golafshani (2003) describes reliability as the consistency shown through performance over time. Therefore, it is considered accurate if the findings of this analysis are compatible with the findings of other related research (Kimberlin & Winterstein, 2008). Reliability analysis was performed to evaluate the reliability of the data collected

for this study. The results as shown in Table 1 indicated that all of the variables in this study (i.e. purchase intention, source’s expertise, source trustworthiness, the richness of message content, strength of message delivery, and tie strength) can be accepted as the range of each variable for Cronbach’s Alpha is between 0.841 and 0.929. These were in agreement with Meyers et al. (2013) who suggested that a robust Cronbach’s Alpha should be more than 0.7.

**Table 1.** Results for reliability analysis.

Variables	Cronbach’s alpha	Number of items
Purchase intention	0.929	5
Source’s expertise	0.841	4
Source’s trustworthiness	0.891	5
The richness of message content	0.923	3
Strength of message delivery	0.911	3
Tie Strength	0.915	5

**4.2. Bivariate correlation analysis**

The bivariate correlation analysis tests the relationship between variables (Raykov & Marcoulides, 2012) through the Pearson correlation. Taylor (1990) considered the correlation efficiency of r; when it is 0.35 to be weak or low, 0.36 to 0.67 to be moderate or medium, and 0.68 to 1.0 to be either high or heavy. Findings based on such analysis as can be seen in Table 2 suggested that the relationship between the competence of the

message source and the intention to buy, the trustworthiness and buying intention of the source message as well as the wealth of message content and buying intention are moderately positive while the relationship between message delivery intensity and buying intention is weak but positive. Also, the results indicated a value of 0.000 for all variables hence statistical relationships among variables in this study are less than 0.01 in p-value.

**Table 2.** Results for bivariate correlation analysis.

	Source’s expertise	Source’s trustworthiness	The richness of message content	Strength of message delivery
Pearson Correlation	.639	.643	.582	.314
Purchase Intention Sig. (2-tailed)	.000	.000	.000	.000
N	180	180	180	180

*Note.* Correlation is significant at the 0.01 level (2-tailed)

**4.3. Multiple regression analysis**

Multiple regression analysis in this research links multiple independent variables to a

given dependent variable. Such analysis is used to investigate the relationships hypothesized, and the results are summarized in Table 3. Beta’s ( $\beta$ )

importance for knowledge, trustworthiness, message material richness, and advocacy power suggest that the experience of the message source has the most effect on the buying intention of the older people. Meanwhile, the t-statistics showed that a confidence interval of  $t > 1.960$  (2-tailed) supports the relationship between variables. These implied that the expertise of eWOM source is positively related to consumers' purchase intention (H1<sub>a</sub>), the trustworthiness of eWOM source is positively related to consumers' purchase intention (H1<sub>b</sub>), the

richness of eWOM message content is positively related to consumers' purchase intention (H2<sub>a</sub>) and the strength of advocacy of eWOM message is positively related to consumers' purchase intention (H2<sub>b</sub>), are supported. The results replicate similar findings of a positive relationship between source's expertise and persuasiveness (Ohanian, 1990b; Pornpitakpan, 2004; Sternthal et al., 1978) that subsequently influence consumer's purchase decisions (Bansal & Voyer, 2000; Money, Gilly, & Graham, 1998).

**Table 3.** Results for multilinear regression.

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-.226	.401		-.563	.574
Expertise	.483	.121	.368	3.996	.000
Trustworthiness	.308	.156	.236	1.975	.050
Richness of message content	.307	.137	.249	2.240	.026
Strength of advocacy	-.195	.084	-.173	-2.313	.022

#### 4.4. Moderation test

This research performed a moderation test to investigate whether the hypothesized relationships of the dependent variable (purchase intention) and independent variables (expertise and trustworthiness of the message source, the richness of message material, and advocacy power) shift with specific moderating variable, i.e. tie intensity (Cohen et al., 2003). Results from the test can be seen in Table 4a, Table 4b, Table 4c and are collectively for H3a. Findings in Table 4a showed that a large pattern exists between variables with 41.33% of the variables being described. In Table 4b, the tie strength as the moderating factor between the competence of the message source and

the purpose of the purchase was found to be moderate. However, its p-value was not statistically significant in terms of tie strength at a significant 5% level and the relationship between tie strength and message source expertise at a significant 5% level, whereas it was statistically significant in terms of the expertise of the message source at a significant 1% level. In Table 4c, the p-value of the expertise of the tie strength and message source was not statistically significant as  $p > 0.05$ , thus implying that bond strength positively moderates the relationship between the expertise of the eWOM source and the purchase intention of older consumers is not supported.

**Table 4a.** Results for moderation analysis (H3<sub>a</sub>).

R	R-sq	MSE	F	df1	df2	p
.6429	.4133	1.1701	41.3321	3.0000	176.0000	.0000

**Table 4b.** Results for moderation analysis (H3<sub>a</sub>).

Model	Coefficient	SE	t	p
Constant	.6371	.7333	.8688	.3861
Tie Strength	-.2156	.2173	-.9924	.3224
Expertise	.8128	.1724	4.7147	.0000
int_1	.0273	.0420	.6512	.5158

**Table 4c.** Results for moderation analysis (H3<sub>a</sub>).

	R2-change	F	df1	df2	p
int_1	.0014	.4240	1.0000	176.0000	.5158

Results from the test can also be seen in Table 5a, Table 5b, Table 5c and are collectively for H3b. Findings in Table 5a showed that there is a substantial trend between variables with 42.29% of the variables being described. In Table 5b, the tie strength as the moderating factor between the trustworthiness of the message source and the purpose of the purchase was found to be moderate. Nevertheless, its p-value was not statistically significant for the tie strength at a significant 5% level and the relationship

between the tie strength and the reliability of the message source at a significant 5% level, whereas it was statistically relevant for the reliability of the message source at a relevant 1% level. In Table 5c, the p-value of the connection intensity and the trustworthiness of the message source is not statistically relevant as  $p > 0.05$ . This indicates that binding intensity positively influences the relationship between the trustworthiness of the eWOM source and the purchasing intention of older consumers is not endorsed.

**Table 5a.** Results for moderation analysis (H3<sub>b</sub>).

R	R-sq	MSE	F	df1	df2	p
.6503	.4229	1.1511	42.9857	3.0000	176.0000	.0000

**Table 5b.** Results for moderation analysis (H3<sub>b</sub>).

Model	Coefficient	SE	t	p
Constant	.2236	.7178	.3115	.7558
Tie Strength	-.1079	.2218	-.4867	.6271
Expertise	.9830	.1691	5.8115	.0000
int_1	-.0078	.0419	-.1870	.8519

**Table 5c.** Results for moderation analysis (H3<sub>b</sub>).

	R2-change	F	df1	df2	p
int_1	.0001	.0350	1.0000	176.0000	.8519

Additionally, results from the test can be seen in Table 6a, Table 6b, Table 6c and are collectively for H3b. Findings in Table 6a showed that there is a large model between variables with 34.81% of the variables being described. In Table 6b, the results based on the intensity of the tie as the moderating

factor between message material richness and purchase intention found a moderate relationship between the variables.

Nevertheless, its p-value was not statistically significant in terms of tie strength at a significant 5% level and the relationship between tie strength and message content

richness at a significant 5% level, whereas it was statistically significant in terms of message content richness at a significant 1% level. In Table 6c, the p-value of the binding intensity and richness of message content is

not statistically important as  $p > 0.05$ , thus suggesting that binding intensity positively affects the relationship between the richness of eWOM message content and the buying intention of older consumers.

**Table 6a.** Results for moderation analysis (H3<sub>c</sub>).

R	R-sq	MSE	F	df1	df2	p
.5900	.3481	1.3002	31.3281	3.0000	176.0000	.0000

**Table 6b.** Results for moderation analysis (H3<sub>c</sub>).

Model	Coefficient	SE	t	p
Constant	.0819	.7618	.1075	.9145
Tie Strength	.1941	.2117	.9169	.3604
Expertise	1.0130	.2009	5.0431	.0000
int_1	-.0624	.0446	-1.3984	.1637

**Table 6c.** Results for moderation analysis (H3<sub>c</sub>).

	R2-change	F	df1	df2	p
int_1	.0072	1.9557	1.0000	176.0000	.1637

Results from the test which are collectively for H3d can be seen in Table 7a, Table 7b, and Table 7c. Findings in Table 7a showed that there is a considerable trend between variables with 19.16% of the variables being described. In Table 7b, the results based on the tie strength as the moderating factor between advocacy strength and purchasing intention found a moderate relationship between the variables. The p-value was

statistically important in terms of tie strength and the relationship between tie strength and advocacy strength was at a modest 1% level. In Table 7c, the p-value of bond strength and advocacy strength is statistically significant as  $p > 0.05$ , thus suggesting that bond strength positively influences the relationship between eWOM advocacy strength and purchasing intention of older consumers is not supported.

**Table 7a.** Results for moderation analysis (H3<sub>d</sub>).

R	R-sq	MSE	F	df1	df2	p
.4378	.1916	1.6122	13.9086	3.0000	176.0000	.0000

**Table 7b.** Results for moderation analysis (H3<sub>d</sub>).

Model	Coefficient	SE	t	p
Constant	-.0038	.8230	-.0046	.9963
Tie Strength	.9040	.2074	4.3583	.0000
Expertise	.8307	.2429	3.4197	.0008
int_1	-.1596	.0496	-3.2168	.0015

**Table 7c.** Results for moderation analysis (H3<sub>d</sub>).

	R2-change	F	df1	df2	p
int_1	.0475	10.3480	1.0000	176.0000	.0015

## **5. Conclusion and discussion**

This study aims to understand the power of eWOM, in particular the knowledge of the source, the trustworthiness of the source, the richness of the quality of the message, the strength of the advocacy, the strength of the bond, and the intention of the older consumer to buy the mobile phone among the older consumers. In order to do so, Aristotle's rhetoric theory of reasoned action and Selective Optimization with Compensation (SOC) theory were integrated into the theoretical framework in this study. The integration of both theories provided necessary perspectives to better grasp the relational antecedents of eWOM influence on consumers' buying behavior. The theory of reasoned action sheds light on how the influence of eWOM from people around the consumers can impact their purchasing intent. Meanwhile, the SOC theory sheds light on the norming process adapted by aging consumers when they have the intention to buy. The process though is liable to external influences such as eWOM that bring possible impact towards the buying intent. Such impact is henceforth examined as a moderator between variables using the hypothesized relationship and tie power. Results from data analysis give support to all of the variables used in this study. A bivariate correlation analysis showed a positive relationship between the message source's competency and trustworthiness, the richness of message content, and the strength of message delivery with purchase intention respectively. It also suggested that the experience of the message source has the most impact on purchase intention among older consumers. Tie strength tested showed that binding intensity only has a positive impact on the relationship between the richness of eWOM message content and the purchasing intent of older consumers.

In summary, a review of empirical evidence gathered supported all of the hypotheses in

this study suggesting that the source and content of eWOM messages also affect the buying intent of older people. Findings indicated that trustworthy advice from those they trust and considered experts encourages older consumers to act upon their intention to buy. That is because they are more likely to embrace information delivered in eWOM messages instead of challenging it. Nevertheless, the trust they place in others allows them to be exposed to the risk of being vulnerable to others' actions. When the suggestions obtained are insightful and have a clear emotional appeal, older consumers are often encouraged. This form of commercial appeal is more successful because ads that are filled with high emotions due to their perceived limited time and diminishing cognitive capacities appear to convince them.

## **6. Implications and future recommendations**

The population of older consumers is growing in numbers which subsequently gives stakeholders promising business opportunities. Efforts to sell cell phones to older generation customers are missing though. These efforts are advantageous not only to advertisers but also to customers if pursued. This study henceforth helps to undertake such efforts by providing a basis for a better understanding of how eWOM could influence the purchase intention of consumers towards mobile phones, particularly among older people. This research also complements previous consumer behavior studies particularly those that are tech-savvy (e.g., Ye et al., 2019; Shah et al., 2019). Findings will help strengthen the existing practice of advertisement for mobile phones while strategizing further advancement based on the newly learned insight from this report. It also helps marketers understand better on older consumers. This study's limitation



stems from the fact that it focuses solely on older consumers within a certain area only, hence further studies should involve

different age groups of consumers and wider study scope.

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## MOBILE GAME DEVELOPMENT OVERVIEW

**Abstract:** *Mobile game development is a rapidly evolving field that has gained immense popularity in recent years due to the widespread adoption of smartphones and tablets. Game developers now have access to powerful tools and technologies that allow them to create engaging and immersive games that can be played on a variety of mobile devices. The development process involves multiple stages, including concept design, prototyping, coding, testing, and publishing. Developers need to pay close attention to factors such as gameplay mechanics, user interface design, and performance optimization to ensure that their games provide a seamless and enjoyable user experience. Mobile game development is a complex and challenging process, but it offers tremendous opportunities for developers to showcase their creativity and talent while reaching a massive global audience.*

**Keywords:** *Mobile game development, android, java programming language, technologies, concept design*

### 1. Introduction

Mobile game development is a rapidly evolving field that has gained immense popularity in recent years due to the widespread adoption of smartphones and tablets. With access to powerful tools and technologies, developers can create immersive and engaging games that can be played on a variety of mobile devices. This has led to a surge in demand for skilled game developers who can design and develop high-quality games for the mobile platform.

The process of mobile game development involves several stages, starting with concept design, which is the process of coming up with an idea for a game. Once the concept is finalized, the next step is prototyping, where a basic version of the game is created to test the gameplay mechanics and user interface design. The development process then moves on to coding, where the game is programmed using various programming languages and software tools. Testing is a critical stage of game development where

the game is tested to ensure that it works correctly and is free of bugs.

Publishing is the final stage of mobile game development, where the game is made available to the public on various app stores such as Google Play or the Apple App Store.

Developers must pay close attention to several factors during mobile game development to ensure that their games provide a seamless and enjoyable user experience. For example, gameplay mechanics, user interface design, and performance optimization are crucial factors that must be carefully considered to create a game that is both fun and engaging.

Mobile game development is a complex and challenging process that requires a high level of skill and creativity. However, it also offers tremendous opportunities for developers to showcase their talent and reach a massive global audience. With the continued growth of the mobile gaming industry, it is an exciting time for aspiring game developers to enter this dynamic and rewarding field.

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## **2. Platforms for Developing Mobile Games**

With the growth of the mobile gaming industry, game developers have access to a range of platforms to develop games that can be played on mobile devices. In this chapter, various platforms will be presented which are available for mobile game development (Dimitriadou et al., 2021).

### **2.1. iOS Game Development**

iOS is a mobile operating system developed by Apple and is used in its iPhone, iPad, and iPod Touch devices. iOS game development is popular due to its strong user base and the Apple App Store being one of the largest app stores in the world (Zirkle and Hogue, 2014). iOS game development requires developers to use Xcode, Apple's integrated development environment (IDE), to create games for iOS devices. Developers can use various programming languages, such as Objective-C or Swift, to develop iOS games. iOS game development requires developers to pay close attention to factors such as user interface design, gameplay mechanics, and performance optimization to create high-quality games that provide a seamless and enjoyable user experience (Manning and Buttfield-Addison, 2014).

One of the key benefits of iOS game development is the standardization of Apple's hardware and software ecosystem, which provides a more streamlined development process. As such, iOS game developers have a more predictable development environment, enabling them to create high-quality games that work smoothly across all Apple devices.

### **2.2. Android Game game design problemDevelopment**

Android is an open-source mobile operating system developed by Google. Android game development is popular because it allows

developers to reach a massive audience. With the Google Play Store being the largest app store in the world, game developers have a vast market to target with their games.

Android game development uses the Java programming language and can be done using Android Studio, an integrated development environment (IDE) specifically designed for Android app development. Android game development requires developers to consider various factors such as device fragmentation, which refers to the varying screen sizes and hardware configurations across Android devices. As such, developers must optimize their games to work smoothly on a range of devices.

In addition, Android game development requires developers to be familiar with the Android SDK, which provides the tools and APIs necessary for building Android applications. Developers must also consider factors such as user interface design, game mechanics, and performance optimization to ensure that their games provide a seamless and enjoyable user experience.

## **3. Objective C vs Java progaming**

Objective-C and Java are two programming languages commonly used for game development on mobile platforms such as iOS and Android. Main differences between Objective-C and Java for game development will be provided in next chapters as well as examples of games developed using each language.

### **3.1. Objective-C for Game Development**

Objective-C is a programming language used primarily for developing iOS and macOS applications. It was the primary programming language used for iOS app development before the introduction of Swift. Objective-C is a high-level language that combines the features of C programming with object-oriented programming (Kochan, 2014; Hillegass,



2011).

Objective-C is commonly used for game development on the iOS platform because it provides access to various iOS APIs, such as the Core Animation and Core Graphics frameworks (table 1). These APIs enable developers to create high-quality graphics and animations for games. Objective-C also has a large developer community, making it easier for developers to find support and resources when developing games.

Example of Games Developed Using Objective-C:

1) Infinity Blade: Infinity Blade is an

action game developed by Chair Entertainment and Epic Games using Objective-C. It was released in 2010 for iOS devices and was one of the first games to demonstrate the capabilities of the iOS platform

2) Temple Run: Temple Run is an endless runner game developed by Imangi Studios using Objective-C. It was released in 2011 for iOS devices and became an instant hit, spawning numerous sequels and spin-offs.

**Table 1.** Objective-C Code Example

```
#import "ViewController.h"
#import <QuartzCore/QuartzCore.h>
@interface ViewController ()
@property (nonatomic, strong) CALayer *ball;
@end
@implementation ViewController
- (void)viewDidLoad {
    [super viewDidLoad];
    self.ball = [CALayer layer];
    self.ball.bounds = CGRectMake(0, 0, 50, 50);
    self.ball.position = CGPointMake(self.view.bounds.size.width / 2, self.view.bounds.size.height / 2);
    self.ball.backgroundColor = [UIColor redColor].CGColor;
    self.ball.cornerRadius = 25;
    [self.view.layer addSublayer:self.ball];
    CADisplayLink *displayLink = [CADisplayLink displayLinkWithTarget:self
selector:@selector(moveBall)];
    [displayLink addToRunLoop:[NSRunLoop mainRunLoop] forMode:NSDefaultRunLoopMode];
}
- (void)moveBall {
    CGPoint center = self.ball.position;
    center.x += 5;
    center.y += 5;
    if (center.x >= self.view.bounds.size.width || center.y >= self.view.bounds.size.height) {
        [self.ball removeFromSuperlayer];
    }
    self.ball.position = center;
}
@end
```

This game creates a red ball that moves diagonally across the screen until it reaches the edge of the screen. It uses a **CALayer** to draw the ball and a **CADisplayLink** to update the game state and redraw the screen.

Note that this is just a simple example to demonstrate the basic structure of an iOS game written in Objective-C. More complex games will require more advanced coding techniques and frameworks.

### 3.2. Java for Game Development

Java is a popular programming language used for game development on the Android platform (Liang, 2014; Ogihara, 2018). Java is an object-oriented language that is easy to learn and provides a wide range of libraries and frameworks that make game development easier (table 2).

Java for game development on the Android

platform provides access to the Android SDK, which includes tools such as the Android Studio IDE and the Android Virtual Device (AVD) manager. These tools enable developers to create and test games on a range of Android devices.

Example of Games Developed Using Java:

- 1) Candy Crush Saga: Candy Crush Saga is a popular puzzle game developed by King using Java. It was released in 2012 for Android devices and has since become one of the most popular mobile games in the world.
- 2) Angry Birds: Angry Birds is a physics-based puzzle game developed by Rovio Entertainment using Java. It was released in 2009 for iOS devices and later ported to Android, becoming one of the most popular mobile games of all time.

**Table 2.** Java Code Example

```
public class MyGame extends AppCompatActivity {  
    private MyView myView;  
  
    @Override  
    protected void onCreate(Bundle savedInstanceState) {  
        super.onCreate(savedInstanceState);  
        myView = new MyView(this);  
        setContentView(myView);  
    }  
    class MyView extends SurfaceView implements Runnable {  
        private Thread thread;  
        private boolean isRunning;  
        private Paint paint;  
        private int x, y;  
  
        public MyView(Context context) {  
            super(context);  
            thread = new Thread(this);  
            isRunning = true;  
            paint = new Paint();  
        }  
    }  
}
```

```
x = y = 0;
}
public void run() {
    while (isRunning) {
        if (!getHolder().getSurface().isValid()) {
            continue;
        }
        Canvas canvas = getHolder().lockCanvas();
        canvas.drawColor(Color.WHITE);
        paint.setColor(Color.RED);
        canvas.drawCircle(x, y, 50, paint);
        getHolder().unlockCanvasAndPost(canvas);

        x += 5;
        y += 5;

        if (x >= getWidth() || y >= getHeight()) {
            isRunning = false;
        }
        try {
            Thread.sleep(16);
        } catch (InterruptedException e) {
            e.printStackTrace();
        }
    }
}
}
```

The same example as presented above programmed in java language. It uses a SurfaceView to draw on the screen and a separate thread to update the game state and redraw the screen.

Note that this is just a simple example to demonstrate the basic structure of an Android game written in Java.

#### 4. Mobile Gaming Performance on iOS and Android

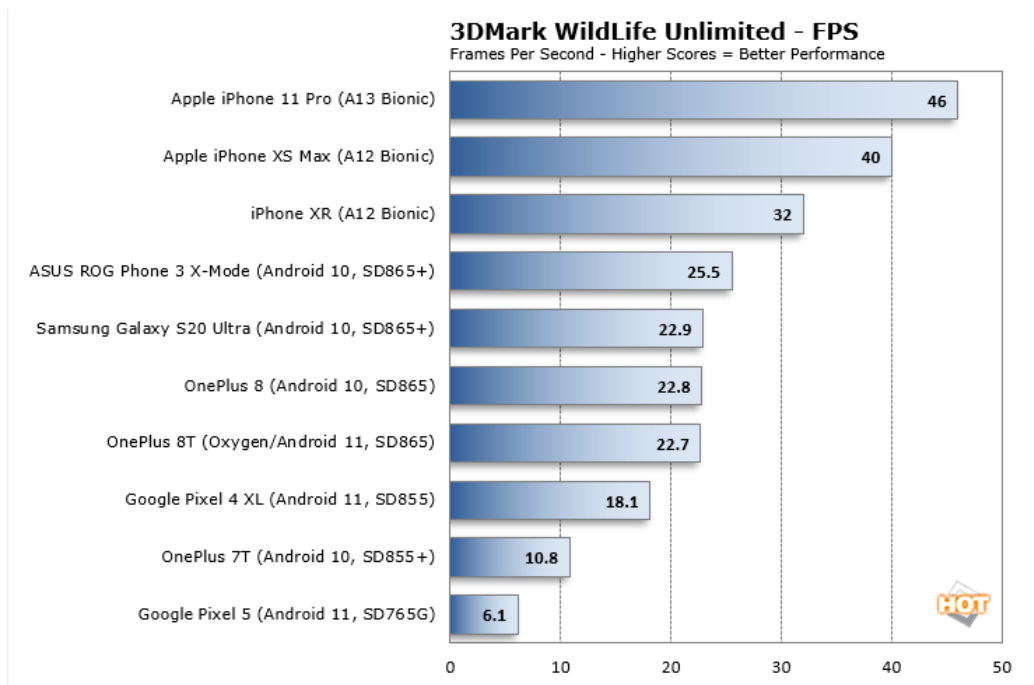
Mobile gaming performance can vary between iOS and Android devices due to a variety of factors, including hardware, software, and optimization. Some authors

said (Journal, 2022), iOS devices tend to have better performance than Android devices, but there are exceptions and variations depending on the specific device and game being played (Figure 1).

**Hardware:** One factor that can affect mobile gaming performance is the hardware of the device. iOS devices tend to have higher-end hardware components, including processors, GPUs, and memory, which can result in better gaming performance. However, there are many high-end Android devices that are capable of delivering excellent gaming performance as well.

**Software:** Another factor that can affect mobile gaming performance is the operating system software. iOS devices tend to have better optimization and more consistency in terms of software and hardware integration,

which can result in smoother and more reliable gaming performance. Android, on the other hand, can have more variations in software and hardware, which can result in less consistency in gaming performance.



Source: (<https://www.mobigaming.com/2020/10/23/android-vs-ios-who-leads-in-mobile-gaming/>)

**Figure 1.** iOS vs Android gaming performance

**Optimization:** Finally, optimization can also greatly affect mobile gaming performance. Game developers may optimize their games differently for iOS and Android devices, which can result in different performance levels. Additionally, device manufacturers may optimize their devices differently, which can also affect performance. Overall, good optimization can greatly improve mobile gaming performance regardless of the platform.

iOS devices generally have better gaming performance than Android devices due to

higher-end hardware, better software optimization, and more consistency in software and hardware integration. However, there are exceptions and variations depending on the specific device and game being played, and good optimization can greatly improve gaming performance on both platforms.

## 5. Conclusion

In conclusion, mobile game development has become a highly competitive and lucrative industry, and choosing between iOS and

Android platforms can be a critical decision for game developers.

Both platforms have their strengths and weaknesses when it comes to mobile gaming performance. iOS devices tend to have better hardware, software optimization, and consistency, resulting in smoother and more reliable gaming performance. However, Android devices have made significant strides in recent years, and many high-end Android devices are now capable of delivering excellent gaming performance.

Ultimately, the choice between iOS and Android platforms will depend on various

factors, such as the target audience, game genre, monetization strategy, and development resources. Developers should consider these factors carefully when deciding on the platform to develop their mobile game.

Regardless of the chosen platform, good optimization is crucial for achieving optimal gaming performance. Game developers should focus on optimizing their games for the target platform, taking into account the hardware and software differences and testing their games on a range of devices to ensure consistency.

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## **GAME DEVELOPMENT AND CONNECTION TO MODERN SOFTWARE ENGINEERING**

***Abstract:** Modern software engineering principles must be thoroughly understood for the complex process of game creation to be successful. This entails integrating cutting-edge software tools and technology to build interesting and enjoyable games while implementing industry-standard techniques, such as Agile development. Building a flexible, maintainable, and scalable foundation of code is essential to creating a successful game. This may be done by using efficient project management, a collaborative team, and industry best practices.*

***Keywords:** game development, software engineering, Agile development, software tools, modern technologies, project management, teamwork, code quality, scalability, maintainability*

### **1. Introduction**

Video games today require a combination of expertise in game production and software engineering. Both professions are rooted in the same fundamental concepts of creating software and applications for computers, but there are some essential differences between them. Game production requires a deeper understanding of the art and narrative side of gaming, while software engineering is all about developing and coding the necessary technical features for an application to work properly.

The field of software engineering is centered on the orderly and effective creation of software. This includes using tried-and-true methods, strategies, and equipment for creating, coding, testing, and maintaining software. Producing high-quality, dependable, and maintainable software that satisfies user needs is the aim of software engineering (Farley, 2021, Sommerville, 2020).

On the other hand, game development refers to the process of making video games. This

covers the creation of video games, as well as their design and programming. To produce games that are both entertaining and technically sound, game creators apply the principles and methods of software engineering. Also, they use specialized platforms and tools to create games, such as level editors and game engines.

Creating a realistic and engaging game world is one of the major problems in game creation. A thorough understanding of computer graphics, physics, and artificial intelligence are necessary for this. These technologies are employed by video game designers to produce dynamic characters, realistic landscapes, and fun gameplay (Flanagan, 2009).

Game creation and software engineering share certain difficulties as well. Developers, artists, and designers must work closely together and communicate effectively in order to succeed in both industries. Both also need for thorough testing and debugging procedures to guarantee that the final output is of the highest caliber and free of errors and flaws.

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## **2. Problems of Game Development in Classic Software Engineering**

The design and implementation of a game is a complicated process that calls for the use of software engineering techniques. There are difficulties in game creation, just as there are in every software development effort. These difficulties may appear at various stages of game development, from game design through implementation, and they may have a big impact on how well the game performs.

Meeting player expectations is a big challenge in game creation. Gamers anticipate an interesting, difficult, and enjoyable game. Game developers must have a thorough awareness of the gaming business, be up to date on trends and advances, and be able to produce original and cutting-edge game mechanics if they are to live up to these expectations.

Project scope and timeline management is a big obstacle in game development. Games development projects sometimes have tight deadlines, and adjustments to the project's scope might affect the budget and schedule. Game developers must be able to prioritize activities, manage resources effectively, and have a clear idea of the project's scope in order to overcome this difficulty.

Technical intricacy is a major obstacle in game creation. To create engaging and convincing environments, game developers need to have advanced programming and design skills. To create realistic worlds, dynamic characters, and fun gameplay, game creators need a thorough understanding of computer graphics, physics, and artificial intelligence.

Game creators must use software engineering development techniques to solve these obstacles. This comprises developing, coding, testing, and maintaining software using tried-and-true procedures, methods, and tools. For instance, game developers can

successfully control project scope and timeframes by using agile development approaches. Agile development places a strong emphasis on iterative development and ongoing feedback, which enables game creators to adjust to shifting requirements and deliver high-quality games on schedule.

Using already-developed game engines and libraries is another strategy for addressing the difficulties associated with game development. By giving game developers a framework, game engines enable them to produce games faster and more affordably. On the other side, libraries offer pre-built elements that can be used to increase the functionality of the game, such as music libraries and physics engines.

Game creation poses particular difficulties that can be resolved by using the concepts of software engineering. In-depth knowledge of the gaming sector, project management expertise, technological know-how, and the capacity to use the appropriate procedures and tools are requirements for game developers. By overcoming these obstacles, game creators may produce captivating and engrossing games that live up to users' expectations.

## **3. Project management practice**

Project management is the practice of planning, organizing, and managing resources in order to achieve specific goals or objectives. A project is a temporary endeavor designed to produce a unique result, product, or service. Project management is used in a variety of industries and fields, including construction, engineering, software development, and business.

The project management process typically involves five stages: initiation, planning, execution, monitoring and control, and closure. During the initiation phase, the project is defined and stakeholders are identified. The planning phase involves



developing a project plan, which outlines the project's scope, objectives, timeline, budget, and resources. The execution phase involves carrying out the project plan and completing the work. The monitoring and control phase involves tracking progress, identifying and addressing issues, and making adjustments as needed. Finally, the closure phase involves wrapping up the project and delivering the final product or service to the client.

One of the key principles of project management is that it is focused on achieving specific goals or objectives. These goals or objectives should be clearly defined at the outset of the project and communicated to all stakeholders. In addition, project management emphasizes the importance of planning and preparation. A well-planned project is more likely to be successful than one that is not.

Another key principle of project management is that it is a collaborative process. Projects typically involve a team of people with different skills and expertise. Project managers must be able to work effectively with their team members and stakeholders in order to achieve the project's goals.

Effective communication is also critical in project management. Project managers must be able to communicate clearly and effectively with their team members, stakeholders, and clients. They must be able to provide regular updates on the project's progress and address any concerns or issues that arise.

Project management also involves risk management. Projects are inherently risky, and project managers must be able to identify potential risks and develop strategies to mitigate them. This may involve developing contingency plans, allocating resources to manage risks, or making adjustments to the project plan as needed.

Finally, project management emphasizes the importance of continuous improvement.

After a project is completed, project managers should evaluate the project's success and identify areas for improvement. This feedback can be used to improve future projects and ensure that the organization continues to improve and grow.

Overall, project management is a complex and dynamic process that requires a range of skills and expertise. Effective project managers must be able to plan and organize effectively, communicate clearly and work collaboratively, manage risk, and continuously improve their processes and practices. By following these principles, organizations can successfully manage their projects and achieve their goals.

#### 4. Modern Principles of Software Engineering Project Management to Proper Game Development

The success of a game development project depends on how well it is managed. Therefore, it is crucial to apply project management principles to ensure that the project is delivered on time, within budget, and with the desired quality. As many authors show (Adams, 2014; Adams and Dormans, 2012; Flanagan, 2009, Cruz and Paiva, 2006) some project management principles that are commonly used in game development practice:

- 1) **Define the project scope and objectives:** Defining the scope and objectives of the project is the first step in project management. This involves identifying the features, functionality, and content of the game, as well as the target audience and business goals. Defining the scope and objectives helps to establish a clear vision of what the project should accomplish and ensures that all team members are on the same page.

- 2) **Develop a project plan:** A project plan is a roadmap that outlines the tasks, activities, and timelines for the project. It includes a schedule, a budget, and a list of resources needed to complete the project. The project plan serves as a guide for the team to follow and helps to identify potential risks and challenges that may arise during the project.
- 3) **Assign roles and responsibilities:** Assigning roles and responsibilities is critical to the success of a game development project. Each team member should have a clear understanding of their role and responsibilities, and how they fit into the overall project plan. This ensures that everyone is working towards the same goal and that there is no duplication of effort.
- 4) **Communicate effectively:** Effective communication is essential in game development projects. Regular team meetings, progress reports, and status updates help to keep everyone informed and aligned with the project goals. Effective communication also helps to identify issues and risks early, so they can be addressed before they become major problems.
- 5) **Manage risks:** Game development projects are often complex and unpredictable, with many potential risks and uncertainties. Effective risk management involves identifying, assessing, and mitigating risks throughout the project lifecycle. This ensures that potential problems are addressed before they become critical and helps to keep the project on track.
- 6) **Use agile methodologies:** Agile methodologies are widely used in game development projects due to their flexibility and adaptability. Agile approaches involve iterative development and continuous feedback, which allow for rapid prototyping and

testing. This enables the team to respond quickly to changing requirements and make adjustments to the project plan as needed.

- 7) **Quality assurance:** Quality assurance is critical to ensure that the final product meets the desired standards. This involves testing the game thoroughly and identifying and fixing any bugs or issues. Quality assurance should be integrated into the project plan from the beginning and should be an ongoing process throughout the project.

Project management principles are critical to the success of game development projects. Defining the project scope and objectives, developing a project plan, assigning roles and responsibilities, communicating effectively, managing risks, using agile methodologies, and ensuring quality assurance are all essential components of effective project management in game development. By following these principles, game development teams can ensure that their projects are delivered on time, within budget, and with the desired quality.

## 4.1. Agile Technologies in Game Development

Agile project management technologies are becoming increasingly popular in video game development. An agile approach is flexible and can adapt to changing requirements and priorities during the course of a project, making it ideal for the dynamic and creative environment of video games.

One of the most common agile approaches is Scrum, which consists of several phases such as Sprint planning, Daily Scrum, Sprint review and Sprint retrospective. These phases are repeated in cycles until the project goal is achieved. This approach allows for faster decision-making and flexibility in the team, as well as the ability for the client to be involved in the development of the game and provide feedback during the project

(Keith, 2010).

Another agile technology often used in video game development is Kanban. This methodology is focused on visual work management and continuous product delivery. Each task is displayed on the board and goes through several stages until it is completed. This method allows a clear visualization of the progress of the project and facilitates the identification of problems during the work.

Agile project management technologies in video game development also include test-driven development (TDD), which is based on writing tests before developing code. This method enables early identification of problems and reduces the number of errors in the final product. It also enables faster deliveries and adaptation to changes in requirements.

## 5. Conclusion

While software engineering and game development may seem distinct, they are inextricably linked when it comes to video game production. Software engineering provides the underlying structure and architecture for the game, while game development focuses on designing and implementing gameplay mechanics, graphics, and sound. The successful integration of these two disciplines is essential for the creation of a high-quality video game that is engaging and enjoyable for players.

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One of the main challenges of game development is the need to balance creativity with technical proficiency. Game developers must be able to think creatively in order to design engaging gameplay mechanics and characters, but they must also have a deep understanding of software engineering principles in order to implement these ideas effectively. Similarly, software engineers must be able to design flexible and scalable systems that can accommodate the ever-changing demands of game development.

Another challenge in video game production is the need to work effectively in a team. Game development typically involves a large team of artists, designers, programmers, and testers, all working together to create a cohesive and engaging experience for players. Effective communication, collaboration, and project management are essential for ensuring that everyone is working towards the same goals and that the project stays on track.

Despite the challenges, the fusion of software engineering and game development has led to some of the most popular and beloved video games of all time. From classics like Super Mario Bros. and The Legend of Zelda to modern hits like Fortnite and Overwatch, video games have become an increasingly important part of our culture and entertainment industry. As these two disciplines continue to evolve and innovate, we can expect to see even more groundbreaking and memorable video games in the future.

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## ALGORITHM FOR THE DEVELOPMENT OF INFORMATION REPOSITORIES FOR STORING CONFIDENTIAL INFORMATION

***Abstract:** Due to the intensive use of the Internet, network security is becoming a key foundation for all web applications. Intrusion detection by analysing records in network processes is an important way to solve problems in the field of network security. It has been identified that an intrusion can threaten not only the integrity of the data but also the system itself. With the development of information technology and an increase in data transfer speeds, there are threats of incorrect use of the Internet. The authors determine that more reliable control systems are needed that solve the problem of network protection without human intervention. In a number of sources, attention is focused on the possibility of autonomous detection of the vulnerability of programmes and protocols by analysing the criteria for the behaviour of the system itself. Many models are built on informal methods, such as signature ones, in which it is difficult to obtain a correct assessment of effectiveness and completeness. The authors start from the fact that the attack is characterised by states and transitions. The possibility of using neural networks has been tested. A distinctive feature of a neural network is that they start working only after the learning process. This is one of the main advantages of a neural network over conventional algorithms. The paper shows that the development of information storages is possible provided that an equilibrium state is reached when the system does not allow expanding the attack space and the information storage is available for both external access and remote disconnection. The learning model consists of arrays of data with a distributed storage environment. This is the main component of improving the performance of the intrusion detection system. The experimental results obtained showed that the proposed approach identifies anomalies more effectively than known methods. The paper is devoted to the development of a method for detecting attacks based on information about the behaviour of deviating values in the network.*

**Keywords:** Databases, Unauthorised Access, Internet Security, Network Processes, Virus Software.

### 1. Introduction

One of the first works in this field was a work from the USA, which defined the basic

concepts and solutions to problems. The first works were rather conceptual – there was an attempt not to build instrumental filters or methods but to try to apply probability

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theory to solve these problems. A number of sources describe the attack from the intruder's standpoint and are based on the concepts of the invasion target. The use of anomaly detection and attack detection tools is hampered by the areas of destination. The narrower the scope of application, the easier it is to apply certain research tools to it since it is easier to choose the appropriate model of network objects' behaviour (Song et al., 2015). Learning is based on connections between neurons that determine the ratio of input and output signals of a neuron. The neural network is based on the "level of training" and does not allow analytical calculation of errors. The disadvantages include the fact that the network topology and the location of nodes are determined only after a sufficiently large number of trials and errors. The main disadvantages of the neural network are inefficiency in User to Root (U2R) and right-to-left (R2L) intrusions and low reliability (Xiaoru & Ling, 2021). To solve these problems, a new approach to the deviation method based on intrusion detection is proposed. The detection of deviations is carried out to increase the stability of intrusion detection. This approach consists of two stages: training with working datasets and testing with datasets with intrusion patterns. Such data is used to prepare intrusion detection at the initial stage of implementation. Normal data sets increase the performance of intrusion prevention. If the number of errors exceeds the threshold value, the tested data set will be characterised by the system as an unauthorised action. Various methods can be used to detect intrusion but each of them is specific to a particular method. The main purpose of the intrusion detection system is to detect attacks effectively. It is important to identify the attack at the initial stage to reduce its negative consequences. In this paper, an approach of deviating values is proposed, in which the anomaly is measured by deviation factors (Gaoyu et al., 2019).

In recent years, not only the complexity of software products has increased but also the threat from virus software (Lavrov et al., 2017). It is precisely such software elements that are very popular in the black markets and are currently evolving very rapidly. They enable corporations and sometimes countries, to cause great harm to their economic and political opponents (Zhang, 2021). The virus software market is constantly growing and developing (Son et al., 2008). From small programme blocks embedded in executable files of other programmes to complex independent multi-level systems consisting of a large number of components that have different goals and objectives: installers, loaders, masking programmes, etc. The main medium of distribution of such software in the modern world is the Internet. There are a lot of intrusion detection methods but most of them are either impossible to apply in practice or are so cumbersome that they considerably reduce the performance of the user's system or the network itself. Therefore, the question of the relevance of these developments lies in the concretisation and modernisation of existing methods that theoretically fulfill the set goals but in practice they are difficult to implement (Wang et al., 2021). The use of anomaly detection and attack detection tools is complicated by the areas of destination. The more specific the speciality is, the easier it is to apply certain tools to it. Most often, certain methods come from the specific features themselves, which can "cover" all the weaknesses in ensuring the operability of the system (Dong et al., 2019).

The possibility of working with neural networks was also considered but a huge disadvantage when working with them was the difficulty of verifying the results of the study of training samples (Liu & Zhang, 2020). The adaptive method is suitable for working with network elements. It is characterised by the fact that even with low

computational complexity it will have a low level of false messages (Akritidis et al., 2020). Since this method has high performance and minimal computing power, it is suitable not only for working with databases (for which it was originally developed) but also for describing the behaviour of network elements. This method will provide high reliability when detecting attacks or unrecorded actions (Sivapriya & Kartheeban, 2018). Adaptability, in turn, will help to attract a solution to the problem in one system for a number of others. It is the problem of adaptability that is critical for most ready solutions. By combining this method, it is possible to preserve and improve the very formula of attacks using network elements (Aksvonov & Antonova, 2018). The relevance of these works is to obtain a product that can be used for any systems (Rui et al., 2020).

## 2. Materials and Methods

Given the growing threats of unauthorised access to user or company data, enterprises must constantly spend huge amounts of money to protect their data. Small enterprises are under threat, as well as large companies and holdings (Sivaram et al., 2021). Security for small businesses can depend on many aspects, such as:

- defining security policies and procedures;
- IT investment solutions;
- personnel security issues;
- data security issue;
- network security;
- virus protection;
- intrusion detection policy;
- using access cards;
- backup procedures and disaster recovery plans.

Unauthorised access is often referred to as a weakness in a controlled system where control elements cease to be effective. In

addition, unauthorised access to the system can be opened due to an error in the software, which can be used by attackers to gain access to the system or network. Detection of vulnerabilities and unauthorised actions are essential to improve the security of the network. The operating system is exposed to unauthorised access only when there are all the prerequisites for running the application, not part of it. Such applications can be various kinds of editors (photo, video), as well as numerous software complexes for performing various tasks (players, engineering applications, navigation centres) (Lavrov et al., 2015). Both the system and all applications that are compatible with this system can be subjected to unauthorised access. The reason for the occurrence of such illegal actions and abuses is the fulfilment of the following conditions:

1. wide application of this system;
2. open core access (opensource systems);
3. insufficient protection.

All these conditions are necessary to gain unauthorised access to the network, programme, or operating system. The condition of popularity is necessary for the attack to make sense and its impact to have visible consequences. It makes no sense to hack or gain access to networks that several people know about. If the system has only a couple of copies and is used by a narrow circle of specialists, then its attractiveness for hacking decreases. Another condition is the widespread distribution of the system, which affects its attractiveness for hackers (Jeong et al., 2008). System security is based on architectural or software solutions that prevent unknown functions from accessing user files and vital parts of the system. Security blocks unauthorised activity but therewith imposes certain restrictions on the capabilities of some software elements of the user (Tian, 2021). Most of the methods and software solutions available on the market cannot guarantee a consistently high level of

protection of the system, local and global networks. The problem lies in the rapid growth of new threats. The main danger of such growth is that with intensive flows of intrusions, it is almost impossible to ensure their detection by 100%.

The reasons for this increase in threats are the following factors. Mostly, the threats are created to defeat computers on the global network and the volume of writing viruses is growing every day. At such a pace of development of tools for gaining access to network components, it is impossible to write signature database updates to antivirus companies on time and considering the number and variety of threats (Jain et al., 2013). The rapid growth of threats implies that the vast majority of computers will be affected even before the release of new virus signatures. Antivirus companies need to constantly release signature updates to compete with each other and this reduces the time for analysing malicious code and negatively affects the quality of the final product. Employees simply do not have enough time for qualitative analysis of intrusion codes (Shokrzadeh et al., 2015). Neutralising malicious code is also not an easy task. Since the writing of viruses stands on a commercial basis, technologies using methods of hiding from antiviruses based on the vulnerabilities found are being developed and applied. These technologies complicate the task of recognising and removing intrusions. Threats can encapsulate self-defence procedures to prevent deletion by deactivating system utilities for registry access or process control. It also uses code that monitors the integrity of threat files and the keys necessary for operation in system registries. There are acute problems of efficient consumption of system resources. To track traffic in real time, antiviruses must have modules for working with system events, which will allow filtering streams and making threats that can compromise protection impossible. Most system events

and the frequency of their occurrence can greatly slow down the work when elaborating on threats. There are problems of incompatibility of antiviruses. Often, due to conflicts of system event interception routines, it is impossible to work with different antiviruses at the same time. There is a need for new methods of combating threats that will be based on behaviour analysis and will be able to bypass encryption. Such approaches should effectively combat old and new modifications of viruses, while maintaining high performance and minimally loading the system. It is also important to teach the system to autonomously detect unauthorised actions without accessing databases.

### 3. Results and Discussion

Modern malicious software contains a wide range of viruses that harm not only the infected system but sometimes the entire local or global network. Viruses are divided into classes with common characteristics: habitat; algorithms of operation, and destructive power. The habitat is divided into: file; boot; macro viruses, and network. File viruses are mounted in files. Boot ones are hidden in boot sectors on the hard disc. Macro viruses infect documents and spreadsheets of text editors. Network viruses spread through mail or networks. Viruses can be combined to complicate their detection. Combining masks, the presence of viruses in the system while attackers destroy it or steal user data. Examples of such combinations are file-boot and network macro viruses. They have a complex algorithm of operation and use stealth and polymorphic technologies to get into the system. Virus algorithms characterise:

1. residency;
2. using stealth algorithms;
3. self-encryption and polymorphism;
4. the use of non-standard measures.



The resident virus encapsulates its part in RAM, which then intercepts the operating system's access to the infected objects and is written in them. Resident viruses are stored in memory and are active until the computer is turned off or the operating system (OS) is restarted. Stealth algorithms hide viruses in the system. The most common stealth algorithm is the interception of OS requests to read/write infected objects. Stealth viruses therewith "substitute" unaffected areas of information instead of themselves. In the case of macro viruses, this is a ban on calls to the macro viewing menu (Liu et al., 2020). Self-encryption and polymorphism are used by all types of viruses to complicate the virus detection procedure as much as possible. Polymorphic viruses have no signatures and do not contain a single permanent piece of code. In most cases, two samples of the same polymorphic virus will not have a match. This is achieved by encrypting the main body of the virus and modifying the decrypting programme. According to destructive capabilities, threats are divided into:

1. harmless viruses – do not affect the operation of the computer in any way, except for the reduction of free memory on the disc as a result of their distribution;
2. safe viruses – the impact of viruses is limited by the reduction of free disc memory and graphic, sound, and other effects;
3. dangerous viruses – can lead to serious computer failures;
4. very dangerous viruses can lead to programme loss, data destruction, erasure of information necessary for computer operation, which is recorded in system memory areas and even contribute to accelerated wear of mechanisms, such as hard disc drive heads.

The analysis shows that it is necessary to develop methods and models for recognising both old and new modifications. Signatures allow detecting already known viruses. A signature is a set of features that can be used to characterise an object. The signs allow briefly describing huge objects. Hash functions that characterise an object using short features also function on this principle. Signs of file type, date, address, and size are called "weak signatures". A signature is a unique sign of an intrusion, through which a fragment containing it can be attributed to threats. If the intrusion is not unique, the signatures that describe it will be of the same type and will be a sequence of consecutive bytes and addresses in the file of this sequence. If the file size is known, this will be an additional trigger for the reliability of threat detection. The more information there is about the attack, the more accurately it can be characterised. Different signatures are used for different types of intrusions. The strongest signature includes an unchanged part of the virus (if it is polymorphic), which considerably increases the size of the signature. Fragmentation is used to minimise the size and length of signatures. Fragmentation allows using intermittent signatures that have two parts: common (characterising the entire type of intrusion) and unique (manually modified).

There is also a method of "halved" signatures, which allows using parts of different signatures when identifying polymorphic threats. The method operates with bit fields and may not be used with all signatures (everything will depend on their type). The difficulty of recognising polymorphic intrusions is that they remain unchanged after decoding the body into memory. The difficulty consists in the determination of the decryption time, which is the timer for the start of the intrusion. Halved signatures can detect even such intrusions by decrypting the executing fragment and already executed one. The

disadvantage of the method is the size of the signatures, so control codes are used. They are formed from the virus code and are unique. There may be several intrusions with the same control codes (collisions) but this will not affect their detection. Control codes can replace the hash functions Secure Hash Algorithm (SHA) and Message Digest 5 (MD5), despite the complexity of their application they are very compact and fit into one word (32 or 64 bytes) and eliminate the possibility of collisions. When using hash functions, the following fields are available in the antivirus database: offset, length, and hash of the file. When working with a file, the antivirus checks the hash of the fragment in the database with the specified offset and compares it with the reference value. The values are equal, which means the fragment will be the one of interest. This method is not inferior in accuracy to signature methods and has high performance and minimal requirements for system resources. The main advantage of signature methods is the accurate detection of the type of virus. This feature allows adding both signatures and methods of blocking threats to the database. Disadvantages of the signature method: threat samples are needed; the need for updates; manual threat analysis in case of collisions; identifies only known threats.

The main disadvantage of the method is minimal autonomy and dependence on updates. This method is the best from the standpoint of monetisation – the user should always pay for the possibility of updating his system. The main purpose of heuristic analysis is to track unknown and new modifications of unauthorised actions. It accepts and examines programme files, and based on the results of the work, a conclusion is made about the presence of intrusions. To get the correct result, the following steps should be performed:

1. Semantic analysis It allows recognising and converting the

executed commands into an operable form. After that, these commands are analysed to find sequences in the code of programmes that implement dangerous actions.

2. Interpretation. This step helps to find polymorphic programmes (when the action begins to perform an intrusion not immediately but at the end of a certain predetermined time or cycle). This step requires launching the application. A command stream is used for detection, which can have negative consequences for user information, so executing this code on a computer is not desirable. To do this, the emulator simulates hardware and software functions that record the activity of the executable code.
3. Pragmatic analysis. Allows determining the purpose of the attack algorithm based on the content of the teams and their groups.

**Semantic analysis** The programme affects many factors (values of registers, processor flags, memory areas). Most of these parameters will not be considered when detecting intrusions. When detecting, discrete models of viruses are used, and not every programme action acquires the status of "events", which are programme actions related to system calls that lead to changes in the system. Semantic analysis searches for and recognises sequences of commands in the disassembler listing that implement events belonging to "discrete" models. Recognition occurs as follows: a set of any elements (bits, bytes, words, or their sequences) that can be represented as an "alphabet", and these elements themselves are "letters of the alphabet". Combining elements and making different sequences out of them, different "phrases" are acquired.

Many phrases are described and will be the "language". For reference types of intrusions, finite automata are created to recognise a sequence of assembler commands that implement their behaviour. The programme is first disassembled and then recognised by automata. Based on the number of recognised fragments and their functionality, the analyser makes a verdict on the harmfulness of the executable file. Semantic analysis is divided into static and dynamic. Static one consists in disassembling the executable file image from the drive and analysing it by finite automata. This method is ineffective due to the distribution of packers and anti-hacking software protection systems. Such programmes archive/encrypt the contents of executable files, after which the programme code cannot be disassembled. The problem is solved by using libraries of unpacking algorithms, with which the antivirus can extract packaged files. The effectiveness of the method depends on timely updating of the packer type and unpacking support.

The dynamic approach uses semantic analysis with a debugger/emulator. In this case, it is not the disassembler listing that is checked but code fragments during step-by-step execution or interpretation that have preprocessing. Commands arrive at the input of the machine sequentially, as they are interpreted by the emulator, which gives an advantage when analysing packaged or self-modified objects since it becomes possible to examine objects after the wrappers/cryptographers restore the original bodies in memory and transfer control to them. This method works without using packer libraries but is resource-intensive. Dynamic semantic analysis is widely used in most antiviruses. Its advantage is a low level of possible errors and the disadvantage is low efficiency when working with non-standard codes since the machine is most often configured to recognise a given sequence of certain characters. It is enough

to find a sequence equivalent in functionality, for the recognition of which the automat is configured, and the method will lose effectiveness. For example, replacing some commands with equivalent blocks. An application programming interface (API) functions can be used instead of InternetOpenURL, and wsock32.dll, socket, send, recv instead of InternetReadFile libraries to perform similar functions. This will lead to the fact that the machine will not be able to switch to its final state and recognise the threat. For the automat to continue recognising the fragment, it is necessary to modify it considering all possible variants of the equivalent code, and this is practically impossible.

Interpretation of malicious code by the emulator. The emulator creates an artificial environment to simulate the necessary functionality for research with a high level of protection of the user's system. Even if a malicious programme or virus is running, it will not be able to harm the system or network from the emulator. The need for emulation is that the programme is not a static object, and it is not always possible to recognise it by static methods. Examples of such programmes are polymorphic viruses and packers. The static signature is programmed to appear after executing a certain number of commands. Commands can be executed, as well as debuggers – sequentially, making a stop after executing the command, setting the processor to single-stepping mode. This is how code tracing is used in real conditions. The condition will be the need to monitor the work of the human debugger to control the process and stop it. In addition, the operator will be able to determine any access of programmes to the external environment. Antiviruses, when monitoring the actions of running programmes, also use debuggers that are completely controlled by their internal

control system – the proactive protection module. This module can recognise and block standard types of unauthorised actions, working as a kind of filter. Notably, such an analysis will take place in real-time execution of programmes, and this will allow receiving up-to-date data on the presence of threats. The analyser examines the interaction of the programme with the system (checks the arguments of API function calls), giving the programme the access to real computer resources, which guarantees the correctness of the results. The disadvantage of this method is the possibility of threats entering the system and malfunction. For security purposes, programmes are run in the emulator to proactively protect against unauthorised access. During emulation, the programme is executed on an interpreter that reproduces the external environment: devices, memory, system calls. The logic of threat recognition remains similar to proactive methods. The disadvantages of emulation are:

1. The need to model computer hardware nodes and OS components. This is a complex process and requires a detailed study of the systems on which these methods and software products will work. There are many programmes on the market that emulate the main modules of the system when working with intrusions but virus writers do not stand still and have learnt to bypass even emulators. Important in emulation is modelling of work on the Internet. Here it is necessary to simulate the functions of downloading and receiving files and then saving them to disc.
2. Low performance. The emulator describes the processes of a running system, and this requires the use of huge computing resources. The speed of the software model is much lower than that of the hardware counterpart, even considering its maximum possible optimisation. Some developers create special emulation systems using physical processors, which allows them to

conduct research with maximum capacity.

3. The limitation of the "depth of emulation". Most often, a limited set of commands is used during emulation. Only a part of the programme is emulated and the emulator stops working either after executing each instruction, or by emulating the operation of blocks, and only then conducts tests for threats. At the end of the programme, its emulation loses its meaning since it goes through a cycle of waiting for new events. Such actions can be new input data or commands. When switching to standby mode, the emulator should shut down and move on to the next programme. There are two approaches to determine the onset of such a cycle. The first is by setting the emulation steps. For example, to finish the emulation after performing a specified number of different steps or operations. To finish the emulation by completing a certain number of steps or a certain number of different commands. The second approach is to set the time for emulation. After the time allotted for execution, the programme finishes the emulation. This method will be able to bypass the limitations of the command counter. It will not slow down the system because empty cycles do not load the system even when repeated. The time for performing these operations is set experimentally.

The disadvantages of heuristic methods are that heuristic analysis produces a lot of false detections when working, as well as complexity: despite the complexity of the correct setup, the method can slow down the system. These disadvantages, due to the specific features of heuristic methods, are difficult to compensate even with hardware. With their further use, it is advisable to modify and refine them to fulfil the intrusion detection task assigned to them. For the effective use of heuristic analysis methods, it is necessary:

1. To increase the effectiveness of recognising new threat modifications.
2. To reduce the level of false responses.
3. To increase the speed of the method.
4. To minimise the degree of use of system resources.
5. The possibility of adaptability.

Modern heuristic methods based on behavioural analysis and emulators allow effectively identifying unauthorised actions of a known type and unknown to the system. Artificial intelligence methods allow implementing learning opportunities for threat diagnostics. These methods can considerably improve the reliability and protection of computer systems and networks. Numerous heuristic methods are implemented based on the use of neural networks, artificial immune networks, and multi-agent systems that can detect intrusions. Notably, these methods have certain disadvantages that either slow down the overall performance of data processing systems or sacrifice accuracy. To choose the optimal tools, let us consider the most popular methods of threat detection. Production systems are systems that use a production model of knowledge representation. The production model of knowledge representation is one of the most common. The representation of knowledge through the rules has similarities in some respects with the rules of inference of logical models. This allows carrying out effective inference through products and, in addition, due to the natural analogy of the human reasoning process, these models more clearly reflect knowledge. In production systems, knowledge is represented using sets of rules of the form: "if A, then B". Here A and B can be understood as "situation – action", "cause – effect", and "condition – conclusion". However, one should not equate the production rule and the logical

sequence relation. The fact is that the interpretation of products depends on what is located to the left and right of the logical sequence sign. Commonly, A implies some information structure (for example, a frame), and U implies some action that consists in its transformation (transformation). The logical interpretation of the expression under consideration imposes restrictions on A and B. Generically, such a model has the following form:

$$P = (K, U, A \rightarrow B, E), \quad (1)$$

where: K is the class of this situation; U is the activation condition;  $A \rightarrow B$  is the essence of the product; E is the termination condition. The production model can be simplified by the order or priority that the entire set of products can be introduced. The order means that each subsequent product is used only when the previous product is not suitable. With priorities, the products with the highest priority are initially used. To combat contradictions when expanding databases (for example, the same priority), it is possible to use returns. The components of such a system are a knowledge base, working memory, and an output mechanism. The knowledge base, using products, describes the subject area. The working memory contains facts about the current stage of logical inference. The output mechanism selects the rules that the product data can fulfil. Production systems are used in the signature analysis method. Such an analysis is effective only when intrusions occur according to the same algorithms (signatures). If the attack scenario is known, then it is compared with the user's actions and if actions similar to intrusions are detected, they are blocked or deleted. If the signature does not fully correspond to the user's action but partially, then the option of notifying the operator or the antivirus system about the possibility of intrusion is possible. Most often, this method is used by network

attack detection systems (Snort, RealSecure, eTrustID, Antivirus by Zaitsev (AVZ), KasperskyLab, Microsoft Security Essentials (MSE)). Signature methods are widely used today and need constant updates to maintain efficiency and competitiveness. Production models can confirm an intrusion by working through audit files, running processes, and network ports. The advantages of production systems are as follows:

1. modularity – each rule describes a small, relatively independent piece of knowledge;
2. incrementality – the ability to add new rules independently of other rules;
3. The convenience of modification as a consequence of modularity and incrementality;
4. transparency of the system (ease of tracing the logic and explanation of the conclusion).

Disadvantages of production models:

1. the withdrawal process has low efficiency since, with a large number of products, a considerable part of the time is spent on non-production verification of the conditions for applying the rules;
2. checking the consistency of the production system becomes very difficult due to the non-deterministic choice of the products to be performed from the conflicting set.

Most of the shortcomings can be corrected by optimising for a particular production system. The statistical method considers the appearance of characteristic signs, according to which it is concluded that there is unauthorised activity. This method produces probabilistic conclusions about the presence of intrusions (when the behaviour of the system has stopped proceeding in a routine way, the statistical method will be able to identify it). When calculating the frequency of access to processor commands, a table of

their activity is built, based on which a decision is made about the presence or absence of an intrusion. This method perfectly detects polymorphic viruses that use a minimal set of commands in the descriptor. A popular method is based on the operators of probability theory and described by the following Bayes' equation:

$$P(D_i|S_j) = \frac{P(D_i) P(S_i|D_j)}{P(D_1) P(S_j|D_1) + P(D_2) P(S_j|D_2) + \dots}, (2)$$

where:  $S_j$  – events;  $D_i$  – diagnosis;  $P(D_i|S_j)$  is the probability of correctness of the  $i$ -th diagnosis detection of the  $j$  event;  $P(D_i)$  is the probability of the  $i$  diagnosis;  $P(S_j|D_i)$  is the conditional probability of occurrence of the  $i$  feature of the event  $j$ . A sample of viruses and programmes is being built, where the final data will be designated  $P(D_i)$ . Then viruses are taken and ratings  $P(S_j|D_i)$  are determined. The results are used to build data on the presence of threats. Intrusions are scanned in the system to generate a sample of events  $K, S = \{ S_1, S_2, \dots, S_K \}$ . Then the probability is found that this activity will be diagnosed  $D_i$ . To diagnose, the probabilities  $P(D_i|S_j)$  for  $S_j$  from the set  $S$  are calculated. Next is the probability:

$$P(D_i|S) = P(D_i|S_1) * P(D_i|S_2) * \dots * P(D_i|S_K). (3)$$

Then the probabilities of intrusions are calculated and the largest one is selected. This approach is not effective when working with email clients since not all signs can be described by this method. Artificial neural systems (ANN) are models of the neural structure of the brain that mainly learn from experience. The natural analogue proves that many problems that are not yet subject to the solution by machines can be successfully solved through neural networks. The ANN is a network of processors (neurons). They

process and transmit information to the following neurons. ANN are solving increasingly complex tasks step by step. The feature of ANN is training. During training, connections of neurons are detected that determine the ratio of input and output signals. During training, the ANN begins to identify additional dependencies between input and output data. When the network is trained, it can get the correct answer for new data that was not in the initial sample. The correct solution will be obtained if the original data is incomplete. The ANN allows independently receiving and processing data and the ability to generalise data. The ANN is combined with various types of architectures. The most popular application of ANN is recurrent and of direct distribution architectures. The training of the ANN can be carried out according to the initial data, without the initial data (the ANN produces a solution from the input data) and with reinforcement (using penalties). ANN can be implemented with existing complexes (Neuro solutions, Matrix Laboratory (MATLAB)) or known algorithms. To build such a network, it is necessary to have training samples. The development of a training sample depends on the process and purpose of implementation. ANN can also be implemented when building network protection systems. Based on the ANN, it is possible to organise the detection of unauthorised behaviour in networks.

The main thing in the development of the ANN is to set up the initial sample since if an error occurs, the learning process will take a lot of time and will consume a lot of resources. After the selection is set, the process is irreversible since it will be completely controlled by the embedded algorithm. It can only signal the input and check the output. Due to this, tracking the work of the ANN is quite difficult. The network topology is selected according to the implementation environment. The method has a number of disadvantages since

it is impossible to correctly select all the functions and their description from the first time. But the configuration of the entire system and its testing before implementing it into the network allows getting excellent performance both in speed and reliability. The most important thing will be to describe the algorithm considering all the subtleties of the process.

Multi-agent systems consist of agents performing tasks assigned to them. They work out only those tasks for which they are designed. Such agents are independent among themselves and there are no disputes between them. The main task is divided into subpoints, the elaboration of which is responsible for the relevant agents. The correct organisation of agents will allow correctly and quickly completing the task, which is performed through the distribution of the entire task into sub-tasks. To solve the problem, agents are grouped under the direction of the operations centre. Multi-agent systems have proven themselves well in protecting against Distributed Denial-of-service attacks (DDoS), which result in the failure of hosts, services, or the shutdown of DNS servers (Domain Name System server) and disruption of the network. This method is proposed in the works when working out DDoS attacks. User agents, violators, and defenders are programmed that can interact. Then the agents of the violators are divided into "demons" (the attack itself) and "masters" (control the attacks). Defenders are divided into: "samplers", "detectors", "filters", and "investigation agents". The "sampler" accumulates information and transmits it to the "detectors", which are responsible for responding to the onset of an attack. "Filters" monitor incoming information, and "investigation agents" counteract attack agents. An agent-oriented system has been created, which shows the work of agents to detect intrusions in the network. The test results showed satisfactory effectiveness of the method in laboratory

conditions. This method has enough positive aspects both for independent use and for combining it with other methods to increase productivity. Currently, all modifications are applied mutually with the methods of both neural networks and artificial networks since this is facilitated by sufficiently high adaptability of multi-agent systems.

Artificial immune systems are one of the tools for detecting threats. They interact closely with neural networks, genetic algorithms, and artificial neural networks. Artificial neural networks that work based on immunological methods that were first discovered in medicine and were based on the work of leukocytes. The natural immune system consists of many functional complexes. The function of the immune system in the classification of body cells for the organisation of the immune response. The analysis of works and models allows identifying the characteristics of immune systems that can be adapted to detect threats in computer networks:

- the use of antibodies to process antigens (similar to forming a response to an intrusion into a computer network);
- the use of antigens as intrusions and the development of appropriate immune responses using antibodies;
- the possibility of training antigens to work on the detection of antigens. Cloning, selection, and removal allow detecting antigens quickly and as correctly as possible through antibodies;
- the possibility of forming an immune response to any invasion (by preserving antibodies corresponding to antigens);
- regulation of the mode of selection of the necessary antibodies by working with the similarity of antibodies (threshold of compliance of the antibody to the antigen). The

similarity allows counteracting the antigen with an antibody as close to it as possible;

- the immune system allows remembering and storing all antibodies that correspond to the antigen known to the system (the memory of the immune system is formed, which functions as a database of signatures);
- the use of antibodies with high similarity allows responding to new unknown intrusions;
- the ability for scaling and adaptability.

By describing the functions of antibody paratopes and epitopes, it is possible to create mathematical models of natural neural networks and apply them in their implementation into information systems. It is through paratopes and epitopes that antibodies and antigens are combined. Such systems have a wide range of applications, ranging from optimisation tools, scanning and pattern recognition systems, building computer and network systems, and ending with the classification of information. Natural neural networks can be used to solve the following tasks: computer security, optimisation of numerical functions, combinatorial optimisation, training, bioinformatics, robotics, adaptive control system, data output, anomaly detection or error diagnosis. Immune systems are a universal model that can be used to solve a variety of tasks. At the moment, natural neural networks are of the greatest interest for use in computer systems. It is in the works that the principles of natural neural networks are used to detect intrusions and attacks in networks. The work describes the creation of natural neural networks with process monitoring elements based on the principles of negative selection (removal of unnecessary antibodies from the memory matrix) when identifying differences in user actions and attacks on the system. Various



methods based on differential equations of delay or derivatives, as well as agent-based models and stochastic differential equations are used to describe the operation of natural neural networks.

A model for detecting unauthorised actions using elements of immune models has been developed. The work of anomalies used in the construction of hybrid elements of network security and capable of detecting attacks with a low level of false responses is described. There is a disadvantage in such systems, which consists in generating a large amount of attack traffic before starting the method. Thus, these methods cannot work in real-time conditions. An adaptive approach based on immune mechanisms has been developed. Natural neural networks repeat the behaviour of the defence of the immune systems of living organisms. The above works demonstrate the prospects of natural neural networks and when working out errors. The application of natural neural networks for error processing is described. The work of agents in the implementation of the detection of unauthorised actions is described. These methods are also based on algorithms of the immune systems of living organisms. Agents act as monitors for each other when performing a common task for them. Each agent monitors other agents for compliance with their task. If the agents cannot deal with the task, they are removed and replaced by others. Most often, the agents work on the algorithms of dendritic cells of the immune system.

The method of combined use of neural networks when working with traffic is described. Such a system is independently trained on input data for the possibility of self-detection of intrusions. The main advantages of such a system are autonomy and high accuracy of threat detection. Low performance is conditioned upon the long learning process. Describe the creation of a multi-agent neural network with the ability to maintain statistics of vulnerable network

elements. The approach allows not only monitoring such nodes more closely but also testing them for intrusion. The possibility of predicting the values of time series using a neural network is considered. A method of clonal selection has also been developed for evaluating the correctness of data. The works are based on the application of diagnostic methods of diseases in medicine to build systems for detecting computer attacks using the theory of neural networks. The search for unauthorised actions was carried out based on combining methods of immune and neural networks. The analysis of modern intrusion detection methods shows that the main area of improving the efficiency of systems lies in combining various methods and technologies to solve problems. There is also a need to create software systems that will help to improve the reliability and efficiency of existing systems for detecting unauthorised actions in computer networks.

In the field of computer security, many resources are aimed at improving the effectiveness of protecting users from unauthorised actions in cyberspace. One of the ways to increase the security of a computer system is to use an intrusion detection system. The diagnostic method is related to intrusion detection systems but is based on principles developed in medicine. Through informatisation in the field of medicine, the development of new milestones in computer technology becomes possible. Unfortunately, such methods are often purely theoretical, that is, those that work only on paper and mathematical models. The main difficulty in their design is the selection of the right technological and methodological base, which will allow such methods to be applied in real conditions. Such methods are based on the diagnosis of intrusions. When diagnosing intrusions, the corresponding functions of the system are monitored, in the same way as in medicine, an examination is carried out, and symptoms of the disease are detected. Symptoms use

the values of examinations to calculate the probability of detecting a certain disease in the human body. Binary symptoms, as a special class of symptoms, use change detection algorithms: threshold or Correspondences by Sensitivity to Movement (CSM) to calculate and form signatures of attacks or unauthorised actions. The Dempster-Schafer theory (Liu et al., 2020) is used to characterise such beliefs, operating with the basic concepts of combining and using merge operators.

The diagnosis is made by analysing the probability of assessment reliability of various sets of the combined evidence penetration structure states of symptoms for the diagnostic tree represented by the specification tree to determine the security of the system or organism as accurately as possible. With this process, the intrusion detection system can combine the characteristics of both signatures and anomaly detection systems, and can detect known or new attacks and unauthorised actions of the system. The system can detect previously known and new attacks similar to the types of intrusions previously declared by the system. The systems built in this way have shown good efficiency when working with pre-defined DoS attacks. The intrusion detection system was built and configured against several known cases of Transmission Control Protocol (TCP) and DoS attacks, which the method could correctly diagnose at runtime. Pseudo-intrusions that were not known to the system in advance were also declared. Such types of intrusions were constructed from the characteristics of known attacks for the testing system and were quite correctly diagnosed and detected. Existing software solutions have some support in terms of intrusion prevention and detection but they lack the ability to diagnose. There are prerequisites for the application of medical diagnostic methods in computer systems. Existing methods cannot fully identify all threats in networks, so

combining new approaches with existing methods can give good results and increase reliability. These systems have disadvantages in the timeliness of detecting attacks but the use of diagnostic methods can positively affect the performance of known methods, minimising the cost of monitoring the network and streams.

#### 4. Conclusions

Collecting information at multiple architectural levels using multiple security filters to perform a correlation analysis of intrusion symptoms allows identifying the symptoms of intrusion first, and then their causes. With their use, it is possible to assess losses in individual components of the system. Previous theoretical methods have shown effectiveness but have not been implemented in real conditions and systems. When talking about diagnostics, the authors imply the ability to clearly identify the causes of intrusions and assess their effects on an individual system of components. Through diagnostics, it is possible not only to detect an intrusion but also to prevent it in advance, using methods of constructing a tree of diagnoses (similar to signatures but working without updates and identifying new forms of attacks and modifications of old ones). This technology can expand the capabilities of intrusion detection systems, raising them to a qualitatively new level. The main idea is to collect information at several architectural levels (network, operating system, databases, and applications) using security filters and complex event processing technology to perform a correlation analysis of intrusion symptoms.

The idea of collecting information from sources was theoretically described earlier. The methods presented in this paper use the concepts of correlation and multi-analysis but do not solve the problem of diagnosing anomalies in the system. The proposed approach considers the process of escalation

from the symptoms of the invasion to determining the causes of the invasion and assessing the damage caused using ontologies. Two sets work in pairs: the first allows observing the symptoms, and the second allows making verdicts about the presence of attacks or anomalies. The output of this process can then be used for recovery processes, and eventually to ensure the reliability of detecting unauthorised actions.

Theoretical tests have shown that this approach improves the results of detecting unauthorised actions in terms of increasing the reliability of the decision-making process. This method can detect new attacks without having any information about them. It is possible to encapsulate signatures, which will not only detect an intrusion but also determine the class and type of attacks.

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## DESIGN AND ANALYSIS OF THE CHAMELEON SCHEDULING ALGORITHM FOR RECONFIGURABLE COMPUTING

**Abstract:** Conventional power generation is the source of widespread worry over the depletion of nonrenewable energy sources and the environmental difficulties that this would inevitably cause. As a direct consequence of this, an increasing number of people are gravitating toward renewable energy sources like as photovoltaic boards and wind generators. Wind power is being put to use for a vast array of applications, some of which include the charging of batteries, the pumping of water, the generation of electricity for homes, the heating of swimming pools, the operation of satellite power systems, and many more. However, despite the fact that they do not need any sort of upkeep and do not result in any kind of pollution, their installation costs are high in many different contexts. Wind energy is quickly becoming a more significant contributor to the total installed power capacity around the globe. In the field of wind energy, the PMSG-based wind turbine equipped with a variable-speed and variable-pitch control system are the most common type of wind power generator. This device is capable of operating either independently or while linked to an existing grid. It is necessary to have a complete understanding of the machine's modelling, control, dynamic, and steady-state analyses in order to obtain the maximum possible amount of power from the wind, researchers must make an accurate prediction of the machine's performance in either mode of operation. The complexity of the systems, the sensors required, the speed of combination, the cost, the breadth of effectiveness, the technology employed, and the popularity of the systems all vary. Multiple control computations are performed on the Wind Energy Conversion System (WECS) in order to produce maximum power in a variety of wind speed scenarios. This is done so that the system can respond appropriately. The purpose of this work is to suggest several methodologies for obtaining dynamic features from the WECS integrated grid. The first technique makes use of the Firefly Algorithm (FA) as well as the Artificial Neural Network (ANN) methods. Both are classification algorithms. By utilizing the most effective parameters for design, the design of the grid-integrated power system design was able to achieve a voltage THD of 11.47 percent.

**Keywords:** Wind Energy, Control Algorithm, ANN

### 1. Introduction

Wind energy is quickly becoming one of the most promising and competitive alternatives

to traditional forms of energy production throughout the world. The utilization of this energy is necessary for socioeconomic

growth as well as economic success. In this day and age, renewable and other nonconventional sources of energy are gaining more attention than they ever have in the past. Wind energy conversion systems, often known as WECS, take use of the wind in order to transform mechanical energy into electrical energy. Control of the speed can be either fixed or variable when using WECS. Operating a wind turbine at varied speeds has a number of advantages, some of which include less strain on the gearbox, higher annual energy collection, elimination of the requirement for blade control devices, and enhanced controllability. In order to keep up with the tremendous rise in size and technology of wind turbines, a control system that was far more complicated was necessary. This item investigates the power flow analysis of grid-connected WECS in a setting with a significant amount of wind variability. It's possible to get the maximum power out of a wind turbine if you control it the right way. Wind turbines are made up of two parts: one that monitors the DC connection voltage and another that determines where the turbine is producing the most electricity. In this chapter, a general introduction to the WECS is presented, including topics such as its dynamic modelling structure, classification, and control topology. During the course of the ongoing inquiry, a filter is being implemented between the WECS and the network in order to enhance power quality during interruptions, reduce total harmonic distortion (THD), power factor, islanding, and frequency, and reduce power factor.

It is possible to use wind power to regulate either mechanical or electrical power; however, electrical power generation is one of the forms of energy generation that is expanding at one of the quickest rates in the world today. Since at least three thousand years ago, people have been taking use of the power of the wind. Around the start of the 20<sup>th</sup> century, windmills were first put to

use to grind grains and pump water. Prior to this time, these tasks were performed by horses. As a direct consequence of this, early phases of the development of modern industry saw a shift away from relying on wind power in favour of fossil fuel-powered engines and electrical networks, which offered a more reliable supply of electricity. The production of mechanical power and the creation of electrical power are the two primary applications for wind energy. The flow of air across the earth is referred to as wind. Because of the sun's influence, the surface of the Earth is heated in an uneven manner. There is a wide range of rates of solar heat absorption over the surface of the Earth due to the differences in land and ocean cover. The atmosphere over land has a speedier ascent in temperature compared to the atmosphere above water. When air that is lighter and colder than the surrounding air rushes up and expands and rises above the air that is heated by the earth, winds are produced. Because the air cools off more quickly over land than it does over water, the winds switch directions as the sun goes down. Significant air winds are produced in the region surrounding the equator because it is exposed to a greater amount of sunlight than the land that is between the North Pole and the South Pole. Wind power is regarded to be a form of renewable energy due to the fact that it is a constant force in the environment. Wind energy is produced when Hydrogen (H) is converted to Helium (He) as a byproduct of nuclear fusion in the centre of the sun. The sun generates heat and electromagnetic radiation as a byproduct of the fusion of hydrogen and helium, and this heat and radiation is sent into space in all directions. Even though just a minute fraction of the sun's rays reaches Earth, they provide most of the energy that sustains life on this planet. Wind power is a significant contributor to the global energy market and a well-established foundation for the development of cutting-edge methods of



power generation. Wind power is a leading energy technology due to the technological maturity of the technology and the speed with which it can be implemented. There is no realistic upper limit to the percentage of wind energy that can be integrated into the electrical grid, making wind power a potentially limitless source of power. This is because there are no upper limits on the amount of wind energy that can be incorporated into the electrical grid. This allows for a much greater potential for its use. The Earth receives approximately  $(1.8 * 10^{11})$  MW of solar power, but only about  $3.6 * 10^{19}$  of this power is converted into wind energy, and approximately 35 percent of this wind energy is lost within 1000m of the Earth's surface, according to a study published in Nature Geoscience. The capacity of the world's wind farms to convert wind power into other forms of energy is approximately  $1.26 * 10^9$  megawatts. Wind power has the potential to satisfy the total demand for electricity around the world, despite the fact that the global consumption of energy has increased by a factor of 20 in the past 20 years. Wind power is the process of harvesting the kinetic energy of the wind and converting it into a form that can be used by humans. This process is referred to as "harvesting the wind." Systems that use the power of the wind as a source of propulsion are included in this category, as the name of the category suggests. To put it another way, the electricity is produced by a pair of wind turbines that are in close proximity to one another. A wind farm is currently being built offshore, and it is anticipated that it will be operational in the not-too-distant future.

## 1.1 Need for wind energy system

The depletion of environmental variables and fossil fuels served as a driving force behind the development of clean and safe renewable energy sources such as wind,

solar, and hydropower. By incorporating WCS, the impact that the conventional electricity system has on the surrounding ecosystem can be reduced. Traditional wind power systems, on the other hand, have a number of technological challenges that will need to be overcome before they can be integrated. All of this contributes to the fact that it is absolutely necessary to find solutions to the difficulties associated with overcoming the nature of distributed wind generators, concerns regarding the power quality of large wind farms, and the need to overcome difficulties associated with the integration of large wind farms (Bondalapati, 2001).

## 1.2 Growth of wind energy systems

Wind power is produced by harnessing the power of the wind to drive electric generators and carry out mechanical work such as milling and pumping. Wind power is an environmentally friendly and renewable form of energy, especially when compared to the combustion of fossil fuels. A wind farm is constructed from a large number of separate wind miles, all of which are connected to one another to create a bigger total.

Onshore wind turbines are a relatively inexpensive method of generating power when compared to coal and gas plants. Onshore wind farms have a considerable impact on the environment due to the fact that, in comparison to other types of power plants, they typically need to be dispersed across a wider geographic area and built in remote or wilderness locations. Wind turbines installed offshore are more powerful and stable than those positioned on land; nonetheless, the construction and maintenance costs of offshore wind turbines are higher. Small onshore wind farms have the ability to sell some of their electricity to the grid or to power regions that are not connected to the grid.

Wind is a fluctuating energy source, and as such, it is unable to create or distribute electricity when it is required. As a direct consequence of this, the amount of power generated changes significantly across very short time periods yet stays the same from one year to the next. Because of this, it cannot be used alone to produce a consistent supply of electricity; rather, it has to be combined with other types of power generation. In order to support the rising usage of wind power in a region, there is a demand for additional conventional power sources (such as electricity generated by fossil fuels and nuclear power, for example). When wind output is low, demand can be lowered by employing various power management strategies. These strategies include having dispatchable power sources, having adequate hydroelectric power with extra capacity, geographically spreading out power generation, and exporting and importing power to neighboring boring regions.

### **1.3 Wind energy conversion system and components**

A wind turbine and generator are included in the setup, in addition to the necessary connection and control systems. Wind turbines can be broken down into two primary categories: those with a vertical axis and those with a horizontal axis. The movement of the turbine is controlled by one or more blades in the majority of modern wind turbines. These blades can direct the turbine either downwind or upwind, depending on which direction the wind is blowing. The orientation of a wind turbine is the primary factor that determines whether it has a constant or variable speed when operating. Electronic electricity converters are necessary for variable-speed wind turbines because they are unable to supply their loads with a constant frequency and voltage without them. This is due to the fact

that wind turbines with variable speeds produce more overall energy. The vast majority of turbine manufacturers employ reduction gears as a means of striking a balance between the requirements of high-speed three-phase generators and low-speed turbine rotors. Direct drive systems offer wind turbines a number of benefits, including high levels of reliability, low levels of maintenance requirements, and reduced overall costs. Direct drive systems are utilised by certain types of wind turbines. In recent years, a number of turbine manufacturers have moved toward employing the direct-drive method in their products. The squirrel cage type and the wound rotor type of wind turbines can now make use of synchronous generators, permanent magnet generators, and induction generators. Previously, only induction generators were available. Two common varieties of generators used in wind turbines are known as squirrel cage induction generators and permanent magnet synchronous generators. There are benefits to be gained from utilising either of the two different types of generators. Induction generators, synchronous generators, and winding-field synchronous generators are the three distinct varieties of generators that are suitable for use in high-power wind turbines.

Utilizing connectivity devices allows for power regulation, a gentle starting process, and other connecting procedures to be carried out. Power electronic converters are often the gadgets that fall within this category. In current turbine inverters, the usage of forced commutation inverters, also known as pulse width modulation inverters, is prevalent because these inverters provide a steady output voltage and a consistent frequency. Inverters for wind turbines have been able to make use of both voltage source voltage-controlled models as well as voltage source current-controlled models. The use of dual PWM converters makes it possible for high-power wind turbines to establish a two

way directional flow of electricity between the generator of the turbine and the utility grid. It is not out of the ordinary for a wind energy system to consist of blades and a tower, a rotor and gearbox, in addition to an alternator. The rate of wind speed rises proportionally with the height of the tower. It is utilized to raise the height of the rotor in order to collect a greater amount of power from the wind.

**Rotor:** It is constructed out of anything that resembles the wing of an aeroplane. When air moves across the blades of a wind turbine, it results in the generation of mechanical power.

**Nacelle:** This apparatus is integrated into the rotating rotor of the turbine itself and is situated at the very top of the tower that houses the turbine. The generator, the gearbox, and the motor are all examples of mechanical components that make up the turbine rotor. The nacelle is able to rotate in response to the direction that the wind is blowing in order to maximise the amount of wind energy that can be harvested.

**Gearbox:** In all other respects, the vast majority of machines have rotor speeds that are lower than one hundred revolutions per minute (rpm). To generate electricity, electrical generators require anywhere from 1,000 to 3,600 revolutions per minute in their motors. In order to generate electricity from a turbine, gearboxes are constructed with the capability of increasing the low speeds of the turbine's rotor to high speeds.

**Alternator:** Alternators are devices that directly convert mechanical energy, such as wind potential, into electrical energy. However, among all of the electrical machines that are used for maintaining a constant speed in wind turbines, the Squirrel Cage Induction Machine (SCIM) is the most well-known. Additionally, it is one of the most significant sorts of wind turbine generators that is now on the market. The rotor of the wind turbine is connected to the

capacitors of the bank, whilst the stator of the bank is connected directly to the grid. This type of machine has a few drawbacks, including a poor efficiency in the system that converts energy, greater maintenance expenses, and a restricted capability to control both active and reactive power. It should come as no surprise that the Doubly Fed Induction Machine, often known as the DFIM, is one of the wind turbine machines that is utilised the most. Roughly half of all wind turbine systems currently in operation make use of this machine's variable speed technology. This helps to lower drive train mechanical stress as well as power oscillation, all while increasing the power that can be mechanically collected. When contrasted to SCIM, DFIM utilises pitch control to restrict the quantity of wind energy that can be captured at higher wind speeds. This is done in order to maximise efficiency. Because DFIM decreases mechanical stress and increases maximum power point tracking (MPPT) for speed controller techniques, it is now able to regulate both active and reactive power with more flexibility. It has been pointed out that the use of brushes in double-fed induction machines (SCIMs) is a disadvantage for wind energy conversion systems, despite the fact that SCIMs are more durable and require less maintenance.

### **Synchronous generators:**

The fundamental advantage of the design of the machine is that it may deliver reactive power to other components of the power system that demand it. This capability is found in sophisticated synchronous generators. In most cases, a synchronous generator is used in wind-diesel hybrid systems. This generator is normally linked to the diesel engine. Synchronous generators that are put on a wind turbine need to have rigorous controls applied to them so that the rotor speed does not go over the synchronous speed when turbulent circumstances are present. In addition to this,

the utilization of spring-mounted or damper-mounted gearbox assemblies is required in order to contribute to the reduction of turbulence. This is a requirement in order to help with the reduction of turbulence. When it comes to applications involving smaller size ranges, synchronous generators typically have a higher price tag than induction generators do. Synchronous generators, to put this another way, are more prone to malfunctioning than asynchronous ones are.

**Permanent Magnet Synchronous Generator (PMSG):**

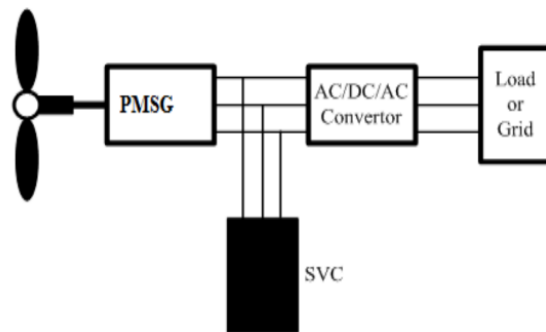
As can be seen in Figure 1, a grid-connected PMSG is required in order to connect direct-drive wind turbines to the electrical grid. The following is a condensed version of the advantages that PM machines have over

machines that are electrically excited:

- Enhanced capabilities in terms of both energy production and efficiency.
- Excitation of magnetic fields does not call for the use of any supplementary power source. The thermal characteristics of the PM machine have significantly improved as a result of the elimination of field losses.
- Increased reliability is achieved through the elimination of mechanical components such as slip rings.
- A greater power-to-weight ratio as a direct result of the reduced overall weight.

The following is a condensed list of the drawbacks associated with PM machines:

One of the most significant drawbacks of utilizing this material is that it loses its magnetic properties when subjected to high temperatures.



**Figure 1.** The General Arrangement of the Full Variable – Speed System Using PMSG

To put it another way, particle matter (PM) has become more desirable as a result of improvements in its performance as well as a decline in the cost of the material. As a result of recent developments in technology, direct-drive wind turbines are increasingly reliant on PM machines that are outfitted with full-scale power converters. This trend is expected to continue. Consider putting variable speed concepts into action, such as those that involve a full-scale power

converter and either a single-stage or multiple-stage gearbox drivetrain, so that you can cut down on the amount of money you spend on your annual energy bill. An illustration of this would be PMSG systems that either have multiple-stage gearboxes or single-stage gearboxes because both types of gearboxes are in high demand on the market.

## 2. Literature survey on grid integrated wind energy conversion system

The idea that wind power can be utilised in a diverse range of ways that are not only good for the environment but also socially and economically acceptable has gained widespread acceptance in recent years. As a result of the diminishing availability of fossil fuels and the growing significance of concerns regarding the environment, there has been an increase in the utilisation of wind power. Wind power generation has been determined to be the renewable energy source with the highest annual growth rate. This is due to the fact that producing electricity with wind is not only beneficial to the environment but also economical. Wind energy conversion systems, abbreviated as WECS, are the devices that are currently responsible for transforming the kinetic energy of the wind into useful forms of power. The mechanical energy produced by wind turbine generators and windmills is then converted into electrical energy. This kinetic energy could be used for a variety of purposes, including pumping water, grinding grain, or powering machinery. Wind turbines garner a lot of attention when it comes to the topic of meeting the targets for renewable energy that have been set by governments all over the world. Wind farms that contain turbines with multiple megawatts of capacity are able to accomplish these goals. In the past year, offshore wind resources have become increasingly more important. Wind turbines on land have been limited in their ability to generate renewable energy due to environmental regulations and controversy; however, offshore wind turbines have a significantly greater potential to do so. Offshore installations require the construction of substantial platforms that are capable of supporting the combined weight of the structure and the wind energy conversion system. Efficiency and

dependability aren't the only factors that need to be taken into consideration for offshore installations. The security of offshore installations is another important factor that needs to be taken into account. The utilisation of wind power in the generation of electrical power is becoming increasingly recognised as a technology that is both beneficial to the environment and economically advantageous. The generation of wind power has witnessed rapid expansion over the course of the last decade, earning it this honour as a result. This chapter covers a wide variety of wind turbine systems, each of which has its own set of distinguishing qualities as well as applications. This introduction to wind energy conversion will cover topics such as how wind energy is generated, what components make up a wind energy system, how the system operates, and what kinds of wind turbines are available (WTs).

### 2.1 Wind energy conversion system

As a result of the growth of the global economy, there is an increasing demand for dependable sources of energy. Because of how favourable the conditions currently are, it is feasible to meet the ever-increasing demand for electricity by harnessing the power of the wind. Wind power has reached a point where it can now be routinely used by utilities as a source of energy generation. This was previously not possible. The improvements that have been made in the industry are to blame for this level of readiness. Reliability, availability, and maintainability of WTG are crucial factors that must be met before wind power can be used extensively. Efficiency in the conversion of wind energy is also very important.

Mittal et al. have compiled a list of the aspects of WECS that pose the greatest amount of difficulty. This report examines the most recent developments in wind

energy conversion systems and discusses them in detail. This course covers a variety of topics, including the categorization of systems, the various options for generators, as well as the social and environmental benefits of these systems. In addition to these topics, a report on the progress of Canadian and IEEE1547 interconnection standards will be presented. This report will cover issues with connectivity for dispersed resources such as wind and electric power systems and hybrid power systems, and it will discuss how the standards are progressing.

A generator that can change its speed and is connected to the grid WECS adhere to the straightforward method of control proposed by Kesraoui et al. for this kind of system in order to achieve the highest possible output power. When it comes to getting the most power out of a wind turbine, the Maximum Power Point Tracking (MPPT) system is the way to go. This system only makes use of direct current (DC) link electricity. MATLAB-SIMULINK was used to develop models of MPPT and search methods, as well as DC-DC and DC-AC converters and PWM controllers. The simulations indicated that the system would be capable of harvesting the maximum amount of wind power and precisely distributing that power throughout the system.

According to C. Xia and colleagues direct-driven WECS equipped with three-level inverters have neutral-point potential balancing. During this training session, the direct-driven WECSs were supplied with power by a three-level (TL) chopper that was positioned in front of a diode-clamped inverter. By utilising a switch-signal phase delay control, also known as SSPDC for short, we were able to achieve a state of equilibrium with regard to the NP potential of the TL inverter. In addition to tracking the maximum power point, the controller that was developed for the boost chopper was also used for this purpose. It contains two PI

regulators and was used for both of these purposes.

The research of Toledo and colleagues looked into the most recent developments in wind energy conversion systems. It would be helpful if you could provide a citation for this. Conducting research on the various aspects of the process that are pertinent to the transformation of wind energy is necessary if one wishes to achieve maximum efficiency.

This study ought to centre on the technical aspects of offshore wind turbine nacelles in addition to the most recent advancements in the field of renewable energy technology. In this article, the technological obstacles, current research and development trends, and potential future study areas for reducing the weight and volume of the nacelle are discussed. This page also includes, for your research and consideration, a comprehensive review of the more conventional methods for generating electricity using wind power.

Both vertical and horizontal axis wind turbines, abbreviated as VAWT and HAWT respectively, are the most common types of wind turbines (VAWT). Activities conducted downwind as well as those conducted upwind are both possible with a HAWT having two or three blades. This HAWT gives you the option to operate at either a constant or a variable speed depending on your needs.

In power plants that operate on renewable energy sources, induction machines are utilised quite frequently. This is due to the fact that not only are they easily accessible, but they also have a reasonable price point. However, static and reactive compensating capacitors can be used in conjunction with large power systems to correct power factor and reduce harmonics. Utility grids have the ability to control voltage and frequency. Asynchronous generators are by far the most common type of generator used in hydroelectric and wind power plants.

Depending on the application, they can also be used in prime movers that are powered by diesel, biogas, or natural gas. Alternatively, they can be powered by gasoline or alcohol-based fuels. An induction generator can be utilised not only as a generator but also as a motor, and it does an excellent job of fulfilling both of these roles. In addition to being the most cost-effective generators currently available on the market, these models feature a sturdy construction that enables them to withstand short circuits.

There is a connection between Sliding Mode Control (SMC) and Field Oriented Control, which is based on dual-stator induction generators (FOC). [11] (FOC). The nonlinear properties of wind turbines that are fitted with electric generators necessitate some interesting control requirements for wind energy conversion systems (WECS) that are connected to the standard electrical grid. The SMC is a robust nonlinear approach that utilises discontinuous control in order to bring the system state trajectories into alignment with a predetermined sliding surface. Getting this done might be possible through the SMC. It is frequently used in situations in which the modelling parameters are uncertain or when there are interruptions from the outside.

Djurovic et al. developed condition monitoring systems for induction generators that are used in wind turbines with electrically asymmetrical rotors. These monitoring systems are used in wind turbines. In order to verify the findings of the study, a time-stepping electromagnetic model as well as experimental data gathered from two distinct test rigs were utilised. The accuracy of analytical expressions that characterise the variation in fault frequency with operating speed has been confirmed by measurement, which paves the way for real-time tracking of fault frequency within a system. These expressions can be found in this section of the article.

Magnets can be used in place of the

excitation windings in synchronous machines due to the lower cost of the magnets and the improved magnetic material they use. The pole pitch on conventional generators is significantly greater than that of permanent magnet excitation machines. Because of this, these machines can be constructed to rotate at speeds ranging from 20 to 200 revolutions per minute (r/min), depending on the rated output of the generator. r/min stands for revolutions per minute. Multi-pole permanent magnet generators may or may not be included in the products that a given manufacturer of wind turbines offers, depending on the nature of their business (e.g. Jeumont, Lagerwey). Changing the speed of the turbine's rotation when the wind is blowing is one way to maximise the amount of energy that can be extracted from the wind.

A method for measuring the maximum power point was developed by Xia et al. in order to determine the maximum power point of WECS that make use of permanent magnet generators. Using this method, one can determine the amount of power that the WECS produces.

It is anticipated that systems that convert wind energy into a form that is usable will benefit from the addition of a device that detects their peak power point. These systems use permanent magnet synchronous generators. During training, an algorithm can be used to quickly discover the ideal relationship that should exist between the voltage at the rectified DC output and the current. By implementing innovative P&O practises, it is possible to reduce the impact of variable wind conditions to some extent. In order for the system to operate in a manner that is congruent with this hypothetical relation, it was made operational.

PI control is essential in order for a process to maintain a constant output over the course

of its lifetime. This suggests that the procedure is operating as it should at the present time.

A PI-based control design approach has become available thanks to the work that was done by Hwas et al. for the purpose of managing the pitch angle of blades on variable-speed wind turbines. When calculating the PI enhancements, one of the possible approaches can be analytical, while the other can be based on simulation. Both of these approaches are distinct from one another. It has been demonstrated through simulations that both of the PI methods have the potential to produce favourable outcomes. In order to construct an experimental test bench in a laboratory and evaluate the performance of the proposed controller in both steady and transient modes, DSPACE 1104 cards were utilised as the primary building material. According to the findings of the tests, FFOPI+I over FOPI controllers proved to be very effective and reliable across the broad spectrum of wind speeds that were evaluated.

Experimentally enhanced fuzzy-fractional order PI+I controllers were developed by Beddar et al. for grid-connected variable-speed wind energy conversion systems. Both a nonlinear load and an ACDC/AC converter that was connected to the grid needed to be controlled using pulse width modulation (PWM). The control system of the MSC is designed to generate the maximum amount of power possible, regardless of the wind speed.

## 2.2 Mathematical modeling of permanent magnet synchronous generator

It is possible that the robustness of a variable-speed wind turbine could be significantly improved by installing a direct-drive permanent magnet synchronous generator (PMSG). PMSGs have garnered a great deal of interest in the field of wind energy applications due to their capacity to function at high power factors while still

preserving a high level of efficiency. The variable wind speeds will cause the output of a PMSG to have an amplitude and frequency that are not stable. Inverters are required for all of these different approaches in order to keep the dc voltage at a constant level. The following expression can be used to describe the voltage produced by the generator in terms of the d-q rotating reference frame:

Equation:

$$V_{ds} = -R_s i_{ds} + \omega_r L_{qs} i_{qs} - L_{ds} \frac{di_{ds}}{dt} \quad (2.1)$$

$$V_{qs} = -R_s i_{qs} - \omega_r L_{qs} i_{qs} + \omega_r \partial_f - L_{qs} \frac{di_{qs}}{dt} \quad (2.2)$$

Where,

$R_s$ - the stator resistance

$i_{qs}, i_{ds}$ - the stator direct and quadrature currents

$\partial_f$ - the rotor flux and

$L_{qs}, L_{ds}$ - the stator direct and quadrature inductance

The electromagnetic torque is expressed as

$$T_e = \frac{3}{2} P [\lambda_f + (L_{ds} - L_{qs}) i_{ds}] i_{qs}$$

The machine equivalent mechanical equation is

$$T_m - T_e = J \frac{d\omega_m}{dt} + B\omega_m$$

Where, H are the inertia constant and equals

$H = \frac{1}{2} \left( \frac{J\omega_b^2}{P_p^2 P_b} \right)$  and friction coefficient in per

unit equals  $B_{pu} = \left( \frac{B\omega_b^2}{P_p^2 P_b} \right)$

The mathematical model using these methods and improving the performance of the grid integrated WECS.



### 3. Analysis of wind energy conversion system using fa-ann technique

Solar, wind, and hydropower are examples of renewable energy sources that produce no harmful byproducts and are simple and inexpensive to deploy. Oil and natural gas have the potential to take the place of more traditional forms of energy. However, as a result of overgrowth, both the output and validity of these systems have decreased. Inadequate alternating current (AC) networks have proven to be troublesome for the operation of big wind turbines because to stability and power quality issues. This article provides an explanation of an alternative wind turbine drive-train layout that utilises the adaptive strategy and combines a number of Permanent Magnet Synchronous Generators (PMSGs) with a cascaded multilevel converter. Combining Artificial Neural Networks (ANNs) and Firefly Algorithms results in a method that is highly flexible. The ANN's capacity to acquire new knowledge is improved with the utilisation of the FA. As a consequence of this, it is possible to reduce the switching losses that occur on cascaded multi-level inverters. The adaptive method, which is computed utilising a PID controller, is utilised in the process of computing the WECS stability study. This portion in whole

#### 3.1 Problem formulation

To achieving the most optimal controller gain settings, the FA-ANN method is applied. To conduct an analysis of the actual power being produced by the proposed system, a PID controller is used. To begin, an inaccurate power value is input into the PID controller, and the gain settings are adjusted so that they are accurate. The method is optimised through the application of the FA-ANN approach. The error data is used as a source of information for the gain

parameters  $k_p$  ( $K_p$ ),  $K_i$  ( $K_i$ ), and  $K_d$  ( $K_d$ ). To achieve synchronisation of the grid as well as the transformation of the coordinates, an integrated phase-locked loop is utilised (PLL). This approach's internal control loops make it possible for it to respond quickly to transients and to achieve excellent static performance in general. Grid currents can be broken down into d-axis and q-axis currents, which enables active and reactive power to be adjusted in a manner that is independent of one another. By utilising this method of control, one is able to realise both a high power factor and sinusoidal grid currents. In order to calculate the total amount of active and reactive power that a wind energy conversion system produces, equations are required.

$$P = \frac{3}{2} (E^d i^d + e^q i^q) + (R^d i^d + R^q i^q) + (L^d i^d + L^q i^q)$$

$$Q = \frac{3}{2} (E^d i^d - e^q i^q) + (R^d i^d - R^q i^q) + (L^d i^d - L^q i^q)$$

The d-axis reference is usually obtained from DC-link voltage controller.

$$P = \frac{3}{2} (E^d i^d)(R^d i^d)(L^d i^d)$$

$$Q = -\frac{3}{2} (E^d i^q)(R^d i^q)(L^d i^q)$$

The three-phase inverse output is denoted by the letters  $i_{abc}$ . Control of a cascaded cascaded H-bridge MLI converter is achieved by first determining the three-phase actual current, then determining the reference current, and finally producing the ideal pulses. This is done in order to ensure that the controlled cascaded H-bridge MLI converter is able to produce the best possible pulses. The performance of the cascaded H-bridge MLI converter was improved by increasing the ideal gain parameter of the converter. This improved the performance of the converter in both control loops. The measured values are additionally affected by

the PLL loops. The utilisation of three PID controllers within the framework of the proposed system enables it to function in complete congruence with the grid. Setting the zero point as the reference point on the q-axis is one way to arrive at the power factor of one. As a result of the superior dynamic responsiveness of the system, switching pulses for inverters can be generated by the system itself. As a result of the PLL, the grid harmonics and phase shifts that would normally have an effect on the source parameters are eliminated. Putting an LC filter between the inverter and the grid helps improve power quality while also lowering the number of harmonics that are produced by the WECS system.

### 3.2 Modelling of wind energy conversion system

There are many different forms of renewable energy, but the one that is expanding at the greatest rate is wind power. A variable speed wind turbine (VSWT), is able to harness the maximum amount of power regardless of the speed of the wind. There are a number of different designs that can handle the variable-speed duty of the PMSG wind turbine framework. These designs include staggered converters and two-dimensional converters. Wind turbines are typical devices that are used to create energy by harnessing the power of the wind. Kinetic energy, denoted by the symbol  $E = W = Fs$ , that was put in to bringing an object from a state of rest to a certain distance, denoted by the symbol  $s$ , while the acceleration is held constant. The following equation can be used to describe Newton's second law: (3.1).

$$F = ma \quad (3.1)$$

The actual wattage of the rotor blades' mechanical power is calculated by subtracting their upwind and downwind powers from their total value in the calculation (3.2).

$$P^w = \left[ \frac{1}{2} \cdot \rho A v_w \cdot (v_u^2 - v_d^2) \right] \quad (3.2)$$

Where  $v_u$  represents the velocity of the rotor blades as they enter the upwind direction in metres per second, and  $v_d$  represents the velocity of the rotor blades as they exit the downwind direction in metres per second, respectively. These two speeds are used as the foundation for the calculation that determines the ratio of the blade tip speed. Now, with the mass flow rate serving as a point of reference:

Equation (3.3), can be written as,

$$\rho A v_w = \left( \frac{\rho A (v_u - v_d)}{2} \right) \quad (3.3)$$

Where  $v_u$  is the average of the velocities that the rotor blades of the turbine experience while they are entering and exiting the machine. The wind turbine has a tip speed ratio that can affect it in a variety of ways. The symbol  $T_s$  stands for ratio between the wind speed blowing downwind to the wind speed blowing upwind, which is defined by the equation (3.4).

$$T_s = v_d / v_u \text{ or } T_s = \text{blade tip speed} / \text{wind speed} \quad (3.4)$$

In the following section, we will discuss the WECS stability study that was conducted using adaptive FA and ANN modelling techniques.

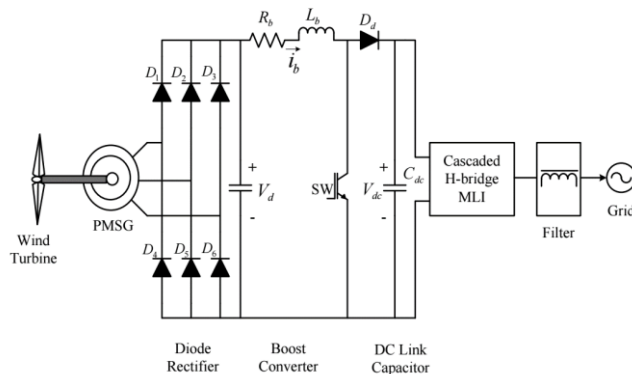
### 3.3 Analysis of ann algorithm based grid integrated wecs

The discussion in this article is focused on a cascaded multilevel H-bridge inverter stability analysis using the ANN algorithm. There is an option for an inverter-based wind energy conversion system like the one shown in figure 3.1. The WECS consists of the elements  $R_b$ ,  $L_b$ , and  $V_{dc}$ . Components such as these are utilized in order to symbolically represent the DC link voltage, in addition to the resistance and inductance. The PMSG has a connection to WECS as part of its mandate to play a part in laying the foundation for the region. It is possible to

eliminate the need for gear or drive train systems in order to reduce the overall cost and size of the system by employing PMSG-related WECS. This will allow for the elimination of the need for gear systems. The PMSG initiator, which is a variable-speed generator, is activated with the assistance of data regarding the wind speed. Dynamic Braking Resistors, also known as DBRs, are an excellent choice for the design of synchronous generators because they do not need to be magnetised by a current. By utilising the DBR, alternating current can be converted into pure direct current, which is then free of any unwanted harmonics. This is possible because of the DBR. It is possible to exert control over the torque and, as a result, achieve maximum power levels when the boost converter and the DBR are responsible for supplying the DC voltage. The smoothing capacitor known as the  $C_{dc}$  is what is utilized to stop the DC voltage from increasing.

This article presents a discussion on the ANN algorithm-based cascaded multilevel H-bridge inverter stability analysis. Figure 3.1 illustrates how the wind energy conversion system works by using an inverter with

multiple levels that are cascaded together. This diagram of the WECS illustrates the resistance  $R_b$ , the inductance  $L_b$ , and the DC-link voltage  $V_{dc}$ . All three of these characteristics are shown. The PMSG, which is responsible for determining the region's basis, is connected to the WECS grid. The complexity of the system, as well as its overall size and cost, can be decreased through the utilisation of PMSG-related WECS, and this can be accomplished without the utilisation of gear or drive train systems. The PMSG initiator, which is a variable speed generator, is activated after a comprehensive collection of wind speeds is made. The Dynamic Braking Resistors, also known as DBRs, are a pattern that is suitable for use in synchronous generators because they do not call for a magnetising current. It is possible to get rid of harmonics by converting the AC into DC, which is why the DBR is used in the process. Utilizing both a boost converter and a DBR, which are connected to one another, is required in order to achieve the highest possible DC voltage. Utilizing a smoothing capacitor like  $C_{dc}$  helps reduce the DC voltage swell that can occur.



**Figure 3.1** Structure of the WECS with Multilevel Inverter

The cascaded H-bridge Multilevel Inverter is responsible for the current variation of the system's output voltage, which consists of five levels (MLI). It is used to develop the

presentation by keeping the regulator's expansion limit and causing the most favorable pulses for the cascaded H-bridge MLI to be created. Both of these things are

necessary in order to develop the presentation. In order for this to be successful, the expansion restriction must be maintained at all times. The WECS gain optimizer, in conjunction with another algorithm, is used to optimize the gain parameters of the cascaded H-bridge multilevel inverter.

### 3.4 Analysis of wecs using adaptive fa - ann technique

A new control strategy has been implemented here in order to improve the power quality provided by WECS. The minimization of WECS consonants can now be improved by utilising a combination of FA calculation and an ANN system. This was not previously possible. It is common practise to make use of the cascaded H-bridge multilevel inverter in order to enhance the ANN strategy for controlling quality concerns regarding the WECS force. In the section that follows the WECS, a calculation of the FA is provided for your reference.

#### 3.4.1 Introduction of Fire Fly algorithm

A model of a firefly was crafted by Yang. Because of their alluring appearance, fireflies are most active at night. They enjoy living in warm environments, and because of their allure, they tend to be most active during the night. There are a number of fascinating aspects related to flame flies, such as the following:

- A model of a firefly was crafted by Yang. Because of their alluring appearance, fireflies are most active at night.
- They enjoy living in warm environments, and because of their allure, they tend to be most active during the night.
- There are a number of fascinating aspects related to flame flies, such as the following:

The bioluminescence technique is in charge of the glinting light of fireflies. There are a couple of theories about the aim and position of blasting light in fireflies' life cycle yet huge quantities of them converge to mating stage. The simple focus of bursting light is to attract the mating associates. The case of these melodic flashes is fascinating and it relies upon the mind-set of flashes, rate of blasting, and proportion of time for flashes are recognized.

#### 3.4.2 Proposed Methodology

The research has been undertaken in the following stages  $\pi$  MATLAB /SIMULINK 7.10.0 is R2010a simulation of Grid integration of Wind Energy Conversion System using FA-ANN algorithm. Performance metrics like PMSG active power, PMSG reactive power, DC-link voltage, wind speed, and THD.

#### 3.4.3 Classification of FA

The algorithms used by Firefly have been through a variety of iterations over the course of their development. Tuning, also known as adaptive parameter control, is a technique that has been utilized in the search for the optimal combination of parameters. A number of different modified and combined firefly algorithms are presented in Figure 3.2.

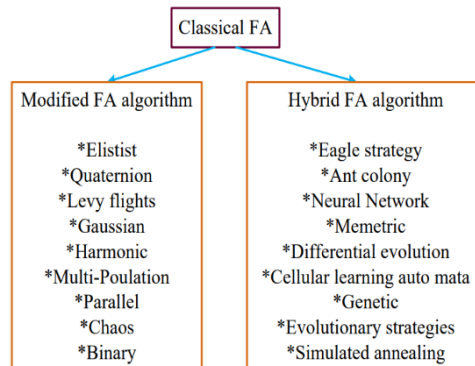
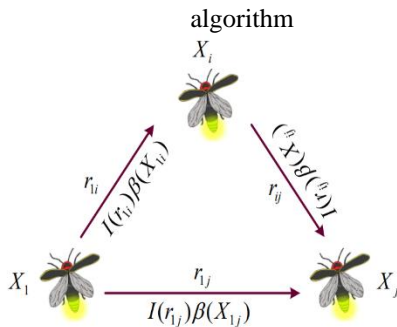


Figure 3.2 Classification of Firefly



**Figure 3.3** A Conceptual View of the Firefly Algorithm which includes locations  $X$ , Distance  $r$ , Brightness  $I(r)$  and Attractiveness  $\beta(r)$ .

### 3.4.4 Adaptive FA-ANN Technique Based Cascaded H- Multi Level Inverter Using Grid Side Variation

In this proposed scheme, the Adaptive FA-ANN strategy has used out the control parameters improvement for WECS structure dependent on the Cascaded multilevel inverter utilizing matrix side variety. The Cascaded Hbridge multilevel inverter can coordinate the controlling of the exchanging problem and matrix side variety. The proposed methodology is the mix of FA and ANN procedure. The FA calculation is to build up the information of ANN. The FA advancement calculation favours the most ideal readiness dataset to direct the ANN for improving the learning introduction. ANN incorporates three layers, for example, input, covered up, and yield layers. The information layer contains various hubs that are plucky by methods for the informational index. Each hub incorporates related loads to the whole hubs in the following layer and too one disposition identified with the same hubs of the following layer. Inclination hubs envelop a yield of one hub and they are identified with the whole hubs of their layer. The loads on the relationship from inclination hubs are known as predisposition loads. The whole loads are evaluated to give

the theoretical of this hub, and a short time later the foundation task of this hub is determined. There are various classes of the foundation task like a stage task, a signed assignment and a sigmoid undertaking. There are numerous classes of the foundation task like a stage task, a signed assignment and a sigmoid errand. The customary foundation task is a sigmoid assignment which is appeared in condition as follows.

$$f(x) = \frac{1}{1 + e^{-x}}$$

The input data are specified by the equation  $x$ .

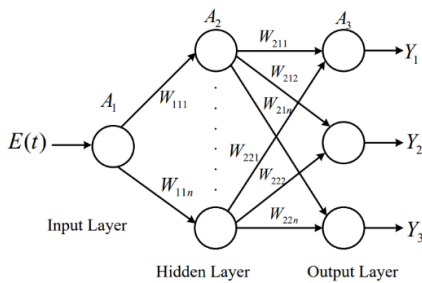
The number of information sources and the number of yields that can be reliably derived from a dataset are what determine the records that make up hubs in both the information and yield layers. The number of hubs that are contained within a hidden layer can be expressed as follows, in accordance with the Kolmogorov hypothesis:

$$\text{Hidden nodes} = 2 * \text{Input} + 1$$

A fake neuron is the basic preparing part and its inside modifiable confinements are recognized as association loads. Fake neurons weight, total and limit approaching signs are utilized to create yield. Data is assembled in the intensity of the interconnections or loads and the edges. The most critical goal of ANN is to decide a gathering of association loads that reduce the shortcoming task. The system is an open couple of yield information and the issue for the time of learning. The procedure depends on the FA. The calculation is gotten from the qualities of the fitter species. It contains successful rummaging strategy like remain alive and scattered in the improvement chain.

In the following section of this article, an in-depth analysis of the ANN is presented for your perusal. One of the neural network architectures that is used today in the most

common applications is the multi-layer feedforward network with the back-propagation learning algorithm. This architecture is used quite frequently. The architecture of a neural network typically consists of the standard components of an input layer, an output layer, and a hidden layer. Figure 3.4 presents an illustration of the training structure for ANNs. Back propagation is the name of the algorithm that is used during the training process for the neural networks.



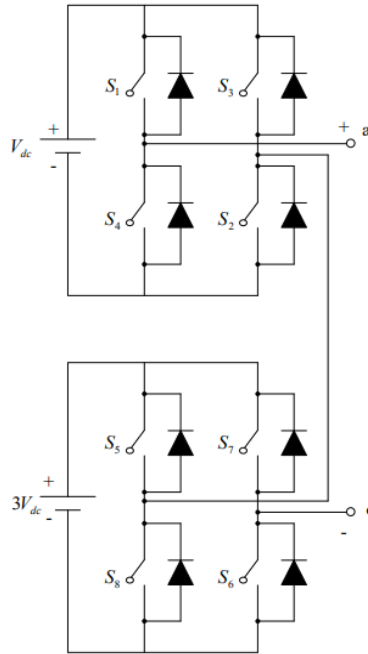
**Figure 3.4** Training Structure of ANN using Proposed Adaptive

As can be seen, the weights for both the input and the output layers have been assigned in this illustration.  $W_{111}$  and  $W_{11n}$  are the weights that go from the input layer to the hidden layer.  $W_{211}$  and  $W_{212}$  are the weights that go from the hidden layer to the output layers, and  $W_{221}$  and  $W_{222}$  are the weights that go in the opposite direction. The outputs of the node are denoted by the letters  $Y_1$ ,  $Y_2$ , and  $Y_3$ . After that, an algorithm known as back propagation is applied to the training of the neural network. The following is an outline of the steps that make up the training algorithm.

**3.4.5 Proposed Cascaded H-bridge 5-Level multilevel Inverter**

The proposed method is utilized by multilevel inverters known as cascaded H-bridges (CHB) (5-level). Figure 3.5 is a schematic representation of an H-bridge multilevel inverter with cascaded H-bridge

input DC sources. There are a total of nine possible output stages when using  $V_{dc}$  and  $V_{dc} / 3$ , including  $4V_{dc}$ ,  $3V_{dc}$ ,  $2V_{dc}$ , and  $V_{dc}$ .



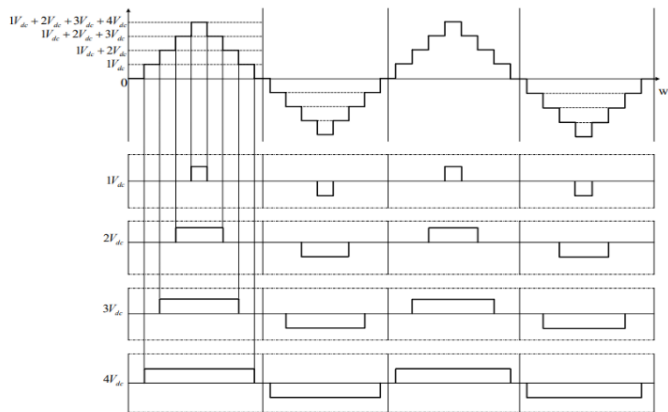
**Figure 3.5** Five Level Cascaded H – Bridge Multilevel Inverter

**3.4.6 Control Strategy**

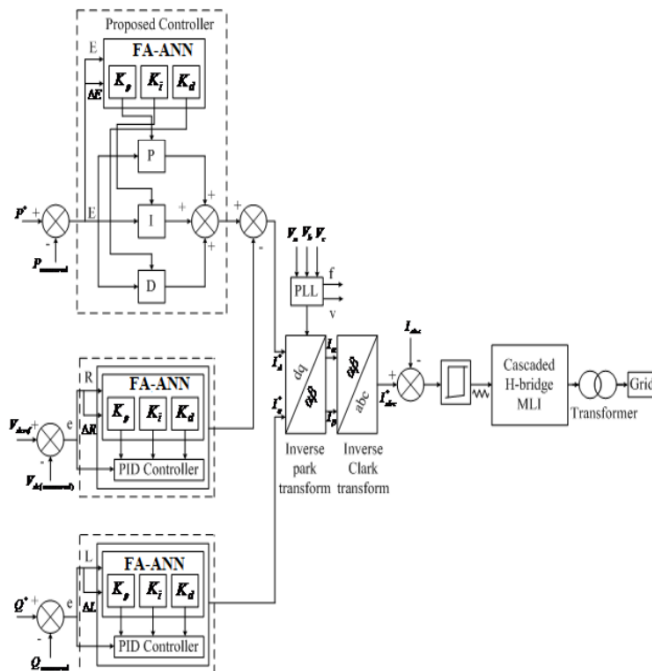
The control strategy for a grid-connected WECS is first deconstructed into its dynamic properties, which are then used to describe the control strategy. Studying the flow of electricity through the grid can be done with the help of the WECS. To put it another way, utilising WECS is a choice that results in significant cost savings. The power that is generated by the WECS is sent to the grid through the DBR. It was necessary to use a rectifier in order to change the alternating current into direct current (DC). When you already have access to the DC power, using a boost converter will enable you to extract the maximum amount of useful energy from the DC power. The maximum amount of power that can be drawn from the cascaded H-

bridge MLI is then used to draw from nine different levels of power. Improving the controller components is one way to increase the likelihood that the project will be successful. The performance of the cascaded H-bridge MLI has undergone further enhancements, and the generation of optimal pulses has been completed. The analysis takes into account not only the real power

but also the reactive power, the regulation of the voltage, and the total harmonic distortion. In this way, a proposed controller is utilised in order to conduct an analysis of the control system's power regulation and voltage regulation blocks. Figure 3.7 illustrates the control structure that is utilised by this method.



**Figure 3.6** Output voltage waveform of five-level cascaded H-bridge multilevel inverter



**Figure 3.7** FA – ANN with PID Controller

### 3.4.7 Power and Voltage Control loops

Because each control strategy is a separate and independent undertaking, it possesses its own one-of-a-kind set of parameters. In a power control strategy, the real power, denoted by  $P_m$ , is computed using the PLL method, and the result is compared to the reference power, denoted by  $P^*$ . After this has been accomplished, the error values are computed and recorded alongside the factor (E). Using the FA-ANN technique, the gain parameters of the controller are optimized for optimal performance. We are able to calculate the system's true output power by utilizing a PID controller. At first, the PID controller takes the error value of the power as its input, and then it tunes the gain parameters to their optimum levels. The FA-ANN method is utilized in order to achieve optimal results with the process. Input for the gain parameters  $k_p$  ( $K_p$ ),  $K_i$  ( $K_i$ ), and  $K_d$  ( $K_d$ ) are taken from the error values ( $K_d$ ). After that, the gain parameters and inputs that work best are figured out. As an input, the PID controller takes into consideration the optimized values for the gain parameters. After this step, PID controllers are able to be fine-tuned, which ultimately results in an output that is more accurate and efficient. In the same way, we are working on the other blocks, and their performances are being evaluated. Using these three blocks, it is possible to generate cascaded H-bridge MLI control pulses and investigate their dynamic properties. The pulses of a cascaded H-bridge MLI that has been optimized for connection to the WECS grid are being studied. The d-axis and q-axis current components of the inverter are responsible for controlling the instantaneous reactive and active power exchange that occurs between the DC link voltage and the grid. Inverters are responsible for producing square waves

with a high frequency. The synchronized reference frame for the direct current quantities of the control variables is depicted in figure 3.4. Grid-side converters can now be easily filtered and controlled thanks to a new method that has been developed. In addition to this, the PID regulator is superior to others in its ability to control DC variables. The phase lock loop (PLL) is then used to obtain the grid angle for the transformation.

A phase-locked loop is utilized in order to accomplish grid synchronization as well as coordinate transformation (PLL). Internal control loops of this strategy ensure a rapid response to any transients and a high static performance. It is possible to separate the d-axis grid current from the q-axis grid current, which enables independent control of the system's active power and reactive power. By utilizing this method of control, one is able to realize both a high power factor and sinusoidal grid currents. In the process of converting wind energy into usable forms, equations are utilized to ascertain the total amount of active and reactive power that is produced.

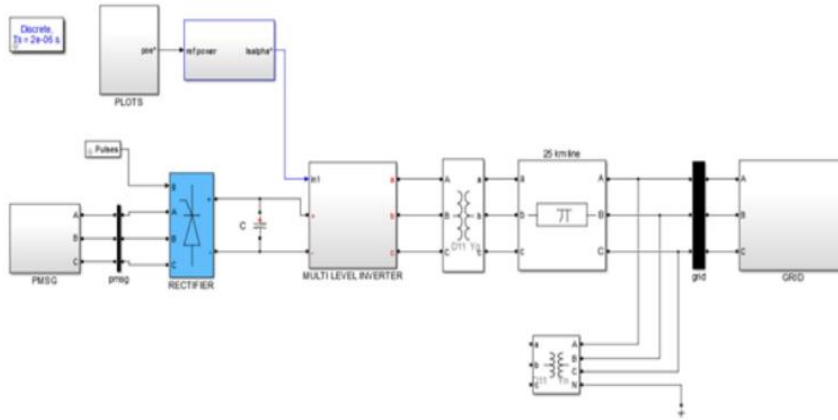
$$P = \frac{3}{2}(E^d \cdot i^d + e^q \cdot i^q) + (R^d \cdot i^d + R^q \cdot i^q) + (L^d \cdot i^d + L^q i^q)$$

$$Q = \frac{3}{2}(E^d \cdot i^d - e^q \cdot i^q) + (R^d \cdot i^d - R^q \cdot i^q) + (L^d \cdot i^d - L^q i^q)$$

## 4. Analysis of grid integrated wecs using fire fly optimization algorithm results

Figure 4.1 shows MATLAB/SIMULINK model of the FA-ANN method with cascaded H-bridge multilevel inverter, and Table 4.1 shows implementation parameters of the PMSG using FA-ANN method.





**Figure 4.1** MATLAB/SIMULINK model of the FA-ANN method with cascaded H-bridge multilevel inverter

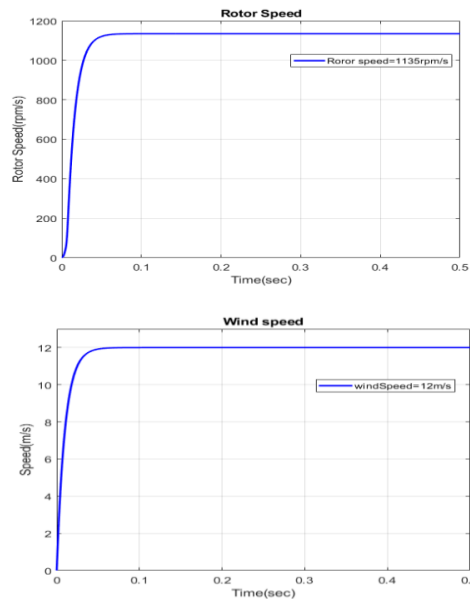
**Table 4.1** Implementation parameters of the PMSG using FA-ANN method

Description of parameters	Values
Rated wind speed	12(m/s)
Base rotational speed	1.2 (p.u)
Nominal mechanical output power	605.142 (W)
Stator phase resistance	0.18 (ohm)
Armature inductance	0.0167 (H)
Pole pairs	4
Rotor type	Round
Flux linkage	0.0714 ( $v_s$ )
Torque constant	0.4286 ( $N_m$ )
Inertia	0.00062J( $kgm^{-2}$ )
Friction factor	0.00030 F(Nms)

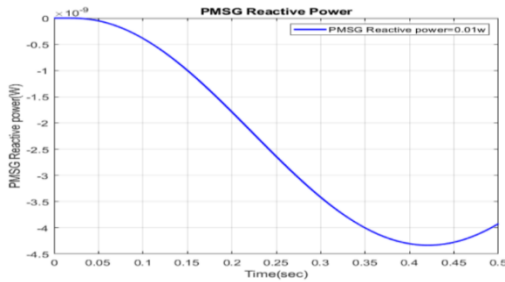
#### 4.1 Analysis of normal wind speed

Figure 4.2, which depicts the device in normal operation and demonstrates how it works, includes an illustration of the rotor and the wind speeds. When the sails are raised to their full height, the wind speed may be measured at 12 m/s; when the sails are lowered, the wind speed may be measured at 24 m/s. If the strategy is put into action, it will be possible to exercise control over wind speeds that are either lower than or comparable to the rated speed. The pitch

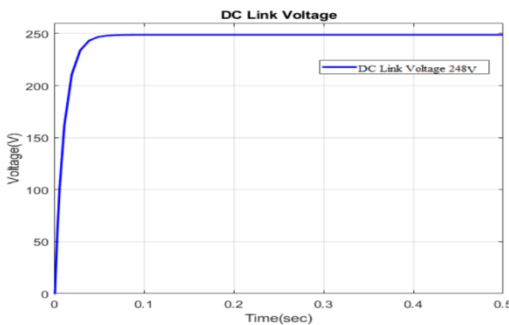
angle control will help to smooth out the output power whenever the wind speed is greater than the cut-in speed of the PMSG.



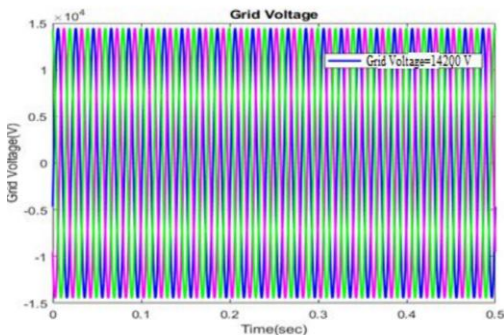
**Figure 4.2** Rotor speed and wind speed in normal wind speed condition using FA-ANN



**Figure 4.3** Active power and reactive power in the PMSG under normal wind speed condition using FA-ANN



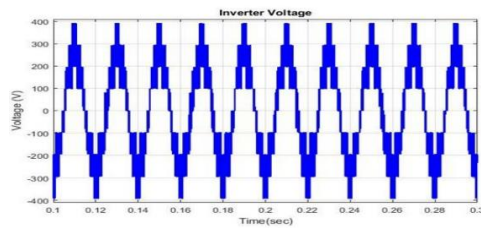
**Figure 4.4** Dc-link voltage in normal wind speed condition using FAANN



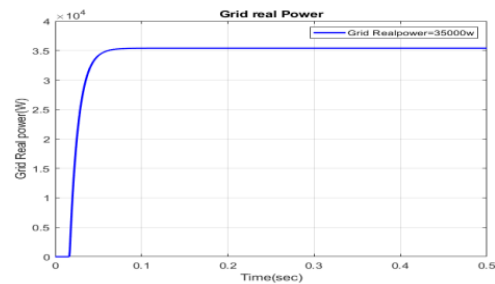
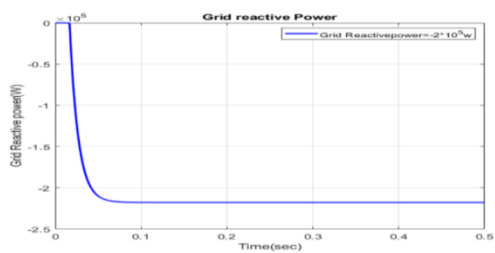
**Figure 4.5** Three-phase voltage and current of grid in normal wind speed condition using FA-ANN

Figure 4.3 depicts the PMSG's active and reactive powers. At normal wind speeds, the PMSG's electrical speed is controlled by the optimum rational speed. At 0.5 seconds, the

PMSG's active and reactive powers settle. As shown in Figure 4.4, the DC-link voltage output in a steady state is perfectly normal under these circumstances. The settling time of 0.55 seconds and the corresponding voltage of 248V were used to determine the DC voltage. Figure 4.5 depicts the grid's three-phase voltage and current performance at normal conditions.



**Figure 4.6 (a).** Inverter voltage power in normal wind speed condition using FA-ANN



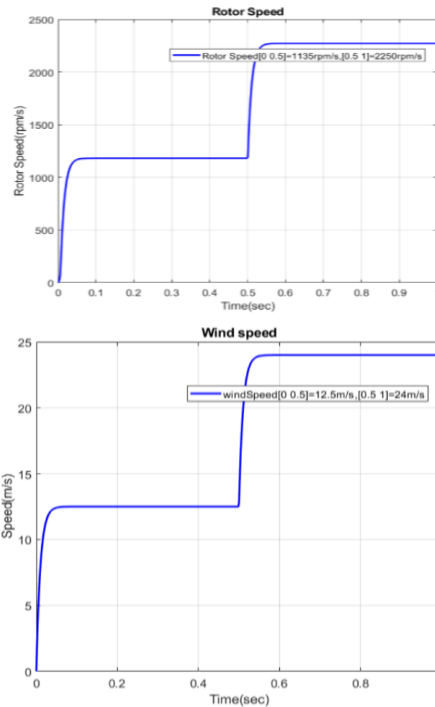
**Figure 4.6 (b)** Grid real and reactive power in normal wind speed condition using FA-ANN

Figures 4.6 (a) and (b) depict various analyses, including those of the inverter voltage as well as the real and reactive power of the grid (b). By referring to this diagram, one can observe that the voltage that is present on the grid is kept at a stable

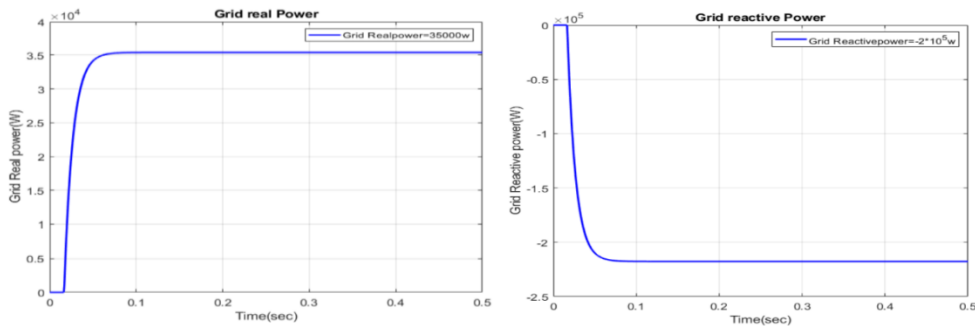
level. As a result of its implementation, it has been demonstrated that the FA-ANN control technique is not only straightforward and reliable, but also enables greater adaptability and lessens the strain that is imposed on the blades of wind turbines. The vast majority of power fluctuations can be brought under control by utilising the FA-ANN method.

### 4.2 Analysis of variable wind speed

In this experiment, the voltages are analysed with the help of a motor that has a variable speed. Utilizing the proposed controller-based cascaded H-bridge MLI, we investigate the active power, reactive power, DC-link voltage, and harmonic compensation performance. The results of conducting tests on the proposed model in relation to different gust strengths are depicted in Figure 3.10. The amount of power and voltage that is output by the wind generator is proportional to the speed of the wind. Because of the large fluctuations in output power that are brought on by the relatively minor shifts in wind speed, the required voltage fluctuation to ensure compliance with grid standards is increased.



**Figure 4.7** Rotor speed and wind speed in variable wind speed condition using FA-ANN



**Figure 4.8** Active power and reactive power in the PMSG under variable wind speed condition using FA-ANN

### 4.3 Simulation Results

The following is the technical specification that the PMSG has developed for the FA-

ANN method: The simulation is run in MATLAB with the help of the Implementation parameters, and the results are displayed here with the assistance of the

Implementation parameters. Based on the Implementation parameters, the simulation is run in MATLAB, and the results are displayed here with the assistance of the Implementation parameters. Figure 3.11 illustrates the PMSG's real and reactive power performance, which was accomplished with the help of the suggested method. Voltages in the FA-DC-link ANN have been the subject of some research and analysis. It is clear that the time required for this DC-rise link is 0.001 seconds, the time required for its top-overshoot is 0.05" seconds, and the time required for it to reach steady state is 0.56" seconds (i.e., 200V settles in 0.56" seconds).

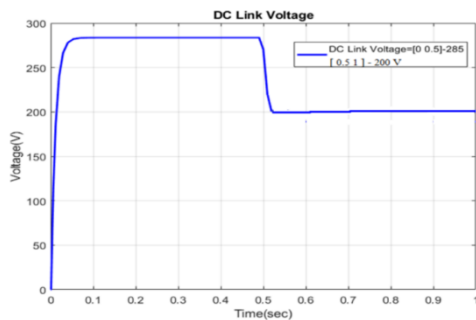


Figure 4.9 DC-link voltage in variable wind speed condition using FAANN

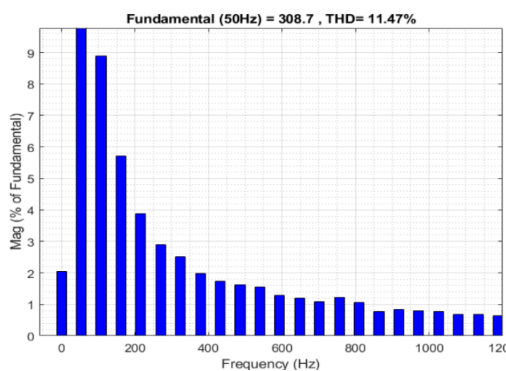


Figure 4.10 voltage THD% analysis of FA-ANN method

The findings of a THD investigation into the suggested procedure are depicted in Figure 3.10. The total harmonic distortion (THD) of the output of the grid-integrated power system control technique that has been proposed is 11.47 % a description of the factors at play Values Maximum wind speed of 12 meters per second speed of rotation at the point where it is slowest 1.2 (p.u) Power from the electrical source 605.142 watts (W) Both the phase resistance of the stator, which is 0.18 ohm, and its inductance, which is 0.0167 H, are very low. Two poles to a pair Rigid-Rotary 4-Rotor The following equation describes the relationship that exists between the torque constant and the flux linkage: Its friction coefficient is 0.00030 F.N.ms, and its moment of inertia is 0.00062 J kgm.

Table 4.2 Comparison of voltage %THD of FA-ANN Proposed Method

	FA-ANN
THD%	11.81
Grid Voltage(V)	14200
Grid Current(A)	10
DC link Voltage(V)	247

## 5. Conclusion

The FA-ANN optimization method is simulated in the MATLAB/SIMULINK environment, and the output waveforms for a variety of conditions are analyzed. The control strategy of the WECS integrated grid is implemented in order to enhance the transient response of the power system. An adaptive FA-ANN technique is used to track real and reactive power in order to reduce the fluctuation in a steady state. This technique is based on the various speeds at which the wind is blowing. The PID controller organizer of the WECS integrated grid is responsible for managing the cascaded H-bridge multi-level inverters. This organizer also incorporates FA and ANN algorithms. A look was taken at the voltage

of the system's DC link. It is clear that the time required for this DC-rise link is 0.001 seconds, the time required for its top-overshoot is 0.05" seconds, and the time required for it to reach steady state is 0.56"

seconds (i.e., 200V settles in 0.56" seconds). The FA-ANN control technique used by the grid-integrated power system has a total harmonic distortion of 11.47 %.

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Z. Qiu, K. Zhou, Y. Li, "Modeling and Control of Diode Rectifier Fed PMSG Based Wind Turbine ", IEEE. The Natural Science Foundation of China under Grant Modeling and Optimization of Wind Turbine Driving Permanent Magnet Synchronous Jordan Journal of Mechanical and Industrial , No. 6, Dec. 2011, pp. 489 – 494.

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## GAME DEVELOPMENT TOOLS AND AI BASED ALGORITHMS FOR CREATION OF GAMEWORLD

**Abstract:** *Game development is a complex and time-consuming process that requires the use of specialized tools and technologies to create immersive and engaging game worlds. In recent years, the use of AI-based algorithms has become increasingly popular in game development, as they offer the ability to generate dynamic and varied game worlds that adapt to the player's actions.*

**Keywords:** *game development, game world, AI-based algorithms, procedural content generation, game engines, level design, conversational AI, game AI*

### 1. Introduction

Game world design theory involves creating a virtual environment that is immersive, engaging, and meaningful for players. The game world design is a critical component of a game, as it sets the tone, atmosphere, and overall experience for the player.

Creating the game world requires multiple process which should be interconnected.

One of the main principles of game world design theory is consistency. A game world should be consistent in its design, with elements that are logically and thematically connected. This helps create a sense of believability and immersion for players. By creating a world that is internally consistent, designers can help players become fully immersed in the game world.

Another important principle of game world design theory is exploration. The game world should be designed in a way that encourages exploration and discovery. This can include hidden areas, secrets, and rewards that player can discover as they navigate the game world. By creating a sense of discovery, designers can help players feel

more engaged and invested in the game world.

Interactivity is another key principle of game world design theory. The game world should be interactive, with elements that can be manipulated or interacted with by the player. This can include objects that can be picked up, doors that can be opened, or enemies that can be defeated. By creating a world that is interactive, designers can help players feel more engaged and invested in the game world.

In addition, game world design theory emphasizes the importance of challenge. The game world should provide challenges and obstacles for the player to overcome. These challenges should be designed in a way that is fair and balanced, but also challenging enough to keep the player engaged. By providing challenges, designers can create a sense of achievement and satisfaction for players.

Another important principle of game world design theory is storytelling. The game world should tell a story through its design and elements. This can include environmental storytelling, where the game world itself tells a story through its design

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and placement of objects. By using storytelling techniques, designers can create a world that is more engaging and meaningful for players.

Finally, game world design theory emphasizes the importance of player agency. The game world should provide the player with a sense of agency and control over their experience. This can include multiple paths or options for completing objectives, or the ability to make choices that affect the game world and its outcome. By giving players a sense of control, designers can help create a more engaging and immersive game world.

Overall, game world design theory is about creating a virtual environment that is engaging, immersive, and meaningful for players. By following these key principles, game designers can create game worlds that are memorable and enjoyable for players.

## 2. Game Engines for World Creation

Game world creation engines are software tools that game developers use to create and design game worlds. These engines provide a wide range of features and tools that help developers create immersive and engaging game worlds more efficiently.

### 2.1. Unity engine

Unity is a powerful game engine that is used by game developers around the world to create a wide variety of games and interactive experiences (figure 1). It offers a range of features and tools for game development, including 3D modeling and animation tools, physics simulations, and real-time rendering capabilities (De Macedo & Formico Rodrigues, 2011; Jitendra et al., 2021).

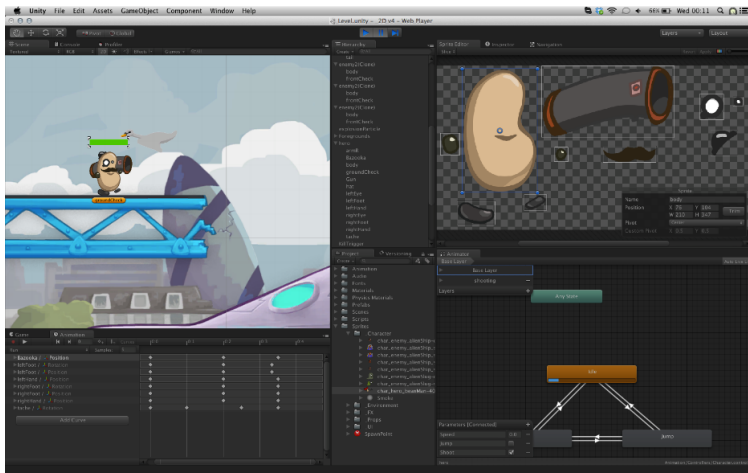


Figure 1. Unity engine interface (source <https://techcrunch.com/2013/08/28/unity-game-engine-to-get-official-2d-game-support-and-a-built-in-ad-service/>)

One of the key features of Unity is its cross-platform support. Games developed in Unity can be easily deployed to a wide range of platforms, including mobile devices, PCs, consoles, and even virtual and augmented reality devices. This makes it a popular

choice for developers who want to reach a large audience with their games.

Unity also includes a visual editor that allows developers to create and design game worlds without having to write code. This

editor includes a range of tools for creating terrain, adding objects to the world, and configuring lighting and effects. It also includes a powerful scripting system that allows developers to create custom behaviors for their game objects using C# or UnityScript (a variant of JavaScript).

In addition to its core features, Unity also offers a range of add-ons and extensions that can be used to extend its functionality. These include tools for creating user interfaces, networking and multiplayer support, and AI and machine learning integration.

Another key advantage of Unity is its active and supportive community. There are a wide range of resources available for Unity developers, including tutorials, documentation, and forums where developers can ask questions and share their

knowledge.

Overall, Unity is a versatile and powerful game engine that offers a range of features and tools for game development. Its cross-platform support, visual editor, and scripting system make it a popular choice for both beginner and experienced game developers.

## 2.2. Unreal engine

Unreal Engine is a popular game engine developed by Epic Games that is used by game developers to create high-quality, AAA games for a range of platforms, including consoles, PCs, and mobile devices (Lee, 2016; Satheesh, 2016). The engine is known for its advanced graphics capabilities, powerful tools, and flexibility (figure 2).



**Figure 1.** Unity engine interface (source <https://techcrunch.com/2013/08/28/unity-game-engine-to-get-official-2d-game-support-and-a-built-in-ad-service/>)

One of the key features of Unreal Engine is its advanced rendering capabilities. The engine uses a real-time rendering system that allows developers to create highly detailed and realistic environments, characters, and effects. It also includes a range of tools for creating advanced lighting and materials, as well as support for high dynamic range (HDR) rendering, which allows for a wider

range of colors and brightness levels.

Unreal Engine also includes a powerful visual editor that allows developers to create and edit game worlds in real-time. This editor includes a range of tools for creating terrain, adding objects to the world, and configuring lighting and effects. It also includes a Blueprint visual scripting system that allows developers to create custom

behaviors for their game objects without having to write code.

In addition to its core features, Unreal Engine also offers a range of add-ons and extensions that can be used to extend its functionality. These include tools for creating user interfaces, networking and multiplayer support, and physics simulations.

One of the key advantages of Unreal Engine is its active and supportive community. There are a wide range of resources available for Unreal Engine developers, including tutorials, documentation, and forums where developers can ask questions and share their knowledge.

Overall, Unreal Engine is a powerful and flexible game engine that offers a range of advanced features and tools for game development. Its advanced graphics capabilities, powerful tools, and active community make it a popular choice for AAA game development.

### 3. Artificial intelligence in game development

Artificial intelligence (AI) is used extensively in gaming development to enhance the gaming experience and provide more realistic and immersive gameplay (Carpenter, 2023; ChatGPT successor creates entire video games in minutes). Here are some ways AI is used in gaming development:

Non-Player Characters (NPCs): AI is used to create intelligent NPCs that can act and react realistically in the game world. NPCs can have various behaviors and personalities, such as aggressive, defensive, passive, or social, and they can learn from the player's actions and adapt to different situations.

- 1) **Enemy AI:** AI is used to create intelligent enemies that can challenge the player and provide a more realistic gaming experience.

Enemies can have different abilities and behaviors, and they can learn from the player's actions and adapt to different situations.

- 2) **Procedural Content Generation (PCG):** AI is used to generate game content, such as levels, environments, and items. PCG can create unique and dynamic content that adapts to the player's actions and provides a more engaging gaming experience.
- 3) **Pathfinding:** AI is used to help characters navigate the game world by finding the best path to reach their destination. Pathfinding algorithms can calculate the shortest or safest route, avoid obstacles, and adjust to changing terrain.
- 4) **Natural Language Processing (NLP):** AI is used to understand and interpret player input, such as voice commands or text messages. NLP can provide more immersive and interactive gameplay by allowing players to communicate with NPCs or control the game using natural language.
- 5) **Machine Learning (ML):** AI is used to analyze player data and behavior to improve the game's performance and provide a more personalized gaming experience. ML can learn from player actions and adjust the game's difficulty, pacing, or content to match the player's skill level and preferences.

### 4. Example of Algorithms in Game Development

An AI chat bot can be used in Unreal Engine to generate a game world by using natural language processing techniques to understand the user's preferences and then using procedural content generation

algorithms to generate the game world. The process can be broken down into several steps.

First, the inputs need to be defined. This involves defining the types of inputs that the chat bot will receive, such as the user's preferences for terrain type, object density, quest types, and NPC personalities. These inputs will be used by the procedural content generation algorithms to generate the game world.

Next, the natural language processing (NLP) algorithms need to be trained. This involves providing the chat bot with a large dataset of text input and corresponding outputs. The chat bot will use this dataset to learn how to recognize and interpret natural language input from the user.

Once the NLP algorithms are trained, the chat bot can be integrated into the Unreal Engine game development environment. The chat bot will be programmed to listen for user input and respond with generated game world data based on the input received.

The generated game world data can then be used to create the game world in Unreal Engine. For example, the terrain generation algorithm might use the user's preference for mountainous terrain to generate a hilly landscape with large rock formations. Similarly, the object placement algorithm might use the user's preference for a dense object population to generate a forest with lots of trees and wildlife.

In summary, the process of using an AI chat bot in Unreal Engine involves defining the inputs, training the NLP algorithms, integrating the chat bot into the game development environment, generating game world data based on user input, and using the generated data to create the game world.

#### 4.1. Use of Natural Language

In essential AI chat bot could be used to help create a game world in Unreal Engine.

User inputs a command such as "Generate a new game world".

The AI chat bot (ChatGPT successor creates entire video games in minutes) responds with a series of questions to help determine the parameters of the game world (e.g. size, terrain type, number of biomes, etc.).

The user responds to each question, providing the necessary information.

The AI chat bot then generates a game world using the parameters provided by the user, using a variety of algorithms and techniques such as Perlin noise, Voronoi diagrams, and L-Systems.

The user can then explore the generated game world in Unreal Engine and make adjustments as necessary.

Here is an example conversation between a user and an AI chat bot:

User: "Generate a new game world."

AI chat bot: "Sure! What size should the game world be? (e.g. 10x10, 20x20, etc.)"

User: "20x20."

AI chat bot: "What type of terrain do you want? (e.g. mountains, forests, etc.)"

User: "Mountains and forests."

AI chat bot: "Okay. How many biomes do you want to include? (e.g. one, two, three, etc.)"

User: "Two."

AI chat bot: "Great. Using the parameters you provided, I will now generate a new game world. This may take a few minutes, so please be patient."

The AI chat bot would then use the parameters provided by the user to generate a new game world in Unreal Engine, using a

variety of algorithms and techniques such as Perlin noise, Voronoi diagrams, and L-Systems. Once the game world has been generated, the user can then explore it in Unreal Engine and make adjustments as necessary (Artificial intelligence. (n.d.).).

## 4.2. In Code Ai Algorithms in Unreal Engine

AI chat bots could be used to create a game

```
// Prompt the user to specify the type of terrain they want
string terrainType = chatbot.promptUser("What type of terrain do you want?");

// Prompt the user to specify the size of the game world
int worldSize = chatbot.promptUser("What is the size of the game world?");

// Use Perlin noise to generate the terrain
for (int x = 0; x < worldSize; x++) {
    for (int y = 0; y < worldSize; y++) {
        float noiseValue = PerlinNoise(x, y);
        float terrainHeight = noiseValue * MAX_TERRAIN_HEIGHT;
        terrain.setVertexHeight(x, y, terrainHeight);
    }
}
```

**Object Placement:** An AI chat bot could ask the user to specify the type of objects they want to place in the game world (e.g. trees, rocks, buildings, etc.), the density of the objects, and any other relevant

world in Unreal Engine:

**Terrain Generation:** An AI chat bot could ask the user to specify the type of terrain they want (e.g. mountains, plains, forests, etc.), the size of the game world, and any other relevant parameters. Based on the user's input, the AI chat bot could use algorithms such as Perlin noise, Voronoi diagrams, and fractal terrain generation to generate a unique and realistic game world.

parameters. Based on the user's input, the AI chat bot could use algorithms such as Poisson disk sampling and random walks to intelligently and realistically place objects in the game world.

```
// Prompt the user to specify the type of objects they want to place
string objectType = chatbot.promptUser("What type of objects do you want to place?");

// Prompt the user to specify the density of the objects
float objectDensity = chatbot.promptUser("What is the density of the objects?");

// Use Poisson disk sampling to place objects
for (int x = 0; x < worldSize; x++) {
    for (int y = 0; y < worldSize; y++) {
        if (PoissonDiskSampling(x, y, objectDensity)) {
            Object* newObj = ObjectFactory::createObject(objectType);
            newObj->setPosition(x, y);
            gameWorld.addObject(newObj);
        }
    }
}
```

**Quest Generation:** An AI chat bot could ask the user to specify the type of quests they want to include in the game world (e.g. fetch quests, kill quests, puzzle quests, etc.), the difficulty level, and any other relevant

parameters. Based on the user's input, the AI chat bot could use techniques such as procedural content generation and natural language processing to generate unique and engaging quests for the player to complete.

```
// Prompt the user to specify the type of quests they want to include
string questType = chatbot.promptUser("What type of quests do you want to include?");

// Prompt the user to specify the difficulty level
int difficultyLevel = chatbot.promptUser("What is the difficulty level?");

// Use procedural content generation to generate quests
Quest* newQuest = ProceduralContentGenerator::generateQuest(questType,
difficultyLevel);
gameWorld.addQuest(newQuest);
```

**NPC Generation:** An AI chat bot could ask the user to specify the type of non-playable characters (NPCs) they want to include in the game world (e.g. merchants, warriors, mages, etc.), the personality traits of the NPCs, and any other relevant parameters.

Based on the user's input, the AI chat bot could use techniques such as decision trees and Markov chains to generate realistic and dynamic NPCs that interact with the player in unique and interesting ways.

```
// Prompt the user to specify the type of NPCs they want to include
string npcType = chatbot.promptUser("What type of NPCs do you want to include?");

// Prompt the user to specify the personality traits of the NPCs
string personalityTraits = chatbot.promptUser("What are the personality traits of the NPCs?");

// Use decision trees to generate NPCs
NPC* newNPC = DecisionTreeGenerator::generateNPC(npcType, personalityTraits);
gameWorld.addNPC(newNPC);
```

Overall, AI chat bots have the potential to revolutionize game world creation in Unreal Engine by providing an intelligent and user-friendly interface for generating unique and engaging game worlds.

## 5. Conclusion

In conclusion, AI algorithms have greatly

influenced the creation of game worlds in the gaming industry. The use of AI algorithms in game development has enabled game developers to create immersive and dynamic game worlds that can adapt to the player's preferences and behavior. With the use of AI algorithms such as machine learning, natural language processing, and procedural content generation, game developers can generate

game worlds with minimal human input, saving time and resources.

The Unreal Engine and Unity Engine are two of the most popular game design tools that game developers use to create game worlds. These game engines come equipped with various AI tools and features that enable game developers to incorporate AI algorithms into their game development process.

AI chat bots can be used in Unreal Engine to generate game worlds by using natural language processing techniques to understand the user's preferences and generating game world data based on the

input received. Additionally, AI algorithms can be used in Unreal Engine to generate game world data for terrain, object placement, and NPC behavior, among other things.

In summary, the use of AI algorithms in game development has revolutionized the way game worlds are created, making them more immersive, interactive, and adaptable to player preferences. As AI technology continues to advance, we can expect to see even more innovative and creative use of AI in game development, leading to more engaging and immersive game worlds for players to enjoy.

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## SPECIFICITY OF THE PROCESS OF INTRODUCING ERP SYSTEMS IN COMPANIES

**Abstract:** *Introducing a new ERP system in companies is a demanding and long-term process, which is associated with high costs. Projects of this type are exposed to risks such as delays, additional unexpected costs or even interruption of the project that we want to avoid. In the relevant literature, the importance of applying established procedures in IT project management is recognized by many researchers when identifying key success factors (CSFs-Critical Success Factors) of ERP implementation. This work is based on the research of critical success factors related to the use of business intelligence, which can be seen as a guide for a system dealing with resource planning in large companies (ERP-Enterprise Resource Planning). This research, based on data on how different businesses are integrating these different technologies, also provides evidence of the critical success factors that drive this integration. An exploratory approach to the analysis of this problem uses detailed analysis as well as interviews to answer many questions. This research resulted in the development of a conceptual framework that identifies the critical success factors of business intelligence and the contexts that influence them, also the study investigates the critical success factors of business intelligence when implemented as a continuation of an ERP system. The research results confirm the relevance of various critical success factors in the application of business intelligence in the stages of its implementation.*

**Keywords:** *information systems, ERP systems, project management*

### 1. Introduction

In the conditions of the world economic crisis, business systems, in the desire to create a competitive advantage, are moving towards improvements in business processes that are most often found in the application of information technology. The introduction of ERP has become necessary if you want the business system to be competitive in

terms of reducing costs, integrating departments, integrating activities, improving business processes and increasing efficiency and competitiveness (Vlachos, 2006, p. 378), but the implementation itself requires significant resources. It is a complex, long-term process, with high risks, and the percentage of successful introductions is small. Also, the same author emphasizes that the business systems that were the subject of research in 2010 and

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tasted the bitterness of failed attempts to introduce ERP solutions, were very cautious in 2012 when they tried again. However, based on the review of relevant literature and experience in practice, some authors emphasize that technology alone does not automatically create a competitive advantage, only with the reengineering, revision and improvement of business processes, it is possible to improve the vision and implement the planned strategy (Botta-Genoulaz, Millet, & Grabot 2005, page 515). Today, business systems use comprehensive software solutions (hereinafter referred to as ERP systems) not only for data collection, but also for supporting the execution of business processes and decision-making, as well as the effective setting of company goals. (Denić N 2016) In the literature, it is stated that ERP (eng. Enterprise resource planning) - the term enterprise resource planning was introduced by Gartner Group Stamford (Jacobs & Weston Jr., 2007) in the early nineties of the XX century. The ERP abbreviation could literally mean advanced management and planning of all resources in one business system. Research in practice shows that the process of selecting and implementing an ERP solution is one of the most important projects of business systems. (Denić N 2020) ERP systems functionally affect the business system, organization, processes, people and technology. In this research work, the intention is to ensure and provide professional instructions and guidelines for the implementation of ERP to people who intend to introduce or deal with implementation projects of these systems. The ERP systems we encounter today have evolved from the previous systems that were used to plan material requirements in production (eng. material requirements planning, hereinafter: MRP) and from MRP II (eng. manufacturing resources planning), which had purchasing, sales and marketing functions

## 2. Theoretical background of the ERP system

ERP systems are very flexible and cover the needs of users in all business sectors. The literature states that there are several types of these systems, one of them being generic forms of ERP systems that are set up for different markets, but must be properly set up before they can be implemented. (Denić N 2022) The advantage of generic ERP systems is that they can be changed and set according to the needs of business systems. The well-known author Keller (1995) states that ERP systems are characterized by the following characteristics:

- The ERP system represents an integrated set of financial distribution, software for the production of an expanded and modified functional model of production resource planning (MRP II).
- It is also a flexible set that can work with the technology that supports it.
- The system is proactive and combines business rules and software. He adapts to the rules of business.

In addition to the above, other ERP systems are encountered in practice, which represent packages that already contain processes and functionality. According to some authors, these systems are aimed at specific markets, such as the automotive industry or retail (Klaus et al., 2000, p. 142). Experiences in practice indicate that these systems are more difficult to change, but even when this is the case, it causes a rather high cost. A successful and functional ERP system helps reduce operating costs, create more accurate demand plans, speed up production, and improve service, all of which lead to better business in the long run (Umble, Haft, & Umble, 2003, p. 244). The Table 1 presents some of the characteristic features of ERP systems according to their nature.

**Table 1.** Typical characteristics of ERP systems according to their nature (Source: S.Uwizeyemungu & L.Raymond, Essential characteristics of an ERP system: conceptualization and operationalization, 2005, str.71.)

Characteristic type	Characteristic	Explanation
Organizational	Integration	Linking functions and hierarchical levels. Connecting different processes.
	Wholeness	A wide range of functionality. Suitable for different types of businesses. Relationship with external factors.
	Uniqueness	Unique reference data. Uniqueness of the interface. Integration of systems management.
	Process orientation	The systems are adapted according to the business processes that achieve the goals.
	Best business practice	The system includes the best business practices of various fields.
Technical	Adaptability	Ability to follow rules and changes in the organization
	Openness	Functional modules (modularity). Portability of functionality.
Informational	In real time	Data available in real time.
	Prediction	A business process can be predicted or simulated.

As presented in the Table 1, the organizational characteristics are those related to the use of the ERP system in the business system, those on which the ERP system has the greatest impact, both on the structure of business systems and on business practice. The technical characteristics of the ERP system are directly related to the ERP system, such as the degree of flexibility and modularity. Information refers to the quality and usability of the data recorded in the ERP system (Uwizeyemungu & Raymond, 2005, pp. 71-72). The most important features of the ERP system are integration, flexibility and process orientation. Uwizeyemungu & Raymond (2005, p. 74) argue that these characteristics are the minimum requirements to define a particular program as an ERP system. However, Botta - Genoulaz and Millet (2006) point out that apart from ERP being focused on the enterprise and resources, it goes beyond the planning function and also includes other tasks such as financial control, operations management, analysis and reporting, and routine decision support.

In the relevant literature, the definition of an ERP system has been given by different authors, but they all have a very similar explanation. For example, Morton and Hu (2008, p. 391) state that ERP systems have become the backbone of the information infrastructure in most medium and large business systems around the world and that they are the basic software packages that connect the flow of information throughout the company's operations. Dotle Ngai et al. (2008, p. 548) define that ERP is a generic term for a large set of activities, supported by applications that contain functional modules and enable the organization to manage its resources.

Like all computer programs, ERP systems also have their advantages and disadvantages. Strengths can be divided into operational, management, strategic, technical

and organizational, while weaknesses are mainly business and technical. According to some authors, operational advantages refer to the benefits obtained from the introduction of ERP systems to operational processes, such as ordering, inventory management and customer service (Zhu et al., 2010, p. 266). The same authors point out that strategic advantages bring competitive advantages and enable the company to grow, and technical advantages increase the capacity of the information system (Zhu et al., 2010, p. 267). Other authors emphasize that organizational advantages are related to the possibility of learning and personal advancement of employees, and they are (Saaticioglu, 2009, pp. 695-697):

- supporting organizational changes,
- determining the company's unique vision and goals,
- transformation into a process organization.

### **3. Characteristics of the ERP system selection process**

Key success factors can be considered as events that happened in a situation and help us to push the boundaries of ERP system implementation process improvement (Somers & Nelson, 2001, p. 2). Decisions on the choice of ERP solutions are extremely important because they have a long-term impact on the success of business systems. Most of the leading companies in the world nowadays do not have a dilemma, whether ERP is needed or not, that is, what kind of ERP solutions are necessary (Chen, 2001, p. 378).

In the professional literature, Lavrence (2008, p. 1) presented the theory of three factors that lead to the selection of an adequate ERP solution. These factors are cost, risk and technology and together they represent the ERP solution selection triangle:

- costs or low price, this is the factor that dictates the choice of ERP solution at the lowest possible price,
- stability is a factor that implies the probability that the ERP solution remains in step with time and represents the level of risk,
- technology is a factor that shows how modern the ERP solution is as a tool based on a technological point of view.

Each of the three factors represents for most business systems one of the main driving forces in deciding on the choice of an ERP solution, and the combination of the two factors represents the classification of the ERP solution.

The results of the research of certain authors indicate that a successfully introduced ERP system brings many strategic, organizational, managerial and technological advantages (Zhu, Li, & Wang, 2010, pp. 266-267), but at the same time weaknesses that are mainly technical and business (Saaticioglu, 2009, p. - 697). By business processes, we primarily mean inventory management and planning, recording their costs, monitoring production, procurement, delivery and payments. Based on the benefits that ERP systems bring to companies, it is easy to conclude that ERP implementation brings numerous advantages. Also, research in practice shows that the best way to choose ERP is that it is an ERP system in accordance with the business processes of specific companies, as it saves investments in changing programs and potential program errors, while business processes in a specific company do not change. According to well-known authors, experience shows that this is not always possible in practice, and that it is almost always necessary to change business processes when introducing a new ERP system (Ngai, Law, & Wat, 2008, p. 551).

The ERP System software market continues its growth trend year after year and research shows that it will continue in the future. It is

obvious that today's market is saturated with different ERP system offerings. It often happens in practice that a company that wants to introduce a new ERP system simply does not know which one to choose.

**Table 2.** Decision criteria for choosing an ERP solution (Source: Government RC College Commerce & Management Bangalore, ERP impact on organizations, 2014, p. 7).

Before the first run	Before the second run	Decision criterion
8	1	The level of support provided by the supplier and the local partner.
10	2	Supplier references.
7	3	Ability to adapt to business processes.
4	4	Upgradeability.
1	5	The price.
9	6	Document quality.
5	7	Functionality.
3	8	Ease of use.
2	9	Ease of implementation.
6	10	Compatibility with existing hardware.

That is why it is best in such cases to contact local providers and check the compatibility of the offered ERP systems with the specifics of the companies themselves. Spending in the world, but also in Serbia, on business intelligence projects is constantly growing. Users are looking for software that can bring them more efficient business and competitive advantage. Whether one chooses SAP, Oracle or Microsoft, as one of the largest producers of this software, business improvement is guaranteed if the system is properly implemented and people who know how to use the system in the right way are engaged. Available data shows that the global market for ERP systems grew by 3.8% in 2013 alone, which means that the

total revenue from sales of ERP systems increased from \$24.4 billion in 2012 to \$25.4 billion in 2013. (Forbes, 2014).

On the global market, SAP with a 24% market share is by far the strongest provider of ERP solutions. The top five ERP solution providers collectively controlled 48% of the ERP market.

#### 4. Key success factors of ERP system implementation

Several studies, surveys and literature reviews have already been conducted to identify factors influencing the success or failure of ERP system implementation (eg Esteves-Sousa & Pastor-Collado 2000, Finney & Corbett 2007). However, no study shows the failure rate and evolution of success over recent years. Despite the fact that ERP solutions have been on the market for two decades, the success of ERP implementation projects is relatively low. Yu (2005) points out that earlier researches have mostly resulted in very different failure rates due to the fact that implementation success is defined quite differently by different researchers. Therefore, the purpose of this research is to study the specific introduction of ERP solutions in order to investigate how and which key success factors the introduction of ERP solutions affected the success of these projects and draw attention to possible shortcomings and key moments of the specific project. Introducing a new ERP system into a business system is a demanding and long-term process, which also involves high costs. Esteves & Bohorquez (2007) indicate that critical success factors (hereafter referred to as CSFs) have been studied quite a lot. Over fifty researches related to critical success factors in ERP implementation are listed in the bibliography from 2001 to 2005. The possible reason is that the researches were not used in practice. Some authors emphasize that these projects are constantly

exposed to risks such as delays, additional unexpected costs or even project termination, which should definitely be avoided (Ngai et al., 2008, p. 548). In this sense, Deloitte research (b.1.) states that 55% to 75% of all ERP projects end unsuccessfully. Therefore, before the introduction of an ERP system, a good project plan must be developed and aligned with the key factors that lead to a successful project and are known in the literature as key success factors.

Well-known authors state that business systems must be aware of the critical success factors (Sternad & Bobek, 2006). The high failure rate is a motivation for further study of critical success factors (Xue et al., 2005). This explains the fact that the study of critical factors of ERP implementation is still a current topic (Lin & Rohm, 2009; Francoise, Bourgault & Pellerin, 2009; Snider, Silveira & Balakrishnan, 2009). In general, the key success factors were one of the first and very actively studied research topics. They can be defined in a limited number of areas, and if they are taken into account and adhered to, they will ensure the success of the project. The professional literature offers fairly similar and general CSFs that are generally grouped into the following factors: top management support, project management, project sponsor, communication and collaboration within the organization, and end-user training. The results stated by Chung (2007, p. 3) in his doctoral dissertation are characteristic that the literature from the last decades showed that the success of ERP ERP solutions is 25%, and the inefficiency is also 25%, while the other 50% of such projects are partially successful and partially unsuccessful. Practice shows that in the world only 9 to 17% of ERP solution implementation projects are successful, it has also been shown that the best ERP solutions in practice cover up to 70% of information needs. Based on a review of the relevant literature, Dezdar

and Sulaiman (2009, p. 1044) elaborated 95 newspaper articles on this topic, published between 1999 and 2008, and developed a systematic compilation of CSFs consisting of 17 categories.

**Table 3.** Critical success factors of ERP projects (Source: S. Dezdar & A. Sulaiman, Successful enterprise resource planning implementation: taxonomy of critical factors. Industrial Management & Data Systems, 2009, p. 1044)

Critical success factors	
Support and commitment of top management	Vendor support
Project management and evaluation	Software analysis, testing and troubleshooting
Business process reengineering and minimal customization	Project management
ERP team composition, ERP software competence and compensation	Careful selection of ERP software
Change management program	Use of consultants
User training and education	Appropriate IT and legacy systems
Business plan and vision	Quality system
Open communication and cooperation in the company	User involvement
Organizational culture	

Well-known authors Esteves & Bohorquez (2007) further indicate that there was a need to create an approach that will be used in practice and which will link critical success factors with implementation methodologies. In this sense, business systems decide to renew the ERP system, and thus to reengineer business processes. The introduction of an ERP system is a demanding and long-term project, which is associated with high costs. Every unsuccessful project brings a big loss to the business system. Statistics show that from 55 to 75% of ERP system implementation

projects are doomed to fail (Deloitte, b.l.). The well-known author Vlahos states in his research that 70% of business systems in the introduction of ERP solutions went beyond the planned financial framework, 40% of companies exceeded the planned deadlines, and only 23% of companies implemented the implementation within the planned time and cost plans.

On the other hand, a successful project can bring many benefits. In their research, Davenport et al. (2003), state that 47% of respondents have adapted their ERP systems to the needs of their business processes. However, the limitation of ERP system modification has been identified as one of the critical success factors of the ERP system, as well as the business success of the company. A high percentage of ERP implementation failures was also observed in earlier research, and often other authors cited this data based on other research that emphasized risk in the implementation project. (Liang, Saraf, Hu & Xue, 2007; Ma & Loeh, 2007; Martin & Huq, 2007; Parthasarathy & Ramachandran, 2008). In research conducted by Ngai et al. (2008, p.551), "A clear and defined project plan" was one of the most cited CSFs in the 10 regions where the research was conducted. According to these authors, it should contain objectives, strategies, scope and schedule. Ngai et al. (2008, pp. 551-560) listed 18 core CSFs and divided them into three main groups, as shown in Table 4.

Well-known authors emphasize that the renewal of business processes is almost always necessary when introducing a new "ERP" system (Ngai, Law, & Wat, 2008, p. 551). A further breakdown of the ERP solution implementation approach is divided into a step-by-step and a Big Bang approach (Andersson, 2008, p. 12). The Big Break approach means abandoning the use of old software solutions at one point and switching to an ERP solution at all locations. Al-Mashari (2003, p. 42) defines the aspects

that need to be balanced when introducing an ERA solution: • Strategic aspect : • Business process renewal aspect: • Technological aspects: • Project management aspect: • Change management aspect.

**Table 4.** Key success factors divided into three groups (Source: E.W.T. Ngai, C. C.H. Lawin F. K.T. Wat, Examining the critical success factors in the adoption of enterprise resource planning, 2008, p.560.)

Group	Key success factors
Factors on the side of the ERP system implementer or supplier	Choosing the right ERP system implementer
Client-side factors or of an organization introducing a new ERP system	Top management support
	Project management
	Goal, purpose and strategy of the project
	Project supervision and evaluation
	Project sponsor
	Communication
	Project team
	Change of business processes
	User training
	Consideration of existing systems
	Data management and analysis
	Strategy and methodology for the introduction of the ERP system
	Company characteristics
The choice of ERP system	
Development, testing and solving real problems	
Factors at the state level	Local legislation
	Local business practice

It is stated in the literature that ERP solutions bring many advantages to the company's operations, but their disadvantages must always be kept in mind. Len, Chou and Chang (2002, p. 341) state

the following:

- The cost of purchasing ERP solutions is extremely high, which limits the application of ERP solutions in smaller companies,
- the problem of data protection, because companies generally do not have precisely defined rules, which have access rights system, and who can change the information in the system itself,
- The introduction of an ERP solution is difficult and long-term (depending on the size of the company from 10 months to 5 years) and represents a large project that can affect the slowdown of daily work in the company,
- Adaptation of the ERP solution to the desired needs of the company is long-term and the costs are high.

In addition to the mentioned authors, others also studied this topic, so Kim, Lee & Gosain (2005) identified 47 obstacles in different stages of ERP implementation and took them as guidelines for solving problems. Then Wong et al. (2005) studied and defined fourteen critical failure factors and emphasized that the roles of consultants, effective project control and monitoring, as well as reconstruction of business processes to match ERP functions, are extremely important for ERP implementation.

The results of the literature review indicate that business systems must deal with the introduction of a new ERP system in a careful and systematic way. The system can be fully implemented in one step or can be distributed according to modules. Regardless of the chosen method of introduction, it is important that the introduction is based on a methodology that is a standardized process and defined on the basis of experience. In introducing a new ERP system, the business system must also consider key success factors (Ngai et al., 2008, p. 548). Key success factors are areas where things need to be done correctly if we want the project to be successful (Trkman, 2010, p. 126). If they are not taken into account, the probability of failure or interruption of the project increases. A successfully introduced "ERP"

system brings many strategic, organizational, management and technological advantages (Zhu, Li & Wang, 2010, p. 266-267), but also disadvantages, which are mainly technical and business (Saatcioglu 2009, p. 695 - 697).

In relation to the functionalities that the ERP solution must provide, it is necessary to analyze the existing software solutions and determine the complexity of the business processes implemented by the business system (Lav & Ngai, 2007, p. 420). The same authors emphasize that research in various parts of the world confirmed that top management's support for success in the introduction of ERP solutions is not negligible, and its weight in the success of ERP solution implementation is quite high (Ngai, Love, Vat, 2008, p. 14). Also, that inadequate team composition can in some cases lead to an inadequate solution (Ngai et al., 2008, p. 8). The ERP solution should be implemented in accordance with the chosen methodology for the introduction of the ERP solution. The ability to effectively manage the project in relation to the chosen methodology is one of the main factors in the introduction. Rigelhof (2003, p. 14) in his presentation presents the adaptation of ERP solutions. This means that productivity varies over time during the implementation of an ERP solution.

An ERP implementation project is a failure if the ERP solution implementation project exceeds the planned implementation timing and financial framework (Somers & Nelson, 2004; Mol & Loukis, 2005). Even if the ERP implementation project is not implemented on time, within the estimated cost, or does not reach the set specifications, the implementation can still be successful (Zhang, Li, Huang, Zhang, Huang, 2005, p. 60).



## 5. Discussion

Based on the research of the prices of ERP solutions, and the value evaluation of the functions that a certain package provides in the system of small and medium-sized companies, one of the better ERP system solutions for them is Oracle Warehouse Management Systems. Based on practical experience, Microsoft Dynamics AX Lifecycle may not be the most adequate solution for these needs for several reasons. Bearing in mind that Microsoft requires all equipment and operating systems to be their products, which initially increases the cost and makes the previous computer equipment unusable. In addition, it is evident that Microsoft initially offers the cheapest price of the Cloud, however, the other components of the ERP system have a rather higher price than other systems. Research indicates that SAP's Business One system has the highest cost of implementation and maintenance, which on an annual level greatly affects the company's operations. Based on the list of users of Microsoft and Sap ERP systems, it is easy to see that they are leaders in business and that their prices are largely increased because of that leadership. They are followed by Oracle in the third place in the world, it has business intelligence systems with high level performance, the largest database with the cheapest expansion licenses and the lowest maintenance cost, and has the ability to implement on the existing platform. In the ERP implementation project management procedures, the positive experiences of previous projects are very important, which can certainly help in increasing the success of future ERP solutions.

Based on the examination of ERP system prices, as well as on the basis of the ranking list of the evaluation of medium-sized companies, one of the more suitable ERP system solutions would be SAP-HANA. Also, based on experience in the practice of

project management in medium-sized companies, it is not recommended to decide on the SAS ERP system, as well as the IBM ERP system for several practical reasons. SAP is the market leader in the region and in the world with the largest user base, which, when the two companies cooperate, has a positive effect on business. Scalability is great with large databases. The SAP system has the highest cost of implementation and maintenance, but also the largest list of evaluations, which on an annual level greatly affects the company's operations, but the positive side and value of the business system when implementing one of SAP's tools is much more useful.

Mistakes that can be repeated in the following ERP implementation projects are the following: underestimation of the necessary work for the implementation of the analysis phase, wrong assessment of the complexity of the development, misconception about the unity of business processes by the business units of the company, too much adaptation to the wishes of the users, recognizing the active participation of the company's management and limited withdrawal delay. The results of the literature review indicate that science is aware that it is more important to include the management of business systems in the projects of introducing ERP solutions.

IBM's solution for large companies is very effective on the market, as shown by the rating list, with a rich base and quality software, along with partner services with other companies, it provides a very good part of the overall pie in the environment. The good side of the IBM ERP system is that the company is narrowly specialized in those segments where the competition is weak and provides its services to other companies that deal with ERP systems.

Microsoft is the world's second-largest company that, along with its ERP services, provides fully licensed enterprise software, which reflects very well on the value and

quality of the enterprise. Microsoft provides the cheapest Cloud services, which is a very important thing for large companies because of the connection of the company as a whole if the company also has foreign branches.

In the opinion of many authors, SAP is the ideal solution for large business systems, the proof of this is the well-argued rating list. SAP is the leader in the world with constant growth of shares on the world stock market, and therefore the value of the business system that implemented it comes to the fore. SAP has a large user base in the world and here in Serbia, which enables large companies to cooperate with each other. It is the market leader. Its price varies depending on the size and shape of the company.

Positive experiences, that is, those that should be focused on the following projects, are also not negligible. During the implementation of projects in evolved business systems, the following occurred: a partnership relationship between the client and the supplier, an appropriate way of charging for services, the joint use of a software solution specialized in project management, education is limited only to key users, capable IT staff facilitates the work of the supplier, the presence of the supplier at all subscriber locations at the time of transition to production, following the Sure Step methodology, adding automation even after transition to production AND development through pilot solutions.

## **6. Conclusion**

The ERP system provides role-based access, where the level of access assigned to each user of the system is based on their information needs. ERP represents business process management software that allows an organization to use an integrated system of applications or their parts, and in order to manage all jobs, plan their use, collect data and automate a lot of auxiliary jobs on their input. Considering the theoretical basis of

the key success factors in the introduction of ERP systems, it can be concluded that in the evolved cases the key success factors were really important in the ERP project implementation project. In the selected case, 6 of the 18 key success factors in Ngai et al. (2008, pp. 551-560) were shown to be the reason for the termination of the ERP project implementation project.

The statistics of successful implementation of ERP systems in the business environment record a large number of failed projects. The background for the unsuccessful introduction can be found in excessive expectations of interest groups, theoretical planning due to lack of experience, and conflict between key actors, which soon led to a decline in team development and enthusiasm among others. The complexity of the ERP system implementation process is further enhanced by increasingly complex technology. In this research paper, it was shown that for the successful introduction of the ERP system, it is necessary to prioritize, ensure and then maintain the harmony and consequently the commitment of the actors to establish a user trustee who will direct the users to a professional authority, and will also assume the role of a continuous participant in the research, environment and new needs.

The research results indicate that business systems that are capable of changing their organization to a process-oriented one have the opportunity to inform their business processes with the help of ERP solutions. Enterprise ERP implementation projects represent an important milestone for businesses. They can drastically help them in further development, but they can also lead to collapse. The ERP system is a key element of the infrastructure that brings added value to the company's operations. ERP enables a unique view of the company's operations, usually in real time, all with the aim of ensuring that all important information about the business is accurate and available in the shortest period of time,

so that the company's management can act quickly and efficiently on the market. The key success factors of ERP implementation are factors that have a fatal impact on the success and efficiency of ERP project implementation projects. Based on a review of the relevant literature, different authors list different key success factors, but a comprehensive review of the literature shows that there is a significant degree of agreement on the factors with the highest weight.

The importance of key success factors in ERP project implementation projects is great, so it is believed that they can be further examined and analyzed during the implementation of each project. By taking into account the facts about the key success factors of previous projects, the possibilities for success in the implementation of an ERP

solution can be increased. The results show that it is possible to avoid mistakes made on past projects, even though they may have been made by other teams. The expected contribution and results of this research can be upgraded in the future by research on the project's performance from a cost perspective. It is possible to investigate the actual costs of introducing an ERP solution for a certain economic branch or type of activity, the costs of additional software solutions and the costs of rewarding employees for additional work.

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## THE RESEARCH OF CULTURAL ASPECTS INHERENT IN MARITIME COMPANIES, APPLYING MULTI – CRITERIA MODEL OF EMOTIONAL AND SOCIAL INTELLIGENCE FUNCTIONING

**Abstract:** Commencing from the already obtained results of the maritime market research, this work aims at defining and development of the innovative model. The research work will clarify a new approach of understanding the context of maritime companies through the processes that influence the purpose, goals and sustainability of port facilities. By using modern scientific methods and approaches, a new multi-criteria model was developed in the work, which was tested in real conditions and with real data, with solutions for ranking the strategic elements created within the general sub-strategy for each port service. The defined new approach is the starting point for managing the maritime system of transport and for the development of the IMS strategy of the sea port, in the field of communication strategy, on a strategic level.

**Keywords:** Organizational context, emotional and social intelligence, key performance indicators, business performance management, communication goals.

### 1. Introduction

Modern study of common and special problems of the maritime market, realistic (and/or abstract) of the world, requires consideration, acceptance, development and use of modern practical and scientific achievements based on the research of special strategies in the functioning of both social and emotional intelligence. The research of cultural aspects at the level of strategic management in maritime companies is not given sufficient scientific and professional attention. Among the significant reasons for this situation is insufficiently good theory analysis and minimal application of advanced system approaches, lack of interpersonal

connections in teamwork, indifference as a consequence of not accepting comprehensive quality management. As a result of such a situation in maritime ports in countries in transition, we have decentralization and shortening of interpersonal interaction of "homogeneous groups" which, due to non-constructed moral values, in their own way "create" elements of efficiency based on satisfaction, productivity and savings (Popović & Vujović, 2022).

Based on that, this research as a scientific achievement has multiple goals, and provides the possibility of a more detailed and efficient study not only of its individual parts, but of the entire maritime market as a unique system of a special kind.

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From this it follows that the creation of strategic elements is reduced to making relatively short-term decisions with long-term implications, without an upgraded communication strategy (Tauzović, 2001).

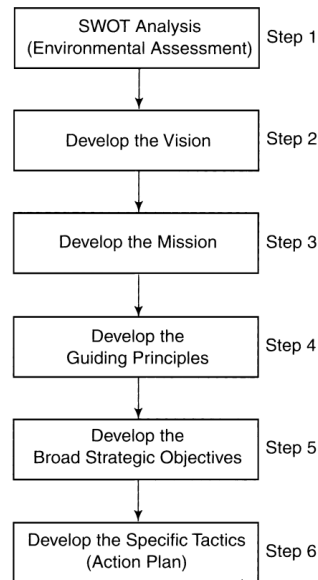
As every, even strategic, management of maritime companies is based on scientific research and practically accepted procedures for solving its problems, a modern systemic approach was taken for initial research, which includes an unformed strategy as a balance of power between the "deserved authority of the leader" and a manager who takes on the responsibilities that should be managed by a lower organizational level.

## 2. The process of strategic planning as a leadership concept for choosing strategic goals

The strategic management process must be viewed as a continuous, iterative process that includes: environmental analysis, directing the institution (mission and goals), formulating strategy, implementing strategy and strategic control (Goetsch & Davis, 1997). (Figure 1) shows the quality approach, integrated with the business strategy in the strategic planning phase, which according to (Goetsch & Davis, 1997 pp.75) constitutes the strategic planning process. The process is shown in six steps.

### 2.1. External analysis

The aim of the external analysis in the scientific work is to look at all relevant aspects of the impact of the external environment on the selected maritime companies and their performance. The analysis of the external environment is carried out due to the collection of information from the environment, the analysis of factors of the external environment, the identification of opportunities and threats and the formation of a strategy (Milošević, 2012).



**Figure 1.** -The strategic planning process (Popovic, 2018) (Adapted and modified from Goetsch, D, 2002)

#### 2.1.1 Technical tools for analysis and data collection from arcs in the environment

In modern maritime companies, numerous quality tools and techniques are used for the analysis and collection of data from the surroundings. In maritime practice, questionnaires, BREST analysis, BCG matrix, McKinsey/GE matrix, business model analyses, critical success factors and SWOT analysis are most often used (Popovic, 2018).

#### 2.1.2 Diagnosing the condition

In practice, according to research (Popović et. all, 2016), in the analytical approach of the SWOT analysis, we have selected four areas that should be considered (Figure 3). In this scientific research, we chose a SWOT analysis to diagnose the state of the port system in the surroundings that implied it:

- *Identification of the strengths* of the Port of Kotor and the Port of Dubrovnik in

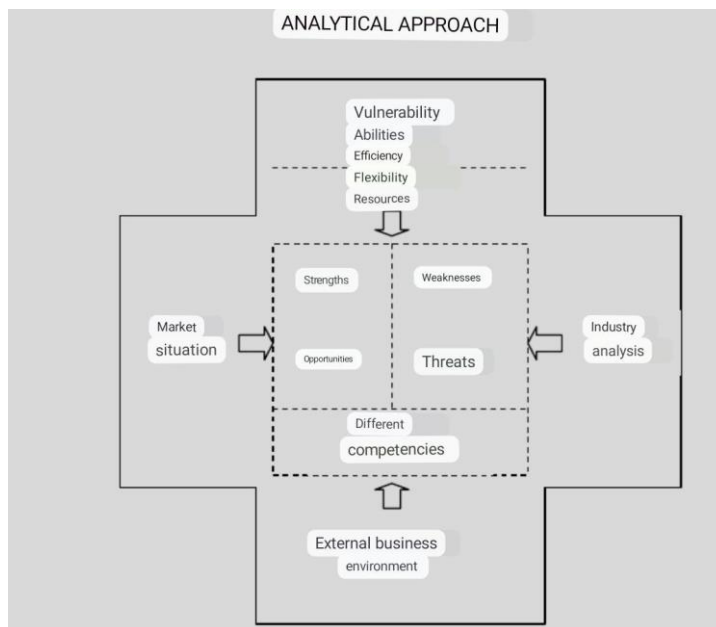


- relation to good reputation on the maritime market, strategic approach to business, high quality of port services, strong management team and others;
- *Identification of weaknesses* in relation to outdated port infrastructure, outdated operational processes, weak management team and others;
  - *Identification of external opportunities* in relation to the availability of new users of port services, the expansion of the maritime market, new technologies and
  - *The identification of external dangers* in relation to the appearance of competitors with lower costs, the appearance of competitors with a higher level of quality of port services, the introduction of new international regulations and state local laws that increase the cost of port operations and

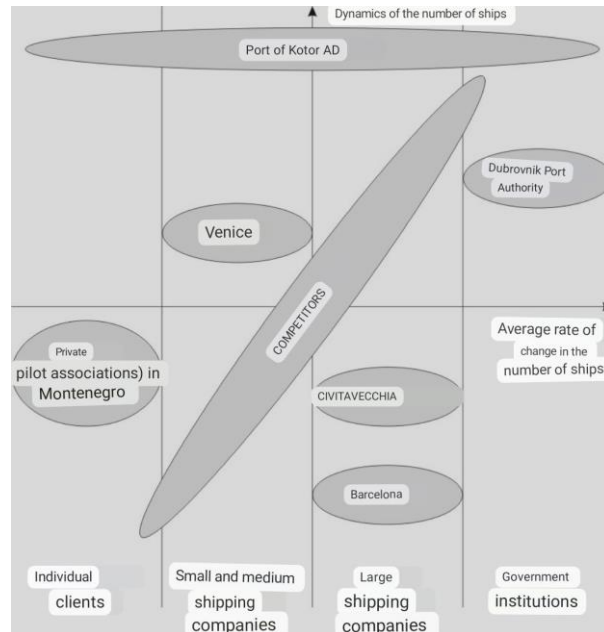
*the emphasis on the weak relations of the port management with stakeholders, i.e. users of port services.*

### 2.1.3 SWOT analysis of the Port of Kotor and the Port of Dubrovnik

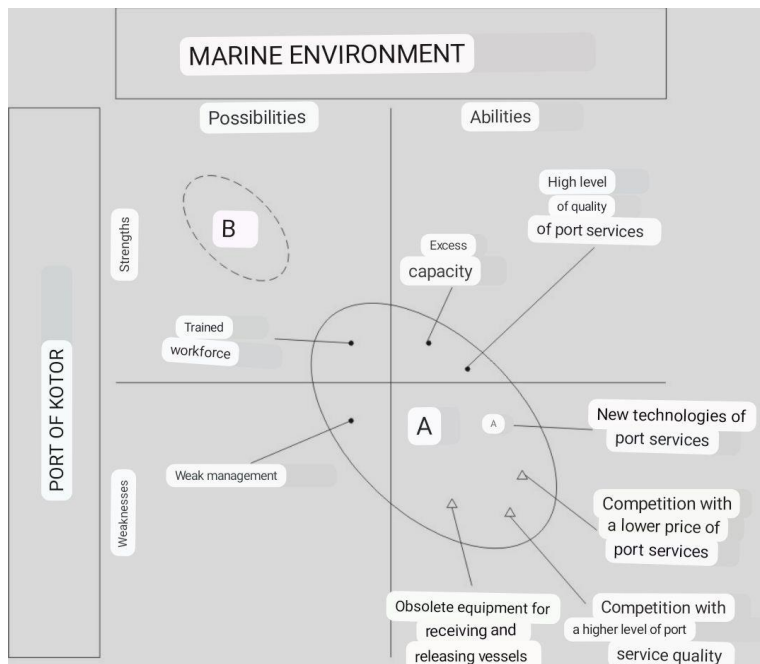
According to the analytical approach (Figure 2), a detailed strategic examination of each part of the Company was carried out in the Port of Kotor (Popovic, 2018). The real capabilities of the Port of Kotor company, the areas of vulnerability caused by the COVID-19 pandemic (eg: the dependence of the Port of Kotor on the users of port services), the effectiveness and the degree of flexibility that the company has in "facing" sudden changes in the maritime market, i.e., in the passenger transport market, were established.



**Figure 2 - SWOT analysis (Popovic, 2018)**  
(Adapted and modified from Popović et al, 2016)



**Figure 3.** SWOT matrix based on the example of the Port of Kotor (Popović et. all, 2016)



**Figure 4.** - Analysis of the competition comparing the rate of the number of ships (Popović et. all, 2016)

The SWOT matrix related to the Port of Kotor and the developed ports of the Mediterranean is shown in (Figure 3). For the analysis and forecast of the dynamics of the number of passengers from cruise ships, comparisons were made between the Port of Kotor and characteristic ports in the Mediterranean (Figure 4). According to the author's research (Popović et. all, 2016)

, financial and strategic goals were defined, according to the examination of functional systems, the examined competences and capabilities of processes and technologies in the Port of Kotor and the developed ports of the Mediterranean. The transition from area A to area B requires increasing competitiveness, permanent training of port staff, improved quality of port services and innovation of port infrastructure. (Figure 5) shows the SWOT matrix and analysis of the

Port of Kotor and port in Croatia. The research serves to understand the current situation in the Port of Kotor and Croatian ports while defining the strategy that should be applied in order to achieve the desired outcome and achieve business goals (Popović et. all, 2016)

In this thesis, SWOT analysis helped us in studying, forecasting and researching the maritime market in the surroundings, i.e. in the study of marine forecasting. In order to avoid confusion with such research, a general and clear distinction should be made between maritime market forecasting and maritime market research. The prediction of the maritime market is related to the prediction of its future events as a whole, or as its tightly interconnected parts - (passenger transport), our research case (Tauzović, 2001).

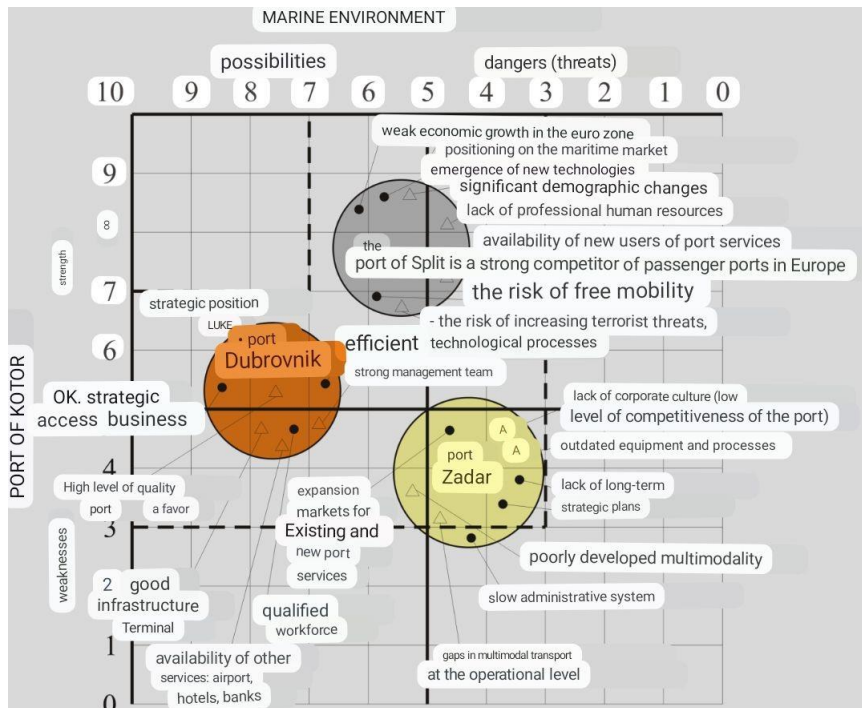


Figure 5 - SWOT matrix on the example of maritime ports in Croatia – research (Popović et. all, 2016)

**2.1.4 Analysis of the competition of the Port of Kotor from the aspect of comparing the average rate of change in the number of ships and passengers**

Research in the paper included:

1. *The collection of data on the needs and expectations of interested parties* was achieved through the media (articles, brochures) and on the basis of information obtained from surveys distributed to users of port services (other sources of information, such as publications, flyers, etc.).
2. *Identifying, analyzing, diagnosing and predicting the development of the situation in the maritime environment.*
- c) *Monitoring, analysis and interpretation of external indicators.*

External indicators were monitored through official data sources, such as the website of the Port of Kotor, websites of other professional maritime companies, websites of stakeholders from the surrounding area, media, etc. Sources or input data were extracted into indicator values. The analysis and interpretation of the indicators was carried out by the quality service of the Port of Kotor through the system management of the process "Review of the Company's IMS"

**Port of Kotor - Port of Dubrovnik**

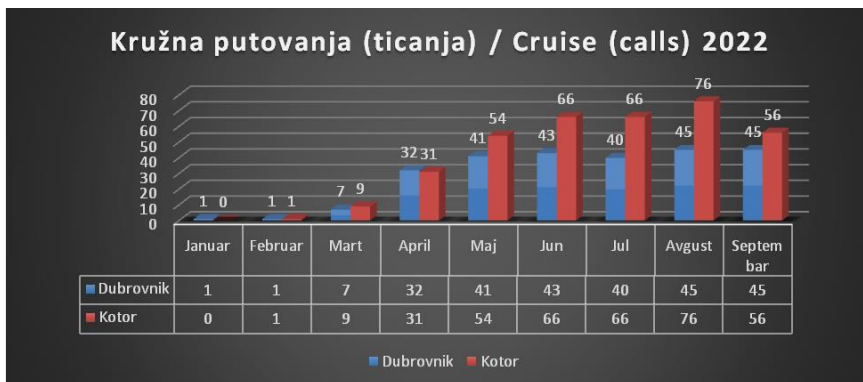
We chose the Port of Dubrovnik, the tenth world port and the third Mediterranean port in terms of the number of passengers on one-day cruises (Form – Lko 12).

The analysis of the dynamics of the number of vessels in the port of Dubrovnik is presented in (Figure 6). A slight constant decrease in the number of ships in the Port of Dubrovnik compared to the Port of Kotor for the year 2022 is noticeable. In 2022, the presence of a greater number of larger ships will arrive.

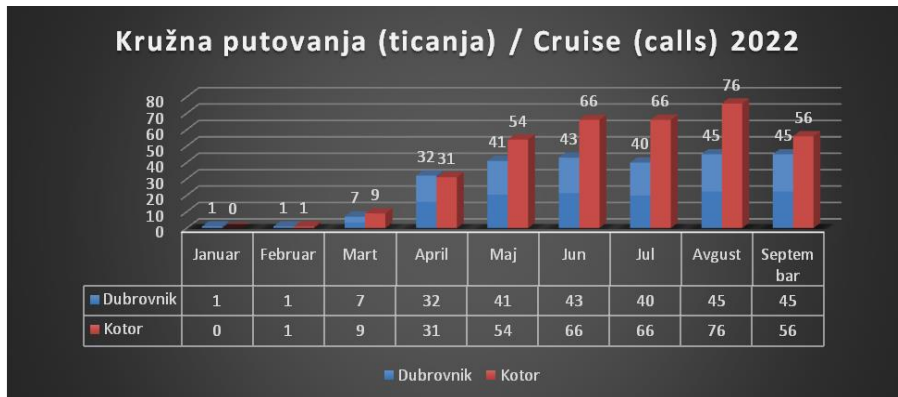
An analysis of the dynamics of the number of passengers in the port of Dubrovnik is presented (figure 7), which shows a slight constant decrease compared to the port of Kotor for the year 2022.

**Port of Kotor - Port of Venice**

The analysis of the dynamics of the number of passengers in the port of Venice is presented in (table 1), which shows a slight constant decrease compared to the Port of Kotor (first quarter Jan-March - 12.59% for the year 2022) and (second quarter Jan-June - 59.98% for 2022).



**Figure 6** – Average annual rate of change in the number of ships Port of Kotor and Port of Dubrovnik for the period Jan. - Sep. 2022 (Form – Lko 12)

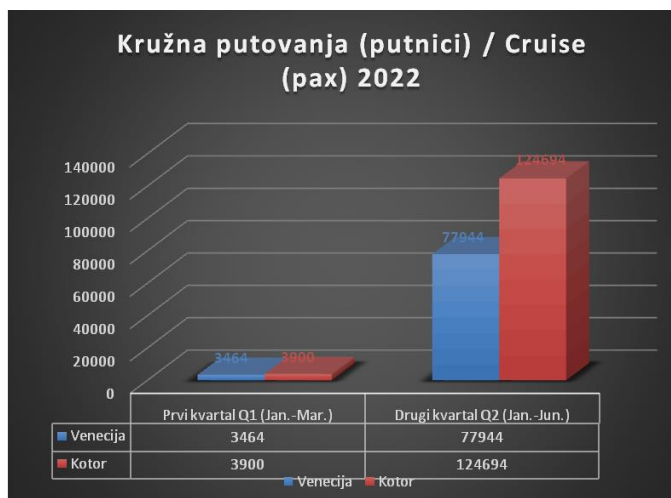


**Figure 7** – Average annual rate of change in the number of passengers Port of Kotor and Port of Dubrovnik for the period Jan. - Sep. 2022 (Form – Lko 12)

**Table 1** – Average quarterly annual rate of change in the number of passengers

	First quarter Q1 (Jan.-Mar.)	Second quarter Q2 (Jan.-Jun.)	Total:
Venecija	3464	77944	81408
Kotor	3900	124694	128594
Stopa promjene	12,59%	59,98%	

In the next phase, the research related to improving the work of strategic managers in maritime practice, whose work is usually opposed to operational managers. Operational management is basically short-term and detailed, taking place in the context of immediate or near future events. Strategic management includes ideas and actions, which are focused on the long-term future of all maritime companies, conducted in conditions of considerable uncertainty.



**Figure 8** – Average annual rate of change in the number of passengers Port of Kotor and Port of Venice by quarters Jan-June. 2022 (Form – Lko 12)

### 3. The influence of emotional and social intelligence in maritime practices

Digital transformation has brought numerous changes in the business world, one of the most important being the need to develop emotional intelligence in maritime companies employees.

Emotional and social intelligence (ESI competence) are connected with motivation, self-consciousness, managing oneself and the relations which make it possible to understand the interaction between one self and other people's emotions (Djurović, 2023).

#### 3.1. ESI as a fundament of successful leadership

The World Economic Forum has ranked emotional intelligence as one out of ten most important skills required for success in a workplace. It has recently been viewed as a key segment of successful leadership.

Social intelligence at work is about understanding and managing the relations with other people in business environment. That includes the ability to communicate, collaborate, solve problems, motivate others, understand differences and adapt oneself to a situation. Social intelligence helps the maritime companies' leaders to better understand and adapt to different styles of communication and work within a team,

which enables more effective collaboration and increases the agility and satisfaction of the employees, port services users and other stakeholders. All of these directly influence successful management, which is a key factor in modern maritime companies' productivity and income increasing.

#### 3.2. Formation of communication strategy in maritime ports

Strategic management represents a modern approach to maritime ports management, which implies a continuous process of constant adaptation of maritime companies to the changing environment, in which the environment exerts a permanent influence on maritime companies. Strategic management of maritime companies includes establishing and defining goals, determining the strategy, the process of implementing the defined strategy and control of realization and obtained results (Tuzović, 2001). The importance of skills is not equal at all management levels (Figure 9). Thus, technical skills that include knowledge of methods, techniques and tools characteristic for specific tasks (sales tasks, port service, procurement and others) are especially important at the lowest levels of the organization. Although other skills are important for managers at the lowest level of an organization, technical skill is not as valuable as other skills at the top of the hierarchy.

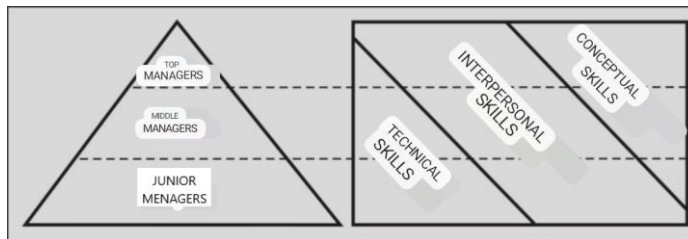
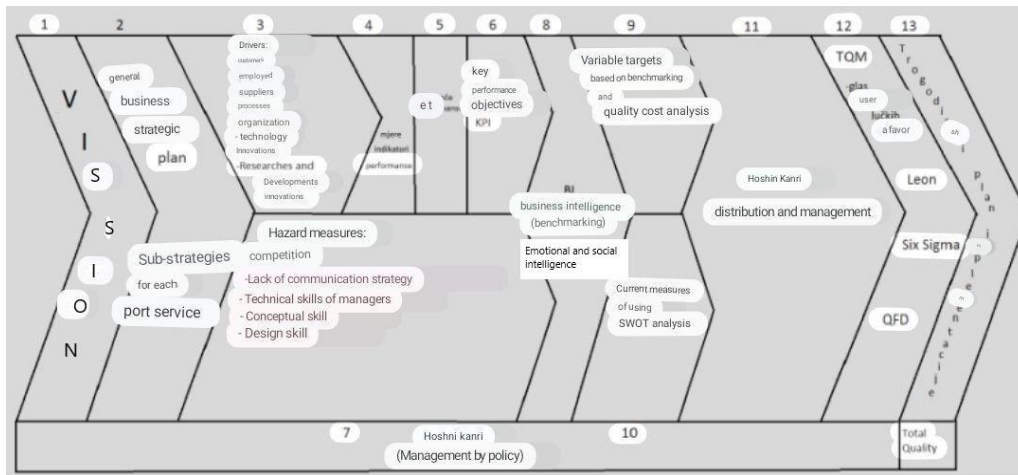


Figure 9 – Organizational hierarchy-skills and function of managers

## 4. Creation of vision-operational activity of improving the communication strategy

According to the author's research (Ansoff, 1995) Hoshin, management is connected with strategic planning and the BSC method

(Business Scorecards). This method is used for so-called policy management, which means that strategic elements (vision, mission, etc.) are transformed into tactical and operational quality improvement projects, which is shown in (Figure 10).



**Figure 10** – Organizational hierarchy-skills and function of managers

In Figure 10, all phases (from 1 to 13) are shown. (1- Strategy- 2-Vision) - it contains strategic elements within the general business strategic plan and separate sub-strategies for each port service. Phase (3 – Drivers, eng. drivers) as phases (4, 5, 6) were described in the previous thesis (Popović et. all, 2016).

In phase (7), the management of seaports is observed through the double function of research. The first phase of the research was related to management, which was observed through the management processes of certain port systems. The aim of the research was to achieve a more efficient degree of fulfillment of common goals under the influence of disloyal communication. The second phase of the research was related to management through a special group of people whose job it is to manage the execution of port operations and tasks

performed by other people. The aim of the research was related to the skills of managers, identifying, analyzing, diagnosing and predicting the development of the situation in the conditions of an undefined communication strategy at all levels of management.

Phase (8) refers to the application and recognizes the emotional and social intelligence of the leader as the basic link of effective leadership in the creation of strategic elements of improving the quality of the port system.

In phase (9), the new value of the objectives and the target costs are estimated. In the introduced phase (10), an operational risk analysis is performed, according to ISO 31000 recommendations, which refer to the responsibility of the process owner for each port service. Phase (11) is a key phase and approach in which the Hoshin policy is

strategically developed through its extension to port processes with the aim of later control and verification.

Phase (12) is described in detail in the previous paper (Popović et. all, 2016), while phase (13) refers to the application of project management methods based on project risk.

#### 4.1. A systematic approach to managing the quality of knowledge

The processes of globalization of pre - modern maritime companies in Montenegro essentially mean the defining of new requests and concepts of functioning with knowledge quality.

A systemic approach to strategic change management forms the basis for creating a quality strategy and makes a strategic response in real time through management. The superstructure of phase (7) of figure (10) forms the basis for the creation of a quality strategy. A recognized systemic approach constitutes a quality tool for internal analysis of corporate culture and organizational hierarchy-skills - functions of a maritime company manager (Popovic et al., 2022).

## 5. CONCLUSION

Modern overseas maritime companies create more and more opportunities for global partnership in port services, which increases the number and structure of participants and stakeholders. Maritime practices have had the examples of complicating the understanding processes , as well as those of defining the business goals and strategies.

The goal of this research is that managers in maritime companies must think strategically with the formulation of a clear plan that should define:

- effective achievement of business and strategic goals;
- the way and means of communication of managers, which

is reflected in simple and meaningful messages placed in an adequate context;

- realistically achievable and relevant goals for communication;
- the levels of ability to recognize, understand and manage their own emotions within the business environment .
- the management of relations with other people in the business environment.
- The mapping of knowledge as a tool for forming expert teams.

The management of knowledge quality is especially needed in the situations when neither the management theory with all its models, tools and techniques, nor the management practice with all its standards and instructions, can provide effective answers to the requests of the stakeholders (Popovic, 2018).

The system of management of knowledge quality depends on the engagement of competent personnel within the maritime companies and their understanding the standards. (ISO 10018). To effectively manage the quality within the maritime companies, we need a systematical approach of recognizing, understanding and managing our own emotions in the relations with stakeholders in the maritime business environment.

The permanent improvement implies the upgrade of convenience, adequacy and effectiveness of the quality management system. The analysis and evaluation results mentioned above, as well as the output elements of the review done by the management , should define the need for including and upgrading emotional and social intelligence in permanent improvement, explicitly identifying the opportunities for companies' performance improvement.



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**14<sup>th</sup> IQC**  
**QUALITY  
RESEARCH** **International Quality Conference**

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Ruba El Hawi

## THE ROLE OF DIGITAL PUBLIC RELATIONS IN IMPROVING THE QUALITY OF AIRLINES ORGANIZATIONS SERVICES

**Abstract:** *This research aimed to examine the relationship between digital public relation (DPR) towards improving the quality in the Aviation sector in Jordan. The researcher examined quality based on the variable of the study. A Descriptive and statistics analyses have been used for this research. The sample of the research included managers from digital public relation departments. The research hypotheses were tested using linear regression. The study concluded that there is a relationship exists between the (DPR) and quality in the airline organizations. As Reliability variable was found the most factor related towards DPR rather than the other response and accessibility. A number of recommendations were mentioned. Airlines organizations should pay attention to the importance if using DPR and to train their employees in order to achieve progress and prosperity.*

**Keywords:** *Digital PR, Reliability, response, accessibility, Quality*

### 1. Introduction

As a result of the technical and technological developments produced by the Internet in many different fields, public relations emerged, which was represented in the interactive communication processes between the sender and the receiver, as institutions of all kinds realized that it is difficult to achieve their goals and distinction if they did not approach their clients, or ignore the communication processes successful communication based on interactive communication skills, through the use of advanced technical methods, as the means of communication based on only one direction in providing information is no longer appropriate for the digital environment in which the person lives and the many challenges he faces (Mbama, 2018, p. 1). In line with these digital developments,

“digital public relations” term has appeared, as this term has been used in many studies in various fields, the most important of which is the airlines organizations, whose use lies in employing many digital media in all fields of public relations, in order to improve the quality of airlines organizations services, communicate with and follow-up with clients to reach its desired goals (Khajeheian & Mirahmadi, 2015, p. 86).

As digital public relations are an effective way to improve the quality of airlines organizations services, and work to enhance future visions in the era of digital revolution, and that social media and websites have a prominent role in improving digital public relations, especially its focus on interactive communication between public relations and clients by providing Internet, in order to follow up on clients through digital media, thus digital public relations have become

with enormous capabilities as the basis of human relations (Mbama, 2018, p.1).

The Airlines organizations are considered one of the sector that benefit most from digital and communication developments, because their services are based on communication processes permanently, dealing with clients and following them constantly, and they have the ability to apply all that is new to develop communication processes with high efficiency (Khajeheian & Mirahmadi, 2015, p.86).

Accordingly, this research was prepared in order to focus on the importance of shifting the concept of public relations to digital public relations in all airlines organizations in order to benefit from this shift in airlines organizations services.

## 2. Problem statement

In view of the digital developments brought about by the internet, which were represented by social media in a world full of digital communications, which became the basis for institutions achieving their goals and distinction, including airlines organizations, as they resorted to using these means to improve the quality of airlines organizations services and to communicate with clients through interaction and partnership in all information is on a wide field around the world, as this is due to the reliance of clients of all categories and ages in the current era on digital tools to receive airlines organizations services in a large way, which prompted airlines organizations to pay attention to advanced technologies and use digital public relations as a means to improve the quality of airlines organizations services (Mbama , 2018, p.1).

As the results of Khajeheian & Mirahmadi (2015) and Mbama et al., )2018( study confirmed that many airlines organizations still rely on traditional public relations, which weakened the quality of their airlines

organizations services. Therefore, they resorted to investing digital public relations in improving the quality of banking services through digital tools used by public relations, including social media that allows flexible banking services for clients.

Many conferences in Nigeria 2015 called for the need to rely on digital public relations to improve the quality of organizations services, and although there are many conferences that focused on the importance of digital transformation in public relations, there is a lack of studies and research that dealt with the subject of digital public relations in the airlines organizations, this confirms that there are no clear plans that show how to implement digital relationships in this sector. Also, there are no clear business plans that show how this shift and its implications for the quality of airlines organizations services (Mbama, 2018, p.250), hence the problem of the current study in measuring the role of using digital public relations tools in improving the quality of banking services. And thus, the main question of the study is: What is the role of digital public relations in improving the quality of airlines organizations services in its dimensions (reliability, responsiveness and accessibility).

The study comes its importance from its scientific topic as well as its practical application, where the importance of this study derives from the effort to supplement the studies and research conducted in the field of quality of airline organizations services and digital public relations which are a few, to a assured level, as a result of their sophistication and variety. The importance of this study also derives from the study and research of an important section of the public, which is the aviation sector. Therefore, it can be said that this study is considered one of the few studies, conducted on airlines organizations. The study also draws on the importance of its scientific subject, which can contribute to

illustrate the concepts of the quality of aviation services and digital public relations and clarifying the relationship between them in light of the providing suitable online services. It can also help airlines organizations to adapt and react to quick environmental changes to meet their customer satisfaction.

### 3. Literature review

#### 3.1. Digital Public Relations (NEED MORE INFO)

Public relations is considered one of the ancient activities, as humans started practicing it from the earliest times as a method for achieving reciprocal cooperation between members of society, and with the passage of time, organizations have realized the importance of influencing the public by convincing them of their opinions (Petrovici, 2014, p.81). This aspect was emerged in the United States of America in the early twentieth century, so was invented by (Ive Lee), (Mbama, 2018, p.1). Public relations allow the defining and constant, precise application of a communication or information policy, in the service of an enterprise, administration, collectivity or any other entity, related to its internal or external audience or interlocutors, also public relations are a vital tool of adjustment, interpretation, and integration between individuals, groups, and society. Public understanding and support is basic to existence in our competitive system, to know how to get along with the public is important for everyone (Petrovici, 2014, p.80). And because public relations are the link between the organization and the public, organizations may work at the present time to make all its efforts in order to build a good reputation for it among its audience and to gain their satisfaction, follow-up and cooperation with it, as it is the way to the internal and external masses of many

organizations with different goals and aspirations through Keeping up with recent technological changes and in line with digital developments (Mbama, 2018, p.2). In line with digital developments, the concept of “digital public relations” emerged, where the basic idea of digital public relations emerged about how to use digital means and modern technologies, such as the Internet, computers, and smart phones, to carry out their work efficiently, quickly and at a lower cost, especially in light of a world full of globalization, competition and research. Always on Excellence, in addition to its ability to use the news and media releases that it issues over the Internet, in order to provide its services, inform the public and follow it up with everything that is new and new in it in various organizations and institutions, as well as banking services (Petrovici, 2014, p.80). As digital public relations are an effective way to improve the quality of banking services, and work to enhance future visions in the era of digital revolution, and that social media and websites have a prominent role in improving digital public relations, especially its focus on interactive communication between public relations and clients by providing Internet, in order to follow up on clients through digital media, thus digital public relations have become with enormous capabilities as the basis of human relations (Mbama, 2018, p.1).

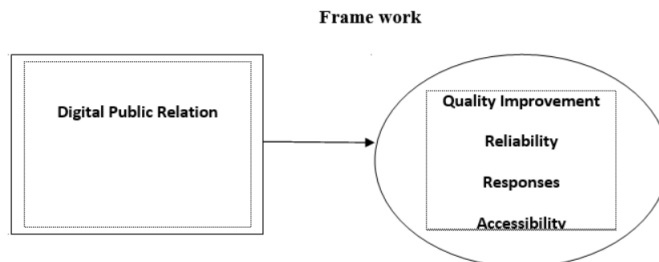
#### 3.2. Quality for Airlines organizations’ (NEED MORE STUDIES)

Organizations’ are keen to keep up-to-date of the quick changes so as to achieve an improved grade of services to meet the difficulties and the rapid changes they face particularly in light of the rising wants of customers. The quality of services is an advantage to be used to improve the organizations position in the market. The quick changes in the financial markets have

transformed the actuality of an organization environment more than what is predictable. Fast technological development and deregulation have led to progressively competitive pressures between financial and non-financial sectors. As a result it is the necessity focus on the quality of services to improve the performance. Since the beginning of the 21st century, the world has observed several technological changes that have a straight influence on dynamic and service projects. In light of these changes, several countries are facing the difficulties of steadfastness in the face of strong struggle, which shows the need to focus on the quality of banking services as one way to complete existence and continuity (Zulfadli et al, 2019, p.2; Al-Habil et al., 2017, p.200). There are ten elementary dimensions of quality that determine the quality of service according to the insight of the customers as

follows: (reliability, responsiveness, accessibility, efficiency and capacity of service providers, courtesy, communication, credibility, Security, Attention, care and upkeep, and tangible physical and human aspects), and the following is the concept of each dimension of the quality of banking services separately:

**Reliability:** is a degree of consistency in service performance and submission of the first time properly. **Response:** is the degree of the speed of response of service providers to the demands and customers wants. **Accessibility:** is the easy access to the service providers and interact with them when essential. In this research the researches aimed to study the variables which are (Reliability, Response, and Accessibility).



**Figure 1.** Quality framework

**4. Methodology**

The researches aimed to examine this study on the airlines organizations in Jordan. Recently, for the last ten years in Jordan all the Aviation business aspects witnessed very fast expansion including passenger and cargo transport. As a result, this progress in the airline sector has led to an increase in the demand for other aviation services, and thus, it was needed to support these changes or the expansion to operate successfully. One of these essential services that are required is the digital service .By that the researchers

will distribute a questionnaire included questions about the study on the study sample which is a purposive sample including Managers who are working in the digital public relation department. And they were (60) public relation managers in the airlines organizations.

**5. Results**

**5.1. Descriptive Analyses**

Demographic variables for the study sample. It appears from the table above that the "male" category in the gender variable got

the largest number of answers from the study sample, as it got "35" samples from the total sample of "60" samples with a percentage of "58%", while the "female" category got the lowest number Of the answers of the study sample, which got "25" samples, "42%".

Also it appears from the table above that the category "from 5 - less than 10 years" in the years of experience variable obtained the largest number of answers from the study sample as it obtained "28" samples from the total sample of "60" samples with a percentage of "47%" while The "less than 5 years" category came with the lowest number of responses from the study sample, which received "11" samples, at a rate of 18%.

It appears from the table above that the "Bachelor" category in the variable of academic qualification obtained the largest number of answers from the study sample, as it got "32" samples from the total sample of "60" samples with a percentage of "53%", while the "PhD" category came with the lowest A number of answers from the study sample, which got "5", a sample of "8%".

Cronbach Alpha ranged between (75-91.6), while the overall stability factor was (89.7), which are high values indicating that the study is acceptable for the purposes of scientific research.

- First question Descriptive analyses Result:

What is the role of digital public relations in improving airlines organizations reliability, The arithmetic mean of the field of the role of digital public relations in improving reliability in airline organizations was low, and tool areas were also low-grade, which got "2.18" and a standard deviation of "0.31". As for the items of the study, their arithmetic averages ranged between "2.20-2.16" and a standard deviation of "0.31 – 1.21" compared with the general arithmetic mean.

- Second question Descriptive analyses Result:

What is the role of digital public relations in improving response in the airlines organizations, that the arithmetic mean of the field of the role of digital public relations in improving the response in airlines organizations' was low (2.17), and tool areas were also low-grade, which got "2.17" and a standard deviation of "0.38", as for the items of the study, their arithmetic averages ranged between "2.15-2.19" and a deviation Standard "0.48 – 1.05" compared with the general moving average.

- Third question Descriptive analyses Result:

What is the role of digital public relations in improving accessibility in the airlines organizations, that the arithmetic mean of the field of the role of digital public relations in improving accessibility in airlines organizations was of a high degree, which got "2.16" and a standard deviation of "0.45", As for the study items, their arithmetic averages ranged between "2.14-2.18" and a standard deviation of "0.51 – 1.25" compared to the general arithmetic mean.

## 5.2. Study Hypothesis:

Are there statistically significant differences in the role of digital public relations in improving the quality of airlines organizations services due to the following variables: "gender, years of experience, educational qualification"?

To answer the hypothesis of the study, a t-test was performed for the variables that contain two levels, while one-way analysis of variance was performed for the variables containing three levels or more, as shown below.

First: gender variable Tests were performed to find the differences between the arithmetic means of the study sample answers to the variable of the place of residence, as shown in the table (1).

It is evident from the table (1) that there are no statistically significant differences in all fields of study according to the gender

variable, as the significance level value for all fields was higher than ( $\alpha = 0.5$ ).

**Table 1.** T-test to find the differences between the arithmetic means of the study sample answers to the variable of residence

Field	Variable classes	Average	standard deviation	Degree of freedom	T value	Significant level
the role of digital public relations in improving reliability in airlines organizations	Male	3.89	.31	59	0.221	0.832
	Female	3.86	.32			
the role of digital public relations in improving response in airlines organizations	Male	3.95	.38	59	2.051	0.085
	Female	3.64	.35			
the role of digital public relations in improving accessibility in airlines organizations	Male	4.79	.47	59	1.802	0.123
	Female	4.38	.53			

Second: years of experience variable One-way analysis of variance was performed to find the differences between the arithmetic

means of the study sample responses to the years of experience variable, as shown in Table (2).

**Table 2.** One-way analysis of variance to find the differences between the arithmetic means of the study sample responses to the years of experience variable

Field	Contrast source	Sum of squares	freedom Degree	Squares Average	F value	Significant level
the role of digital public relations in improving reliability in airlines organizations'	Between groups	.468	2	.234	2.756	.031
	Within groups	4.839	57	.0849		
	Total	5.307	59			
the role of digital public relations in improving response in airlines organizations'	Between groups	.206	2	.103	0.617	.610
	Within groups	9.518	57	0.167		
	Total	9.724	59			
the role of digital public relations in improving accessibility in airlines organizations'	Between groups	.425	2	.212	0.785	.525
	Within groups	15.416	57	.270		
	Total	15.840	59			

It is evident from the table (2) that there are no statistically significant differences in the second and third areas, as the value of the significance level for these two fields is higher than ( $\alpha = 0.5$ ), while there is a statistical indication in the first domain, "The role of

digital public relations in improving reliability in banks" Where the value of the significance level was less than ( $\alpha = 0.5$ ), and to find out in favor of whom those differences were, a Scheffe test was performed, as shown in the table below.



**Table 3.** Scheff'e Test for differences between averages

Field	Category		Less than 5 years old	From 5-10 years	More than 10 years
		Average	3.45	3.59	3.69
the role of digital public relations in improving reliability in banks	Less than 5 years old	3.45		0.311	*0.011
	From 5-10 years	3.59			0.189
	More than 10 years	3.69			

It is evident from the above table (3) that there are statistically significant differences between the "less than 5 years" category and the "more than 10 years" category due to the "role of digital public relations in improving reliability in banks" and with reference to the values of the arithmetic averages we find that the differences were in favor of the "more than 10 years" category, which got an arithmetic mean of "3.69", while the "less

than 5 years" category got an arithmetic mean of "3.45"

Third: educational qualification variable A one-way analysis of variance was performed to find the differences between the arithmetic averages of the study sample answers for the scientific qualification variable, as shown in the table (4).

**Table 4.** One-way analysis of variance to find the differences between the arithmetic means of the study sample responses to the educational qualification variable

Field	contrast source	Sum of squares	freedom Degree	squares Average	F value	significant level
the role of digital public relations in improving reliability in airlines organizations'	Between groups	2.249	2	.750	0.730	.526
	Within groups	58.573	57	1.028		
	Total	60.822	59			
the role of digital public relations in improving response in airlines organizations'	Between groups	2.092	2	.697	.889	.420
	Within groups	44.668	57	.784		
	Total	46.760	59			
the role of digital public relations in improving accessibility in airlines organizations'	Between groups	2.087	2	1.045	1.077	.109
	Within groups	55.303	57	.970		
	Total	58.590	59			

It is evident from the table (4) that there are no statistically significant differences in all fields of study depending on the educational qualification variable, as the significance level value for all fields was higher than (0.5 = &).

## 6. Discussion

This chapter deals with a discussion of the results that were reached, and the recommendations that emerged from those results, and the following is a review of that:

What is the role of digital public relations in improving airline organizations' reliability; The results of the study showed that the

mean of the field of the role of digital public relations in improving reliability in the airlines' organizations was low, and tool areas were also low-grade. This indicates a clear weakness in this aspect, and the researcher returns this result to that there is a weakness in the effectiveness of the level of digital public relations activities in achieving the reliability of the bank, as there may be a weakness in recruiting qualified personnel to practice digital public relations activities, and there may be a weakness in the administration department in following up and following the progress of digital public relations activities. Beside the researches explained this result based on the obtained mean (2.16) that the airlines organizations do not pay attention in updating their activities and information to meet their clients' needs. And thus, the result differed with Mahboub (2018) study, which concluded that the research indicated a positive significant impact of SMU on financial and non-financial performance in MENA countries in terms of profitability, growth and environmental performance. While This result is consistent with the Khajeheian & Mirahmadi (2015) study, which concluded that traditional media still play a dominant role in media consumption of public relations, while new Web2.0 media consist of Mobile communications and Social networks, have never ranked better than fifth from eight. Some reasons have been argued in conclusion.

Results related to the second question: What is the role of digital public relations in improving response in airlines organizations; The results of the study showed that the mean of the field of the role of digital public relations in improving the response in airline organizations was low. As the mean is 2.15 and tool areas were also low-grade. This indicates a clear weakness in this area, and the researcher returns this result to that there is a weakness in the effectiveness of the level of digital public relations activities in

achieving the response, as there may be weakness in the human resources management, as employees with competencies are not employed to practice digital public relations activities, and there may be a weakness in employing and following-up modern technologies within the airlines organizations by the airlines' administration department.

Results related to the third question: What is the role of digital public relations in improving accessibility in airlines organizations; The results of the study showed that the arithmetic mean of the field of the role of digital public relations in improving accessibility in banks was of a low 2.16, and tool areas were also low-grade. This indicates a clear weakness in this area, and the researcher returns this result to that there is a weakness in the effectiveness of the level of digital public relations activities in improving the accessibility of the airlines organizations', as there may be a weakness in recruiting employees who are able to deal with modern technologies, and there may be a weakness in the banking administration in terms of employing and managing modern technologies within the airlines organizations', and perhaps. The researchers explained this result due to the lack of financial resources available in providing these modern technologies, and it may also be due to the lack of awareness of the correct practices for digital public relations within the bank. As digital public relations provide a service that allow employees / users in the organizations to have easily access this also can provide a quick response.

Results related to the Study hypothesis:

1. Are there statistically significant differences in the role of digital public relations in improving the quality of airlines organizations' due to the following variables: "gender, years of experience, educational qualification"?

First: gender variable: The results of the study showed that there are no statistically significant differences in all fields of study according to the gender variable, and the researcher returns this result to that the study sample, regardless of their gender, have the same ideas regarding the role of digital public relations in improving the quality of airlines' services, so it was not found that there are differences in all areas attributable to the variable of gender

Second: years of experience variable  
The results of the study showed that there are no statistically significant differences in the second and third areas, while there is a statistical indication in the first domain, "The role of digital public relations in improving reliability in banks" in favor of the "more than 10 years" category, and the researcher returns this result to that the field of improving reliability in airlines organizations' may require that there be sufficient and long experience in the field of public relations compared with other fields, so it was found that there are differences attributed to years of experience in the field of the role of digital public relations in improving reliability in airlines organizations', in favor of those with years of experience. From 10 years "while the other areas, which are accessibility and responsiveness, did not have differences attributable to the years of experience variable.

Third: educational qualification variable  
The results of the study showed that there are no statistically significant differences in all fields of study depending on the educational qualification variable in airlines organizations', and the researchers returns this result to that the study sample, regardless of their academic qualifications, had the same ideas regarding the role of digital public relations in improving the

quality of airlines organizations' services. Therefore, it was not found that there are differences in all areas due to the variable of scientific qualification.

### Recommendations and proposals

Based on the results of the research, the researcher suggests a number of recommendations for applying digital public relations in airlines organizations', as follows:

1. The necessity of presenting and preparing workshops for the managers who are responsible for the digital public relations departments in airlines organizations', in order to prepare them to effectively practice digital public relations activities.
2. The necessity for airlines organizations's managers to enhance their organizations' services by employing modern technologies and managing them effectively.
3. Ensure that employees are trained on the necessary skills to effectively practice digital public relations activities.
4. The necessity of conducting more research and studies regarding the role of digital public relations in improving airlines organizations' services, in order to identify future proposals.
5. Obtaining the necessary skills to practice digital public relations in banks.
6. Increasing awareness of the importance and role of organizing events in public relations, its methods, objectives, functions and mechanisms to benefit from them in making a bright image for airlines organizations'.
7. Providing the participants with the necessary skills for bank marketing, and introducing the participants to the role of social media in making the airlines organizations' reputation.
8. Empowering employees with effective communication skills and competencies and building mental image through means Social Media.

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## IMPROVING MONITORING OF EQUIPMENT IN THE LOGISTICS SYSTEM

**Abstract:** *In the fast-paced world of logistics, equipment management can be a costly and time-consuming setback. From transport vehicles to warehouse machinery, monitoring these crucial assets and their spare parts is essential for maintaining efficient operations. In this document, there will be presented the possibility of data processing automatization, through various classifications of arms and equipment and calculations, as well, which can improve the way of monitoring quantitative and qualitative parameters of items. This would increase the efficiency and effectiveness of the logistics system in one specific organization, the army. Throughout this article, there will be explored an innovative way to improve equipment monitoring in logistics systems and optimize supply chain management, according to the modern trends of automation and data exchange in manufacturing technologies, including cyber-physical systems, the Internet of Things, cloud computing, and cognitive computing, known as Industry 4.0. The most essential part of it, Quality 4.0, will help the integration of management tools into the quality and quantity control process. The main objective of this article is to show the new model of equipment management in quality products, and optimization processes using real-time data analytics, in order to reduce defects, provide greater responsiveness and reduce the strains on human resources.*

**Keywords:** *Industry 4.0; Monitoring; Logistics; Classification; Quality 4.0; Management.*

### 1. Introduction

Following the specifics of the missions and tasks performed by the forces of the Serbian Armed Forces, there are demands for accurate, timely, and expedient information, and with the development of technologies, requirements, and applications Quality 4.0. Having the right information at the right time is a good prerequisite for effective command and control in general, and especially in the area of logistical support, which is why there is a need to pay considerable attention to the

development of information systems. Due to the volume and complexity of data that appear in logistics processes, the main problem is the impossibility of functioning the modern army without appropriate information support provided by the latest information technology systems. Given that the logistics information system of the Serbian Army is in the initial stage of development and is not sufficiently developed, the main goal of this paper is to see the possible concept of development of the logistics information system, in order to

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create the most favorable conditions for monitoring the quantitative and qualitative state of assets. The development of information systems in the logistics support system would shorten the response time of the system to requests, and reduce the number of personnel and the volume of logistics resources (Jovanović, 2013). The primary task of this paper is the affirmation the importance of automated data processing and monitoring of the condition of weapons and military equipment through information technologies in the logistics system, the number of personnel and the volume of logistical resources would be reduced.

## 2. Informational Needs of Logistics Authorities

The logistics information system should process data and provide information to competent decision-makers about objects of logistics interest throughout the entire life cycle in which the defense system can be found (peace, crises, state of emergency, mobilization, war) (Milenkov, Andrejić, Stanković, Bukvić, 2010). The information system should provide information about the state of elements and subsystems and the system as a whole thing, in qualitative and quantitative forms. The object of monitoring must be well described to facilitate its quantitative and qualitative monitoring and thus better decision-making. Also, the system itself needs to learn how to recognize certain objects and their needs for them. Each object of interest of the system should be described with as many parameters and indicators as are important for making adequate management decisions, and therefore for various types of asset classification in accordance with the needs of competent decision-makers. Also, it is necessary to define the informational needs of each decision-making body and the way of presenting the necessary information: cyclograms, histograms, numerical data, a

form of prose description, etc. (Andrejić & Milenkov, 2012). The problem in the logistics support system is the lack of a single application for monitoring the qualitative and quantitative state of assets, non-updated management of assets in already existing information systems, i.e. lack of valid information on the current state of assets in the army caused by the human factor. Previous attempts to solve the problem of monitoring the state of assets in the army have not had much success. The applications "Information System UbS" and "IS VOZILA" have the greatest practical application, but due to the existence of certain shortcomings, they are not adapted for use by all logistics authorities. A proposal to solve the problem would be the introduction of automated information systems, based on Quality 4.0 and machine learning, where the rapid transfer of information would result in the creation of significantly lower inventory levels while increasing the degree of operative availability of funds. Therefore, in modern conditions, time becomes a critical factor due to more frequent requests for replenishment with critical material resources (Milenkov, Sokolović, Milovanović & Milić, 2020).

## 3. Informational System Model

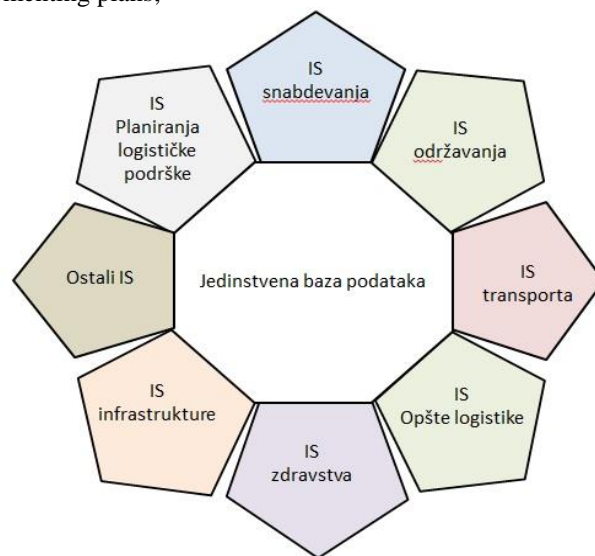
The information system of the logistics authority is intended for better coordination, information, operation, and speed of response of the logistics system. To comply with the requirements, it is necessary that, in addition to the efforts made for the development of the system, the logistics authorities continuously work on the automation of work and the development of the application, and with the development of modern artificial intelligence, they are also working on its application. The information system of the logistics authority should be based on the organizational and formational

structure of the Serbian Armed Forces, information processes in the command system, and the achievements of modern computer technology. The goal of the system is to provide logistics authorities with accurate data on resources, and tasks that they can perform with the available funds, as well as to provide automated calculations for replenishment planning. The information system of the logistics authority, as an integral part of the logistics support of the Serbian Armed Forces, should enable (Milenkov, Andrejić, Sokolović, Cakić, 2009):

- creation of conditions for effective planning and management of logistic support;
- automation of the process of data collection, storage, and processing;
- efficient work of logistics authorities in planning, organizing, and implementing plans;

- provision of accurate records of available funds;
- automation of calculations and provision of reliable information for decision-making;
- providing information to management bodies in real-time.

The basis of an informational system should be information systems of supply, maintenance, transport, general logistics, health, infrastructure, logistics support planning, and other IS (material bookkeeping, operational records, monitoring the realization of material and financial plans, monitoring data on resources in society, monitoring the state of logistics personnel, monitoring the state of resource protection, etc.) (Zlatnik & Mares, 2020). The concept of the information system is shown in Figure 1.



**Figure 1.** Functional structure of the information system of the logistics authority

The concept of such an informational system is very complex, and in itself represents a "mega project", which is divided into sub-projects according to logistic functions, to which specific resources are allocated and

the set tasks necessary to achieve the goals are implemented. The sub-project of the Information System of the Logistics Authority shown in the paper is intended for the implementation of supply tasks. The sub-

project presents small applications for solving specific tactical problems that do not violate the global concept of the information system of the logistics authorities and which can, when conditions are created, fit into the global concept of the development of integrated information systems. The application, presented in the paper, is a model of the information system of the logistics authority and is an integral part of logistics support in matters of supply. It was designed in the Microsoft Access program, and supported for application-oriented artificial intelligence towards Quality 4.0. The decision to project the IS model in this alliative program is the request of the logistics authority to automate data collection, and the program provides input in only one place, ie. it omits redundancy, which greatly increases the efficiency of the work of the logistics authorities. The application model consists of several separate databases that are mutually independent. The reason for this design is

the problems of modern technology, where viruses are primarily thought of. In case of an attack on one base, the application can be easily restored, and will not violate the global concept (Milenkov, Simić, Purković, 2015). The starting base is the central base that contains the necessary data for the realization of the requirements of the supply authorities (organizational-formation structure, classification of weapons and military equipment and echeloning of funds by units) and is the starting point for data entry. The central database contains data on the classification of assets, organizational and formational structures and distribution of assets by units, and other separate databases are linked to it, which represent the basis for later transfer and processing of data, preparation of calculations and provision of information in real time. Databases contain data on assets, and by linking to the central database, a connection is made with the classification, which is the basis for further upgrading of the application (Figure 2).

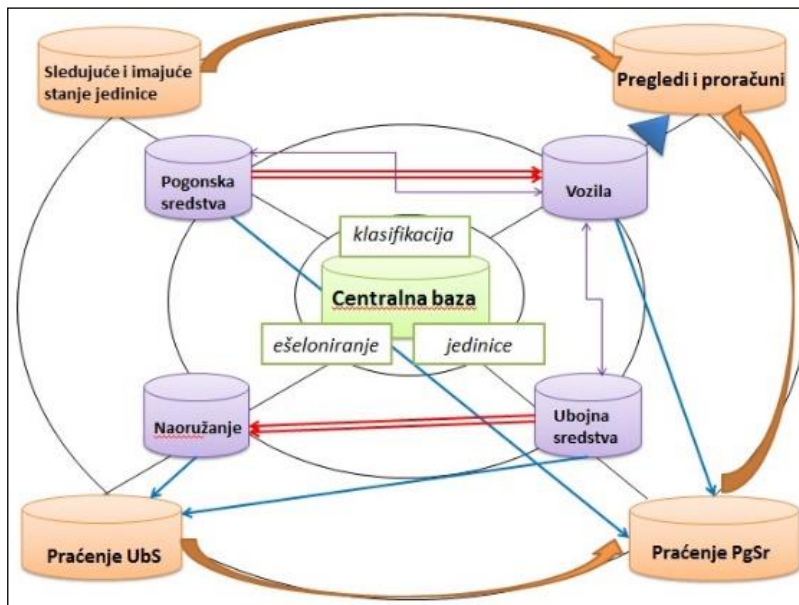


Figure 2. Connection of databases in the application



By creating quantitative monitoring of fixed assets (UbS (eng. ammunition) and PgS (eng. fuel)), the linking of assets and consumers into a single base is realized, and in this way, the condition for budgeting is realized ( ). By linking the database of the following and current state with the monitoring databases, a review and calculation database is formed. However, to obtain the final result, it is necessary to link funds with consumers ( ). For example: to calculate the amount of assets in the cargo box of the vehicle, it is necessary to connect the bases of assets (Sredstva) and the base of the vehicle (Vozila), and where previously it is necessary to enter the dimensions of the cargo box of the vehicle ( ). In the end, by tying all bases in the described way, a calculation is reached, one of the basic elements of which is the base of the vehicle (Vozila). ( ) Data are linked from one database to another and thus ensure constant updating of the complete application. The final outcome is the linking of all databases to the central database and the ultimate goal of the application is achieved, that is, overviews and calculations are displayed, which provide accurate records of the available funds, efficient work of the logistics authorities, and provide information

in real-time. Databases that form the basis of the application, are of relational type. Tables that contain data by binding enable the application itself to work. Each table is identified by a unique name that the database uses to find the table. All that is required is that the user knows the name of the table and the data he needs. Tables and their data are displayed using forms.

Starting the application is achieved through the input mask, where the possibility of direct access to the desired content is given. When accessing, the content is opened in the form of a form, where it is possible to view the status and update the data. The form is that part of the database application that allows entering data into tables instead of directly accessing the tables, then modifying the existing data and their sophisticated display. Creating forms is possible if the data is previously defined in the tables and if they are linked. This prerequisite is the basis. The form itself serves as a more beautiful display of the application, while all actions are performed in the background, that is, through tables and their interconnections. The form shown in Figure 3 is a combination of tables that contain data related to the consumer and the means used by the consumer.

СТРУКТУРА БОРБЕНОГ КОМПЛЕТА			
Шифра	1061		
Назив средства	Пиштољ, полуаутоматски, 9мм, CZ99		
Шифра метка	106AJ	Број метака за 1 б/к	50
		Маса за 1 б/к (кг)	0,72
Напомена	Пиштољ 9 мм ЦЗ 99 намењен је за уништавање живе силе на даљинама до 50м. Најуспешније дејство постиже се на даљинама до 30 м. Пиштољ је полуаутоматско оружје и опалјивање се врши појединачно. Пуни се оквиром од 15 метана.		

Figure 3. Form for displaying the structure of the combat kit

The form is structured from the main form and subform (Figure 3). On the main form, it is possible to select an asset, using the navigation buttons, where the image of the asset will be displayed in the documents field. The field includes legal and normative regulations that regulate the logistic support system, as well as technical documentation related to material resources. The form also shows a detailed description of the assets shown in the "note" field (Napomena).

The subform shows the structure of the combat kit for the selected tool, expressed through the number of bullets and mass (b/k). The "bullet code" field (Šifra metka) indicates the type of bullet intended for the

selected tool. The subform also contains a detailed description of the funds displayed in the "note" field.

For the full operation of an application of this type, it is useful to create queries, which shorten the working time of professional service bodies. The queries used in this application were related to the grouping of assets and the review of the amount and type of assets by unit, all to calculate combat kits and fill tanks, as well as placing assets on a motor vehicle.

The final output of the application is Reports. Reports are based on survey data and calculations for specific units. An example of the report is shown in Figure 4.

Извештај - прорачун п/р за батаљон				
пешадијски батаљон				
Назив средства и опис	Количина	Опис назива ПгС	Ознака ПгС	једно п/р
Аутомобил, ТАМ 5000D	44	ГОРИВО за дизел-моторе, DIZEL D2	DIZEL D2	5280,00 l
		МАСТ вишенаменска, мека	УМ-2	264,00 kg
		УЉЕ, за кочнице аутомобила, гликолно, АТ 2	УКАГ-1	132,00 kg
		УЉЕ, моторно, нарочито детергентно, средње	DS-30/S1	748,00 kg
		УЉЕ, хиподно, средње	НП-90	528,00 kg
Аутомобил, PINZGAUER	5	МАСТ вишенаменска, мека	УМ-2	30,00 kg
		УЉЕ, за кочнице аутомобила, гликолно, АТ 2	УКАГ-1	3,50 kg
		УЉЕ, моторно, нарочито детергентно, средње	DS-30/S1	35,00 kg
		УЉЕ, хиподно, средње	НП-90	29,75 kg
		БЕНЗИН, моторни, безоловни, ВМВ 98	ВМВ 98	375,00 l

Figure 4. Tank filling calculation report

The report shown in Figure 4 offers data on the quantity and name of motor vehicles, a more detailed description of the propellants used by the motor vehicles, designations of the types of propellants, as well as the amount of fuel that represents one filling of the tank and the amount of lubricants and oils in kilograms that follow the observed motor vehicle. In the Name of Asset and Description column (Naziv/Opis), the exact names and detailed descriptions of motor

vehicles are given, based on the Directory of Assets. The next column, Quantity (Količina), shows the number of certain motor vehicles that the battalion has. Then, in the column Description of the name, fuels, oils, and lubricants are described in more detail, more precisely they are described according to the nomenclature name from the directory of motor vehicles, which is used by the motor vehicle that is the subject of our interest. Then, the following table of

PgS designations shows the designations of propellants, which most closely define the matter. The PgS mark (Oznaka) is the most important information for the user. And finally, in the column with the name one p/r (Jedno p/r), the total amount of propellant is shown, which represents one filling of the tank for a certain number of motor vehicles. Tank filling is calculated using the following formula.

$$1 \text{ p/r} = \sum_t Nv * q$$

Where:

p/r - the amount of fuel that follows the unit,  
Nv - the number of the same type of vehicle,  
q - the amount of PgS that fits into the tank.

Reports represent the everyday life of expert logistics authorities, and their automation reduces stress and time spent, above all, on a continuous collection of the same data.

The application also offers a visually processed report, through the realization of graphics (3-D Clustered column), which simplifies the insight into the situation and condition in the unit.

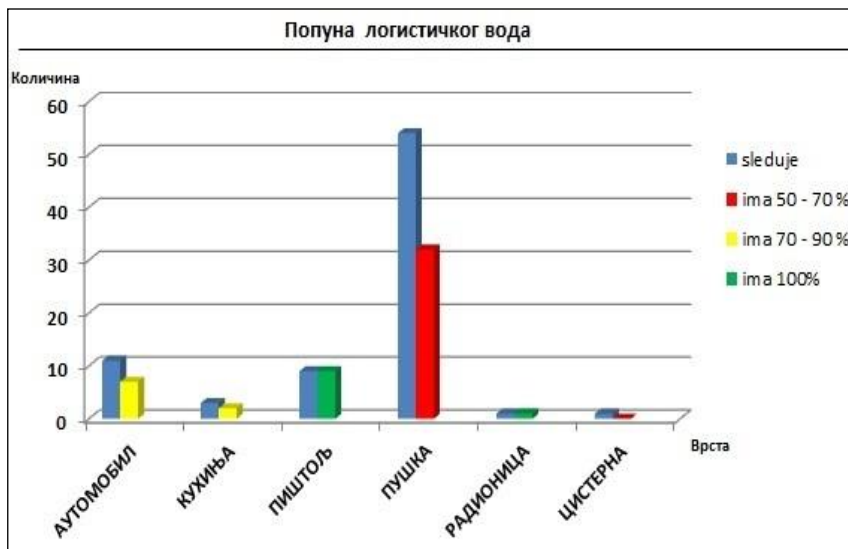


Figure 5. Graphic representation of filling.

The graphic representation in Figure 5 shows the relationship between the following and the current state of assets in the logistics line. The graphic is designed to show a certain percentage of the lack of funds in a certain color, so the amount missing in the range of 50 to 70% is shown in red, which signals to the user that the shortage is alarming and requires a certain action. Further development of the application tends towards the inclusion of machine learning and artificial intelligence to simplify data operations and facilitate the work of logistics

authorities.

## 4. Conclusion

For the sake of compatibility with other systems, it is necessary to provide a comprehensive logistics database designed for application in a wide range of logistics activities and a logistics reporting system that would ensure the timely provision of updated logistics information. Also, it is necessary to work on constant improvement of the application, and above all on:

- development of the system for operational planning;
- development of logistics support instruments that enable: an overview of asset history, exploitation, individual monitoring, and calculations required for planning at the tactical level;
- the development of communication interfaces, which enable the mutual exchange of logistic electronic data and electronic mail services in joint systems.

Designing a logistics information system on one hand develops a global concept and on the other a small application for solving tactical problems.

Contemporary trends in informatics, practice needs, and time constraints require the development of information systems, which can provide a solution for reducing the number of human resources and "reducing the volume of logistical resources". The basic information system of the logistics authority should be integrated into a unified command information system. Its subsystems must function properly, which is achieved by the permanent work of the logistics authorities on the formalization and automation of business operations and the

development of applications. The logistics authorities must work on the verification of empirical findings and their translation into theory.

The proposed model of the information system of the logistics authority can be a starting point for the creation of a unique information system that would enable data availability to all users at all levels of an organization, using machine learning and going towards Quality 4.0. This would facilitate the planning and monitoring of the implementation of logistics support plans, provide accurate records of the current state of funds, provide reliable information for decision-making through appropriate calculations, and provide information to the management authorities in real time and they could deal with more tasks, aimed at the organizational improvement of the existing system of logistical support and improvement of the operational capability of the units.

The final effects of applying the proposed model of the information system are gaining time, reducing the strain on the logistics authorities, increasing the quality of information, and efficient planning and management of logistics support.

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## **FOOD PRODUCTS DEFILEMENT ANALYZER USING IOT**

***Abstract:** In order to make additional, quick profits, shopkeepers frequently adulterate food today. Foods are adulterated by adding things like ripening mangoes, chalk powder to turmeric, starch to curry powder, papaya seeds to black pepper, and other things. Adulteration is a common practise to increase profits, but it can have extremely harmful effects on people. The qualitative spectroscopic method offers a better way to identify the toxic components in milk and other things. The goal of this research is to develop a low-cost, portable, AI-based, non-destructive sensor system that can be used to detect the adulterant in real-time in order to solve this problem. The users can access a dedicated site with an Iot platform from anywhere to view the adulterant that has been found. In this study, the conductivity and pH meter methods were used to examine the food products in order to determine the degree of adulteration present*

***Keywords:** Back Propagation Algorithm, Neural Network*

### **1. Introduction**

Food adulteration is a common practise among shop owners to make quick extra money. Mangoes are ripened, turmeric is mixed with chalk powder, starch is added to curry powder, papaya seeds are mixed with black pepper, and other foods are adulterated in this way. In the long run, these adulterations have negative effects on people. In India, 77.68 million tons of liquid cow milk are consumed annually. Statistics from December 2019 indicated that India plays the best role in the consumption of cow milk. Milk improves human nutrition because it contains significant amounts of essential nutrients like lactose, fat, proteins, minerals, and vitamins. One of the most crucial tests to ensure the safety of people's health is the detection of adulterants in milk because people consume it daily. One approach that is frequently used to address the aforementioned issue is adulteration

detection based on pH and conductivity. The system for the measurement and creation that are created when electromagnetic radiation interacts with matter. The type of interaction between matter and radiation, such as diffraction, absorption, and emission, as well as molecules or atoms may affect the analysis methods used. The Beer-Lambert law explains how the absorption concentration and absorptivity of a substance whose chemical components are measured relate to one another.

$$A = \epsilon CL$$

Where A - absorption coefficient,  $\epsilon$  - molar absorption coefficient, C - concentration of substances, L - path length (cm) Absorption coefficient has no unit.

Spectroscopic methods for detecting adulteration are somewhat expensive, laboratory-based, and provide nondestructive methodology. In previous proposed systems, spectroscopy sensors are used which needs

spectrums for its full-fledged functioning, but in this system we have incorporated two different sensors which detect pH and conductivity of the samples. Moreover this methodology is a physical measurement and does not involve any other chemical substituents. As for adulteration, a few adulterants can be added to milk to fraudulently increase its quantity.

**Table 1.** Adulterants and its responsive wavelength

Adulterant	Responsive Wave Length (Nm)	Method
Honey	1200 -1450	Calorimetric Analysis
Milk	1100	Calorimetric Analysis

A survey is conducted to identify the responsive wavelength of our targeted adulteration in the milk and summarized in Table. 1 and yet to get results for other food ingredients

From the Table 1 the mechanism tests are carried out in a laboratory setting and do not support field testing, so these techniques are not appropriate for real-time analysis and take longer to produce results. Through created IoT applications, the results of the adulterant detection could be viewed from any location.

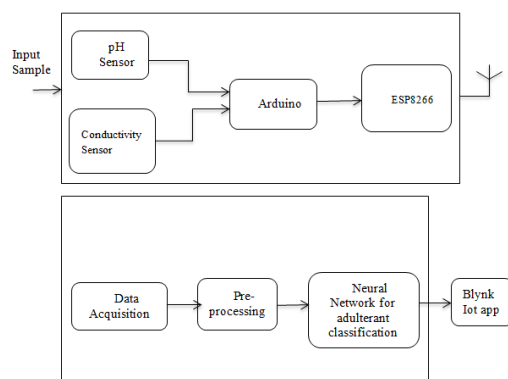
### 1.1 Proposed methodology

Milk is a dairy product that is incredibly nutrient-dense in its natural state. It includes minerals, proteins, amino acids, minerals, and carbohydrates.

- Designing and creating a portable, affordable sensor device that can support in-the-moment non-destructive testing is the focus of the proposed research work.
- To identify four different adulterants and pure milk, adulterant detection is approached as a classification problem and solved using Naive Bayes, Linear Discriminant Analysis, Decision Trees,

Support Vector Machines, and Neural Network Machine Learning Algorithms. The average accuracy for those models is 90%, 88.1%, 91.7%, 90%, and 92.7%, respectively.

- The neural network model's hyper parameter is adjusted to increase accuracy from 92.7% to 100% using a genetic algorithm to solve an optimization problem.
- The sensor system is designed as an Internet of Things (IoT) device to update the detected adulterant in the web server so that anyone can access the results.
- We have discussed about sample preparation, spectral data collection, processing, and the neural network algorithms used for analysis as well as the design of AI-enabled system.
- Here the proposed system detects the adulterant based on the pH level and conductivity which varies with pure and adulterated samples.
- The threshold level is set by comparing the above results with the calorimetric analysis outputs.
- The detected results from the multi-sensor system is then sent to BlynkIoT App, the user will be notified whether the sample is adulterated or not.



**Figure 1.** Design of ai-enabled multisensor system for adulterant detection



## 2. Materials and methods

The following sections covered sample preparation, spectral data collection, processing, and the neural network algorithms used for analysis as well as the design of AI-enabled system. The design of the sensor system developed with artificial intelligence methodology for the detection of adulterants is described in Section 2.1.

### 2.1 Design of a milk adulterant detection multi sensor system with ai

Figure. 1 depicts the designed AI-enabled sensor system's prototype. which includes an ESP8266 wireless module, an Arduino board, a PC used for data logging, and an implemented neural network AI software module, pH sensor, conductivity system. The AI-enabled multispectral sensor system is depicted in Figure. 1. Data from the sensor will be transmitted serially to the Arduino microcontroller and then wirelessly to a personal computer. The user can send the data they've collected to the PC using the Wi-Fi module. For pre-processing, the acquired data is stored. The non-linear neural network receives the pre-processed sample data for additional analysis. The neural network is trained, tested, and validated using these pre-processed data. One of the network outputs will classify or detect whether a substance is adulterated or not.

#### A) pH SENSOR :

- The H<sup>+</sup> ion concentration in the fluid is essentially measured by the PH sensor. The PH measurement sensor is composed of the measuring electrode, the reference electrode, and the temperature sensor. The millivolt signal at the electrode is amplified by a preamplifier to a specific amplitude. The measuring electrode is located at the positive terminal, and the reference electrode is located at the negative terminal. The voltage of the reference electrode is directly

proportional to the amount of hydrogen ions present in the solution, and it has a steady potential and is sensitive to hydrogen ions. When submerged in solution, the reference electrode makes contact with the measuring electrode through the junction.

- Chemistry uses pH to gauge the activity of solvated hydrogen ions. Due to its close relationship to the measurement of hydrogen ion concentration, PH, it is frequently spelt as Ph. At 25°C, pure water has a pH that is very close to 7. The term "acidic" refers to solutions with a pH of less than 7, while "basic" or "alkaline" refers to those with a pH of more than 7. A concentration cell with transference is used to measure the potential difference between a hydrogen electrode and a standard electrode, like the silver chloride electrode, to determine primary pH standard values. A glass electrode and a pH meter, or indicators, can be used to measure the pH of aqueous solutions. The Carlsberg Foundation asserts that pH stands for "power of hydrogen." The potential activity of the sample's hydrogen ions is measured by PH. Both total conductivity and electrical conductance had positive correlations with PH. It is used to determine whether the milk sample is neutral, basic, or acidic. Because its pH is 6.7, fresh milk is slightly acidic.)

- The hydrogen ion potential activity in a sample is measured by the pH scale. The relationship between pH and total conductivity and electrical conductance was positive. It is employed to determine whether the milk sample is basic, acidic, or neutral. (Fresh milk is slightly acidic due to its pH of 6.7.)

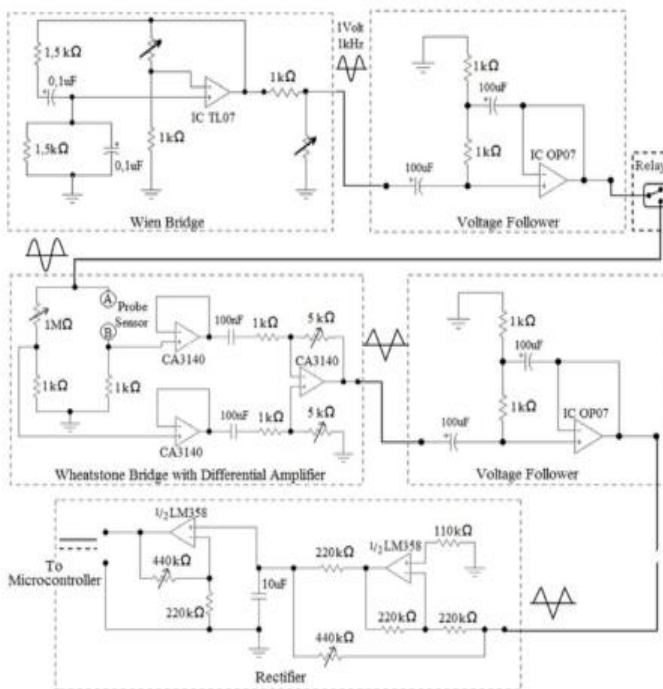


Figure 2. pH sensor

**B) CONDUCTIVITY SENSOR :**

The representative value of the limiting molar conductivity of milk was found to be 75 S cm<sup>2</sup> mol<sup>-1</sup>. The typical conductivity of tap water ranges from 1.2 to 1.6 mS. Even

still, the conductivity of 9% fat milk is between 2.3 and 2.5 mS. Therefore, if the milk conductivity is less than 2.2 mS, it is confirmed that the milk contains water.



**Figure 3.** Conductivity sensor diagram

**C) ARDUINO BLACKBOARD :**

The data from the sensors is gathered by the inexpensive Arduino blackboard and transmitted to the device for additional analysis. The 14 digital input/output pins on the Arduino blackboard are divided into six pulse width modulation pins, four analogue inputs, a universal asynchronous receiver and transmitter, and a serial peripheral interface (SPI). The gathered spectral data is once more sent to the WiFi module (ESP8266) single-chip pin.

**D) DATA ACQUISITION :**

The server PC receives the collected data from the ArduinoWiFi module. The WiFi

module is connected to a USB port, which is used to collect data using the Microsoft Excel data streamer software module. This section outlines the data collection process using an Excel sheet. Live data from a microcontroller is streamed into an excel sheet using a data streamer, which offers two-way data transfer.

**3. Conclusion**

One of the major concerns on the planet is adulteration. However, various spectroscopic approaches required for the detection of adulterants. The designed multi sensor model is used in the proposed model with

artificial intelligence to present the adulterant identifications. This created sensor model non-destructively extracts the data from the sample. The data is subjected to the application of several machine learning algorithms, including Naive Bayes, Linear Discriminant Analysis, Support Vector Machine, Decision Tree, and Neural Network Model, and accuracy of 90%, 88.1%, 90%, 91.7%, and 92.7% are obtained. The user or authorized individuals can access a dedicated webpage with an IoT application from anywhere to view the adulterant that has been found. Milk is tested for various concentrations of sugar, sodium chloride, and urea using a developed method. Within a reasonable amount of time, this system can detect the sugar, sodium chloride, and urea mixture in the milk sample. This system determines the milk's

PH level. To estimate the effects of external factors and increase the instrument's sensitivity, additional research in this area may be conducted. As a result, the sensor's performance can be affected less by changes in temperature, atmospheric pressure, and residual pressure caused by stray gases in the sample. This system keeps the quality of the milk good and prevents people from altering it.

**Table 2.** Summary of results in Honey

Adulterant	Ph	Conductivity (µs/M)
Honey – 25%	3.19	8.82
Honey – 50%	3.14	2.6

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## DIGITAL COMMUNICATION IN AGRICULTURAL EXTENSION IN THE ERA OF THE INDUSTRIAL REVOLUTION 4.0

**Abstract:** *The research starting from the acceleration of digital diera technology in the industrial revolution 4.0 is undeniable and, especially for field agricultural extension workers is the spearhead of the success of agricultural development in the regions. The purpose of this study is to analyze how digital communication can be useful in agricultural extension in the era of revolution 4.0, the methodology used is descriptive qualitative, data collection through observation, interviews and documentation, primary data sources of 14 people and secondary data sources such as reference books, internet souching, and field studies. The results of the study that the extension system is a system of delivering innovations from technological sources to users (farmers) using various approaches and existing methods according to conditions, so that innovations can be utilized by users to increase income and welfare The agricultural extension system can use the approach of: (1) agro-ecosystem; (2) territory; (3) agribusiness; (4) institutional; and (5) welfare. The extension system approach is more directed at growing the regional economy (local economy) so that it can reach all life activities in the social system.*

**Keywords:** *digital communication, agricultural extension workers*

### 1. Introduction

The Ministry of Agriculture wants to foster the enthusiasm of young people to continue the relay of agricultural entrepreneurship in Indonesia, and also develop the use of internet technology to support the production of agricultural products to meet the growing market demand.

The Agricultural Human Resources Extension and Development Agency (BPPSUMBER DAYA MANUSAP) implements the millennial farmer program through an extension institution, namely the Rural and Independent Agriculture Training Center (P4S). It is an institution that

provides agricultural training in rural areas using the principles of democracy, self-help, business development, and integration. The existence of P4S spread across each region makes the farmer program millennials can be implemented equally. This can make the training, counseling and empowerment carried out will be effective because each region has its own character to be carried out by the Millennial Farmer program. Counseling is the right way to develop and improving human resources so that farmers can continue to develop. One of the areas that still makes agriculture the main livelihood is Nganjuk Regency although the demand continues to decline. The reason

for this decline in interest is that agriculture has not much yield. The existence of slashers who directly buy agricultural products at very low prices decreases the interest of farmers. The empowerment carried out by the local government is mostly in the form of providing capital in the form of materials and tool assistance. The development of communication patterns in agricultural extension in Indonesia written by Sadono (2009) explained although declining interest and declining economic output of farmers, the farmer sector is still a job for most of the population in Indonesia. In addition, it became a production granary in the country's foreign exchange earnings for non-oil and gas exports. Agriculture is also a bulwark for the national economy during the economic crisis. Entering the industrial revolution 4.0 that combines technology and the internet, becomes a challenge for the world of agriculture.

Farmers must continue to compete to produce agricultural products and be able to meet market demand. This challenge must be carried out by empowering farmers to become farmers who are able to compete in this era so that farmers must be able and able to process and produce their agricultural products by combining technology and the internet.

Through Ministerial Regulation Number 4 of 2019 concerning Guidelines for the Movement for The Development of Agricultural Human Resources Towards Food Barns 2045, it is explained that millennial farming is farmers aged 19-30 years and/or farmers who are adaptive to technology and innovation (Minister of Agriculture of the Republic of Indonesia, 2019). Millennial farmers don't just stick to age. Millennial farmers take precedence is what their mindset is. So, millennial farmers are not only intended to have human resources aged 19-30 years.

The interest of the Millennial Farmer program is to create smart and digital

farming (Utami, 2020). This is considered important because human resources are not eternal in the sense that there will be an expiration period. In the Millennial Farmer program, the millennial generation creates an agricultural system based on smart and digital farming which can later become a regeneration and also transmit an agricultural system that is more effective, environmentally friendly and also has good results in quality & quantity. Millennial Agriculture is a development effort carried out by the government to farmers. For this reason, in analyzing the existing communication patterns, this study uses development communication theory. Communication is very important in development so it is necessary to understand the elements of SMRCE communication (Source, Message, Receiver, Channel, and Effect) that must be applied in development. Communication patterns regarding agricultural extension have been carried out first, such as research conducted by Hariani (2017) from Halu Oleo University. This study looked at how the communication patterns carried out by PPL in conducting counseling to clove farmers in Wa ode Buri Village, North Buton. The communication pattern found is the application of one-way, two-way and multidirectional communication patterns (Hariani, 2017).

Nunung Nurhayati in his research on the Communication Patterns of the Indramayu Agricultural Extension Center in efforts to disseminate agricultural information concluded that the delivery of messages was carried out formally and informally.

In addition, the form of delivery from the Extension Center to farmers or vice versa is vertical. Instead, horizontal delivery is used for fellow farmers or fellow extension workers. Unclear dissemination of information, inadequate facilities and infrastructure, differences in perception and perspective make obstacles in the

dissemination of information.

In addition, this research also reviews the empowerment of farmers such as research conducted by Laili (2014) from Universitas Brawijaya. This study concluded that the empowerment carried out in Betet Village has been better to realize food security.

Farmers have more knowledge so that their agricultural output also increases. Support from the government with subsidies for aid and seeds. The obstacles that occur are the low quality of human resources and limited tools (Laili, 2014). This study was conducted to analyze the communication model carried out by P4S as an extension institution in conducting counseling for the Millennial Farmer program.

Development communication includes the function and role of communication in message exchange activities with reciprocity between the community and the government starting with the planning, implementation and evaluation of a development. In a narrow sense, development communication is a way of conveying ideas and skills of a development that arises from the initiative with the target of its builders, namely the community in order to understand, accept, and participate in development (Dilla, 2007), Goulet in Theresia (2014) explains the values of development. First, self-sufficiency, that is, having the ability to meet or meet basic needs. Second, the price, which is the freedom of oneself from oppression and not being taken advantage of by the other party. Third, freedom where a person is able to choose solutions to improve the quality of life so as to realize prosperity. Development will cause social changes so that communication has an important role.

This is because communication has a role in changing a person's way of thinking, attitudes, and actions in solving social problems. However, if communication is hampered, it will make the development process cause inequality. The facts of developed countries are like the difference

between villages and cities, the gap between poor and rich.

This will have an impact on how a person thinks, behaves, behaves, and opinions. For this reason, communication is very important in development so it is necessary to understand the elements of SMRCE communication (Source, Message, Receiver, Channel, and Effect) that must be applied in development. Agricultural communication is the activity of exchanging messages between people that have a relationship between agricultural activities, personally and between groups.

Usually, it has a common nature by using symbols in its delivery, and can generally be found in agricultural extension activities (Soekartawi, 1988). The two have a relationship that cannot be let go. Agricultural communication is a science that is not only needed by farmers so that non-farmer communities also need knowledge. In agricultural extension workers need to find and study agricultural communications to be conveyed to farmers (Soekartawi, 1988). Sukartawi also explained that agricultural communication carried out in counseling can be said to be successful if a communicator or extension worker and a communicant or audience (farmer) have similar perceptions in understanding agricultural science provided by extension workers. Therefore, it is mandatory for an extension worker to understand carefully about agricultural communication.

The basic functions of communication include 3 parts that are factors that cause why humans need to communicate, namely: 1) human desire to control their environment. Through communication, humans can know the opportunities that exist to be utilized, maintained, and avoided in things that threaten the surrounding nature, 2) human efforts to be able to adapt to their environment. The process of continuation of

a society actually depends on how the community can adapt to its environment, and 3) efforts to transform the socialization heritage (Cangara 2011).

In general, the consequences or results of communication according to Achmad (1990) can include 3 aspects, namely: 1) Cognitive, which concerns awareness and knowledge, 2) Affective, that is, it concerns attitudes or feelings and emotions, 3) Conative or psychomotor, that is, it concerns behavior or action. The assumptions used in the philosophy of agricultural extension are based on three things, namely: 1) counseling is an educational process that brings about the changes expected by a person or community, 2) counseling is a democratic process that is carried out by not forcing something to the farming community, and 3) counseling is a continuous process. Harun and Adrianto (2011) mentioned that communication is a process that connects one part with another in life.

Counseling activities are defined by various understandings, such as: dissemination of information, lighting or explanations, non-formal education, behavior change, social engineering, marketing innovations (technical and social), social change (behavior, individuals, values, relationships between individuals, institutions), community empowerment (community empowerment) and community strengthening, Mardikanto (2009).

The goal and objective of agricultural extension is the realization of farmers who have independence and freedom in using messages and information in the form of technology, as well as new things in improving their farming business so that it becomes more productive, efficient and profitable (better business) so that a better life will be achieved, and in the end the creation of conditions for people whose lives are prosperous (better community), Padmowihardjo (1999). The goal and objective of agricultural extension is the

realization of farmers who have independence and freedom in using messages and information in the form of technology, as well as new things in improving their farming business so that it becomes more productive, efficient and profitable (better business) so that a better life will be achieved, and in the end the creation of conditions for people whose lives are prosperous (better community).

## 2. Literature review

It is said to be minimal because communication activities are not only informative, namely so that others understand and know, but also persuasive, that is, so that others are willing to accept an understanding or belief, do an action or activity (Effendi, Onong Uchjana, 1995: 9).

In simple terms Ardianto, Elvinaro (2009; 51) explains that communication is the process of conveying understanding between individuals. Human society can exist, due to the human capacity to convey the intentions, desires, feelings, knowledge, and experiences of one person to another. In essence, communication is a behavior, where a source conveys a message to the recipient with the aim of influencing the behavior of the recipient.

According to Onong Uchjana Effeny (1981, 12) defines communication as, "The intended process is by which a person (communicator) conveys a stimulant (the basis of symbols in the form of words) to change the behavior of others (communicator). Meanwhile, the definition of communication media can simply be interpreted as a medium used to convey communication messages.

Then regarding the theoretical foundations used in the research, the author uses the theory of diffusion of innovations developed by Everett M. Rogers. According to Rogers (1983) defines diffusion as the process by



which an innovation is communicated through a certain channel within a certain period of time among the members of a social system. Diffusion is a special type of communication related to the dissemination of messages as new ideas. In the context of communication diffusion innovation is a special part that of the existing communication process because the information exchanged is innovation. The theory of diffusion of innovation is a model that describes the activity of new information exchange that takes place with the aim of the process of adopting innovation in the audience.

Conventionally, the role of counseling is only limited to the ability to convey innovations and influence the targets of counseling through certain methods or engineering techniques, until they adopt the innovations delivered. However, in its development, an extension worker must also be able to become a bridge between the government or the extension institutions he represents and the target community.

In connection with the role and responsibility of extension workers Kurt Levin (1943) introduced that there are 3 (three) roles of counseling consisting of activities such as, self-disbursement with the target community, encouraging the community to make changes, tabulating relations with the target community. The three kinds of designs, bridged into several more detailed roles, by Lippitt (1956): 1) Development of the need to make changes, 2) Encourage the community to make changes, 3) Tabulate the relationship between extension workers or government agencies and the target community. According to Mosher (1968) Relating to the role of extension workers, each extension worker (agriculture) must be able to carry out dual roles such as: 1) The teacher is someone who is able to be a reflection or role model, able to change the behavior, attitudes, knowledge and skills of the target

community. 2) The analyzer is to observe every situation (natural resources, community behavior, ability of funds and existing institutions) and be able to see problems and provide solutions for the target community. 3) Advisors choose the most appropriate alternative technically can be implemented, economically advantageous and acceptable to the social and cultural values of the local community. 4) Organizers are able to maintain good relations with the target community (especially the figures).

In the digital era, digital capabilities are the main prerequisites in order to compete in the long term, but various institutions and companies want to go digital who do not understand the best way to organize organizations in the automation process and develop the infrastructure and talents needed in managing digital information, both development, development, and maintenance of online services (Daub & Wiesinger, 2015). Ferrari, Editors, Punie, & Bre (2013) states that the field of digital competence is fivefold: 1. Information: identify, find, retrieve, store, organize and analyze digital information, assess its relevance and purpose. 2. Communication: communicating in a digital environment, sharing resources through online tools, connecting with others and collaborating through digital tools, interacting with and participating in communities and networks, cross-cultural awareness. 3. Content Creation: Create and edit new content (from word processors to images and videos); integrate and recombine previous knowledge and content; produce creative expression, media output, and programming; dealing with and applying intellectual property rights and licenses. 4. Safety: personal protection, data protection, digital identity protection, security measures, safe and continuous use. 5. Problem solving: identifying digital needs and resources, making informed decisions that are the most appropriate digital tools according to goals or needs, solving conceptual problems

through digital means, creatively using technology, solving technical problems, updating oneself and the competence of others.

Considering that this study is closely related to cybersecurity, the competencies discussed are related to security (Ferrari et al., 2013) including four competencies related to security, namely 1. Protecting devices, to protect devices themselves and understand risks and threats online and to know about safety and security measures, 2. Protecting personal data, to understand the general terms of service, active protection of personal data, understanding the privacy of others, protecting oneself from fraud and online and cyber threats, 3. Protecting health, to avoid the health risks associated with the use of technology in terms of threats to physical and psychological well-being, 4. Protecting the environment, to be aware of the impact of ICT on the environment.

In the global talks that 2020 enters the digital and automation era. Data obtained from the results of the 2025 HR survey (Letink, Garstang Caroline, & Ellimäki, 2020) states that every individual needs efforts to prepare themselves with abilities that cannot be easily replaced by machines and robots. The view of humans is irreplaceable by the rise of automation because robots or machines will run according to instructions or programs created by humans. According to a survey conducted (Dell Technologies, 2019) of global business leaders, the era of partnerships between humans and machines in 2030 as many as 54% of people will absorb and manage information in very different ways. For policymakers, business leaders, and individual workers around the world, the task is at hand to prepare for a more automated future by emphasizing new skills and improving training (Manyika et al., 2017).

The emergence of the definition of types of cybersecurity (Reid & Van Niekerk, 2014) is due to the fact that today all Internet and ICT

users are required to have a basic level of cybersecurity awareness and knowledge to carry out daily activities. This is a necessity in handling cybersecurity issues in the digital age. This condition requires coordination and cooperation nationally and internationally, in the government, community, and private sectors.

It is not enough to handle information security solutions only within the organization. Information security does not only apply to the use of information in personal contexts and the world has become increasingly more and more information-oriented (Reid & Van Niekerk, 2014). Cybersecurity is a collection of tools, policies, security concepts, security protection, guidelines, risk management approaches, actions, training, best practices, assurance, and technologies that can be used to protect the cyber environment and user asset organizations. The organization's assets include connected computing devices, personnel, infrastructure, applications, services, telecommunications systems, and the totality of information transmitted and/or stored in cyberspace. In general the purpose of cybersecurity is availability, integrity (which can include data authenticity and undeniability), and confidentiality (International Telecommunication Union, 2008). The research "Definition of Cybersecurity Gaps and overlaps in standardization" (ENISA, 2017) provides the important context necessary to understand the term cybersecurity and its use. Other cybersecurity domains are communication security, operations security, information security, physical security, public/national security. On the other hand in cybersecurity governance always consider these domains. Organizing information governance activities only from an information security perspective is not enough. The most common objectives of cyberattacks can be system scrambles, system destruction, data leaks, or attempting that the attacked system

cannot function (Ilhan, 2015).

Digital communication is the transmission of electronic information that has been digitally encoded, such as for storage and processing by a computer. In the development of digital communication technology, not only using computers in sending and receiving information but has developed in such a way using android, which also functions as a cellphone (Sumardjo, 2018). Realizing these conditions, it is now our duty for academics and national development stakeholders to build the concept of synergy of extension and development communication in realizing a dignified, just and prosperous community life. This paper discusses how synergies are built and how academic, political, strategic and technical implications in development.

In the current conditions, there are at least three reasons for the importance of synergy of Extension and Development Counseling, (1) Similarity of goals, (2) Complementary roles in development, and (3) The development of communication technology innovation in a society with diverse access to digital communication, has the potential to have an impact on inequality. First, there is a similarity of goals, counseling and communication both aim to occur behavioral changes, both cognitive, affective and psychomotor / conative, only different in their pressure, namely counseling in addition to these three aspects, especially on changes in conative aspects. Second, counseling is responsible in addition to changes in behavior of knowledge, attitudes and skills, but also on attitudes/actions (conative) and application (adoption) in life as a skilled/skilled (skills). Communication makes people smart and insightful, while counseling makes people smart and innovative in their lives. Smart means, in addition to being smart, they are also good at using their hearts so that they become more wise and wise in implementing new ideas, as well as technological innovations.

Third, the very rapid development in digital

technology innovation has turned out to cause a gap in human capacity in development. This is because access to information through digital technology is uneven, so there is a gap with individuals who are less able to access and or are less able to digest information from digital media with those who are better able to access digital communication. The word development in Development Counseling, binds the science of Communication and Extension Science in strengthening human capital (Individuality) and social capital (sociality) to realize the welfare of individuals, families and communities, as well as the environment through the process of human and social empowerment until independent. The synergy of Extension and Development Communication lies in the realization of independence.

Communication and Development Counseling is a combination of three domains of theories: (1) communication, (2) counseling and (3) development. The synergy of the three is the realization of harmony between people and society that is smart, independent, just and prosperous. The potential for social conflict is managed intelligently and optimally through conducive integration in resource and environmental management. The contribution of communication theories in development is "enlightening", that is, producing smart people with insight, expanding alternative life choices, expanding the mastery of innovative information, the importance of synergy of the role of communication technology development in development (digital communication and conventional communication), strengthening communication networks/cooperation, strengthening social capital and so on. The contribution of counseling theories in 3 developments is "educating", educating freedom of action ethically, changing behavior with a heart, strengthening attitudes to be increasingly innovative productive,

emphasizing wisdom and policies in acting, building human capital (individuality), leadership, social entrepreneurship attitudes and other positive attitudes. Both communication and counseling are tied up in the context of development.

An alternative term for counseling in Dutch, the word *voorlichting* is used which means to give light to help someone find their way. This term was used during the colonial period for the Dutch colonies, although counseling was actually needed by both parties. Indonesia, for example, follows the Dutch way by using the word counseling, while Malaysia, which is influenced by English, uses the word development. English and German respectively term it as giving advice or *Beratung* which means an expert can give clues, From various views there are still found some similarities in perception, according to Van den Ban & Hawkins, 2011: 25) one of them, namely that "counseling is the involvement of a person to communicate information consciously with the aim of helping others give opinions so that they can make the right decisions" Here it can be seen that there is a connection between communication and counseling. The source of communication is the party who sent the message or information. In agricultural extension, this source can be extension workers or reforming agents. In the context of development counseling education, competency competencies are needed related to the three synergy keywords "Communication, Counseling, and Development".

The vision of development extension education is related to "The production of competent development researchers, educators and communicators to create an independent, dignified (ethical) society that is prosperous and just". This is realized by developing synergy of communication and counseling systems in equitable development education. In Development, this "Human Development Education" should be a

prerequisite for the realization of an intelligent, dignified, just and prosperous society.

So the mission of development counseling education concerns at least three things, namely: (1) Realizing people and communities are smart, dignified, prosperous in justice. Education that produces Science and Technology for the development of human resources and graduates who are competent in participatory social engineering in human development (human capital) and social development (Social capital) in society; (2) Develop synergy of communication systems and extension systems in actual (appropriate) development. Producing graduates with the main competencies to synergize communication systems and development counseling systems that are adaptive to antisemitic to technological developments and changes in the actual strategic environment (appropriate). (3) Produce competent researchers, educators and development communicators. Producing competent graduates as researchers, extension workers / educators and development communicators in realizing a just prosperous society through the development of science and technology, socio-preneurs and participatory actions that educate people's lives.

The implications of such a vision and mission, several courses, with a level of depth in accordance with the level of competence (Indonesian National Work Competency Standard), are interesting to be discussed and considered in the three perspectives of Counseling, Communication and Development, namely: (1) Counseling, at least covering related theories: Philosophy and Theories of Development Counseling, Development Extension System, Philosophy and Adult Education, Leadership, Social Institutions and Group Management/Social Organizations, Training Management and Integrated Quality Management, Cyber Extension, Socio-preneur and Partnerships,

Preparation and Participatory Evaluation of Extension Programs, Counseling Methods and Techniques, Social Change and Development of Human Resources (Human Capital) and Social Capital (2) Communication, at least includes related theories: Philosophy and Theory of Development Communication, Development Communication Systems and Networks, Communication and Social Change, Cross-Cultural Communication and Management of Potential Social Conflicts, Innovation Communication, Digital and Conventional Communication, Group and Organizational Communication, (3) Development, at least includes theories: Development paradigm development, Local Economic Institutions and Local Wisdom, Fulfillment of Human Needs, Quality of Life Development and Development Indicators, and Sustainable Development.

In addition to these courses, it is necessary to strengthen local content in accordance with the advantages of each institution providing development counseling education.

### **Elements of Communication in Counseling.**

A communication process will be able to take place properly if there are elements that are one unit. There are at least 3 elements of communication, namely: 1). Source/communicator (source/sender) The source of communication is the party who sent the message or information. In agricultural extension, this source can be extension workers or reforming agents. 2). Message (message), Message is information addressed to the recipient. In agricultural counseling, this message can be in the form of counseling materials. The message used in agricultural extension is based on the targeted needs of men and women. 3). Recipient / communicant (receiver), The recipient is the party who receives messages or information, that is, the party who is

expected to change both his behavior and personality. In agricultural counseling, the recipients or targets are farmers (main actors) and business actors and their families. Because the agricultural extension process can be carried out using various methods, techniques and media, the element of communication increases. 4). Channel (channel), Channel is the path through which the message that the source conveys to the recipient. Channels include the use of methods and techniques as well as the use of media that are relevant to the purpose, objectives and nature of the message.

In general, the more senses that are stimulated through various media, the more effective the communication process in agricultural extension. The use of methods, techniques and media for agricultural extension in addition to increasing the understanding of the target to the message conveyed, to encourage the activity and creativity of the target as well as the growth of self-confidence. 5). Effect, the effect of communication is the recipient's response to the messages received and is feedback for the communicator / source of the messages conveyed.

The effect of communication is in the form of changes that are expected to occur in the target as a result of the communication process. The expected changes involve changes in behavior (knowledge, skills, and attitudes), as well as changes in the target personality (independence, toughness, ability to cooperate, self-confidence, the ability to put oneself in a strong bargaining position, etc.). The effects of communication are immediately known, for example changes in knowledge and skills, but some indirect means that it takes a long time such as changes in attitudes and personality. In two-way traffic communication, communicators can get feedback directly compared to unidirectional communication.

### **Development, Empowerment and Independence Counseling.**

Independence is the culmination of the poses of empowerment in the counseling process. Through Development Counseling, individuals or communities must experience strengthening empowerment in realizing the quality of life of themselves, their families, communities and the environment. The context of Indonesia is in line with the ideals of the nation and the national goals contained in the Preamble to the 1945 Constitution, namely realizing just and dignified prosperity. This is in line with Law No. 16 of 2006 concerning the Agricultural, Fisheries and Forestry Extension System and Law No. 13 of 2009 concerning The Protection and Empowerment of Farmers.

Independence is the culmination of one's empowerment. A person's independence is characterized by high filterability, competitiveness and sanding power in his life behavior (Sumardjo, 2014; Sumardjo, 2016). The development of this level of empowerment can occur even from the most helpless (dependent), to empowered (independent) and the peak to independent (interdependent). The individual or society's helplessness occurs when his life depends on the role of the other party, less able to adapt to changes in his strategic environment. Empowered individuals or societies are characterized by high filterability and competitiveness. A person's filtering power is getting higher in line with the breadth of insight and intelligence he has. While a person's competitiveness is characterized by the high ability to manage businesses or resources in his life effectively, efficiently and with quality.

A person's ability to partner, network synergistically with other parties in their lives. The essence of this sanding power is trust, mutual reliability, mutual strengthening, mutual trust and this is the basic material for building social capital in

their living environment. Development counseling is inseparable from efforts to realize welfare in a dignified manner. Law Number 11 of 2009 concerning Social Welfare mandates that the implementation of social welfare in Indonesia includes (1) Social rehabilitation, with the refunctionalization of the social functions of citizens, (2) Social security, namely guaranteed efforts to meet basic needs, (3) Social empowerment, so that the community is able to meet basic needs, and (4) Social protection, so that people avoid the risk of shocks and social vulnerabilities. All of these approaches are relevant to extension activities, especially the social empowerment approach. This approach is very relevant to the principles and philosophies of counseling.

The purpose of implementing social welfare (Law Number 11 of 2009 article 3) is to improve the level of welfare, achieve independence, increase social resilience, improve the ability, concern and social responsibility of the business world as well as the ability of the community's ability and concern institutionally. The principles of social welfare implementation are solidarity, justice, expediency, integration, partnership, openness, accountability, participation, professionalism, and sustainability (Law Number 11 of 2009 article 2). This is in line with the principle of counseling as stated in Law No. 16 of 2006 article 2 democracy, benefits, equality, integration, balance, openness, cooperation, participatory, partnership, sustainability, justice, equity and responsibility.

After going through studies related to counseling and community empowerment practices Sumardjo (2010; 2014; 2016) came to the understanding that in the context of community empowerment the philosophy of counseling is basically "to develop the empowerment of non-formal education participants in an adaptive, participatory, dialogical and synergistic manner to realize

human capital and social capital into an increasingly qualified, independent and dignified livelihood".

In empowerment, there is a meaning that the philosophy of counseling is a planned effort (Sumardjo, 2016):

1. Developing the empowerment of participants means liberating citizens of society from ingenuity of ignorance (cognitive), incompetence (psychomotor-conative) and unpreparedness (affective) adapting to actual life and or liberating from the domination of others.
2. Develop an adult education process (andragogy) for community members, namely meaningful non-formal education as an effort to improve the quality of behavior through learning outside formal schools.
3. Developing adaptive abilities to be increasingly anticipatory, actual, dynamic, with a dialogical communication approach so as to be able to develop a synthesis of various solutions and innovations, as well as participatory (voluntary change) and synergistic there is a convergence of interests with social partners.
4. Developing human capital to be competent and increasingly professional, as well as social capital, namely realizing an empowered and independent society (better community).
5. Improving the quality of life that is increasingly prosperous (to improve their level of living).
6. Realizing individual independence (interdependent) by strengthening filtering power (smart and moral), competitiveness (effective, efficient and quality), and sanding power (sovereign and synergistic in partnership).
7. Realizing a dignified human being and society (sovereign, prosperous, just and civilized).

This view is in line with the philosophy of counseling presented by Kelsey and Hearne (1955) in (Sumardjo, 2015; 2016) the following: "The Philosophy of extension is based on the importance of individual in the promotion of progress for rural people and for the nation". The philosophy of counseling is based on the interests of

individuals in order to develop progress for rural communities and the state. The philosophy is basically "To help people to help themselves through educational means to improve their level of living". Helping people in helping themselves with education as a means to improve their lives.

The value system that underlies (guides) counseling is basically client empowerment, the importance of future life (anticipatory), and trust (optimism) in the future. An important belief (belief) that exists in extension workers about the nature of reality is to have a systemic perspective (thinking systems that are holistic, not partial), rational and non deterministic. Extension workers should believe in knowledge and learn that knowledge is acquired and transmitted i.e. that learning is context-bound (philosophically idealistic, realistic and pragmatic) and that learning is an active, adaptive and actual process (Sumardjo, 2016).

An extension worker or every person involved in empowerment at least has an idealistic, realist and pragmatic philosophy, which is to have a clear picture of the future, based on the reality of life and has benefits for his life and future. Idealistic philosophy is the belief that truth exists in ideals, goals or logical conditions that can be realized, so that everyone needs to have a foresight of the ideal future that he believes can be realized.

Realistic philosophy is the belief that truth exists in the reality of life. Pragmatic philosophy is the belief that everyone believes the truth to exist in something that is considered beneficial to real life. Community empowerment is basically a process of developing the potential and abilities of individuals / communities so as to strengthen their capacity, to solve the problems they face so that they are able to meet the integrity of their lives.

Community empowerment is carried out through learning/ educational activities and

other efforts (for example helping the provision of certain facilities), aimed at improving their ability and willingness to act to overcome the problems and threats they face in everyday life. Learning activities are an active effort of a person aimed at developing insights, knowledge, skills and mental attitudes that have an impact on the growth of the ability to act intelligently in solving problems and meeting their needs.

### **3. Research methodology**

The research method used in this study is descriptive qualitative, namely research conducted on independent variables, namely without making comparisons or connecting with other variables. Moleong (2007:6) explains qualitative research is research that intends to understand the phenomenon of what the subject of research experiences 13 by means of descriptions in the form of words and language in a special natural context and by utilizing various natural methods. The way this description comes from interviews, observations, including quotations and summaries from documents.

Data Collection according to Arikunto (2010: 22), Primary Data is data in the form of verbal or verbally spoken words, gestures, or behaviors carried out by a trustworthy subject, in this case it is a research subject (informant) with regard to the variables studied. and secondary data is data obtained from graphic documents, photo photos, films, video recordings, objects, and others that can enrich the primary data. Secondary data collection through data obtained from library materials, among others, comes from documents or data regarding laws and regulations, Decrees (SK), journals, the internet, books, literature, and other sources.

Interviews Interviews were conducted at the Sibayak Lingga Farmer Group to get the problems experienced by the farmer group. Researchers visit the site in person whether

the counseling is carried out or not.

### **4. Research methodology**

Agricultural extension is defined as an out-of-school education system for farming families in rural areas, where they learn while doing to be willing, know and be able to solve the problems they face properly, profitably and satisfactorily (Wiriatmadja 1983). Or in other words, agricultural extension activities are an activity of conveying information to others, with the expectation that the person can change their behavior by willing to carry out the information conveyed.

Meanwhile, Law of the Republic of Indonesia Number 16 of 2006 concerning the Agricultural, Fisheries and Forestry Extension System (SP3K) states that the agricultural extension system is a whole series of developing the abilities, knowledge, skills and attitudes of the main actors (agricultural activity actors) and business actors through counseling. Therefore, the law states that Agricultural Extension is a learning process for the main actors (agricultural activity actors) and business actors so that they are willing and able to help and organize themselves in accessing market information, technology, capital, and other resources, as an effort to increase productivity, business efficiency, income, and welfare, as well as increase awareness in preserving environmental functions.

Because agricultural extension activities are learning activities, it cannot be separated from interaction and communication activities with each other between farmers and agricultural extension workers. Therefore, communication is an important factor that can support the achievement of counseling goals either in technology transfer or other efforts so that farmers can farm and live better.



### **Aspects of the Communication Process.**

Judging from the process, counseling is communication in the sense of the word there are two components, namely humans, one as a messenger or communicator and the other as a message recipient or communicant. In this process the agricultural extension officer acts as a communicator (messenger), while the farmer is a communicant (recipient of the message). The difference between communication and counseling lies in the purpose, where the purpose of communication is general, while the purpose of counseling is special, namely to improve the knowledge, attitudes and skills of farmers as the target. The goal will be achieved when there is an understandable and two-way communication.

But it could happen misunderstandings in communication, where the message cannot be understood by the recipient of the message well. This is due to the presence of factors inhibiting communication between the sender and recipient of the message. According to Purwanto (2009) there are factors that hinder communication that can be grouped into four main problems, namely: 1) problems in developing messages; 2) problems in the delivery of messages; 3) problems in receiving messages; 4) problems in interpreting messages.

Avoiding all of this, in agricultural counseling it is necessary to plan in advance, so that the agricultural extension process to help farmers achieve their goals can be carried out properly, by eliminating the inhibiting factors that are most likely to occur in communication. It seems that the role of communication is very large in extension activities, which will affect from planning to implementation and evaluation.

Extension workers as communicators are messengers, while the target in this case is called communicants very much that is influenced by their background, both individually and in groups. For the extension

workers themselves, are they ready to communicate from sharing aspects, whether the message they carry is in accordance with what the target wants as well as the channel or media they do is appropriate or is it appropriate for the method they use. However, the most important element in making this behavior change is the occurrence of good communication between the messenger, namely the extension officer, and the recipient of the message is the person who is expected to change his behavior.

### **Aspects of Communication Objectives.**

According to Slamet (1978), detailing the existence of three objectives in communication which in practice are often carried out together with different weights of emphasis on the three goals, namely: 1) Informative, providing news information, 2) Persuasive, coaxing and 3) Entertainment, providing entertainment. In the context of agricultural extension activities, it always contains these three kinds of goals even though the levels are not always the same. This is because the main purpose of counseling is to educate. That is, influencing others to be willing to accept / carry out the information they convey happily. Nonetheless the weight of "entertainment" must be kept from always being dominant, so that the information provided can be conveyed in larger portions so as to allow the target to obtain it quite completely and clearly.

We are currently in the digital era 4.0. An era where a lot of information is obtained by utilizing information and communication technology. Existing information can now be conveyed with the help of digital technology that is developing rapidly, information that used to be obtained through face-to-face and manually can now be disseminated through technology. With the digitalization of technology today, counseling will be more effective and efficient. Agricultural extension workers must be able to utilize

information technology to increase the enthusiasm of farmers in order to increase agricultural productivity. Extension workers must take advantage of technological innovations that have developed well.

Minister of Agriculture (Mentan) Syahrul Yasin Limpo (SYL) asked the millennial generation of agriculture to take advantage of the new paradigm of the digital world in developing farming. "Agriculture is no longer the same as agriculture in the past. In the digital era like now, the agricultural sector is also adapting to technology 4.0 to answer the challenges ahead. Dedi said agricultural extension workers must be able to utilize information technology to increase the enthusiasm of farmers in order to increase agricultural productivity. Extension workers must take advantage of technological innovations that have developed well. "The characteristic of successful extension workers is extension workers who can increase productivity in their respective target areas by utilizing cultivation innovations."

Meanwhile, Rizali Anshar, an agricultural extension worker from South Kalimantan Province, has utilized digital technology by conducting counseling media through video. In the MSPP activity, Rizali shared tips on how to make counseling videos so that they can be accepted and understood by farmers and stakeholders in agriculture. One of them is for the selection of material in the video based on events that are viral or are being hotly discussed. The type of video chosen should be consistent, if from the beginning you choose a video about ornamental plants then the video made should always be about ornamental plants.

Rizali explained that what affect video quality is voice quality and body language. With an excited voice, it will make people watching more excited. But even though you have used a good voice, you still have to use good body language too. "There is a special technique in making videos on Youtube so

that the videos made are more watched by the public in this case, especially farmers. There is such a thing as a youtube algorithm that can cause more viewers.", There are fatal errors in making videos including Misdirected content, Less interesting content, Focus on tools, Adsense, Inconsistent.

### **Security Education, Training, and Awareness (SETA) Program**

The Security Education, Training, and Awareness (SETA) Program can be defined as an education and training program designed to reduce the number of cybersecurity breaches that occur due to an individual's lack of awareness of cybersecurity. The SETA program can also be defined as a program that targets all users in an organization to help them become more aware of the principles of information security for their work. The SETA program also helps organizations deal with the risk of compromise due to employees' ignorance of how to perform secure IT-based tasks. This is important for every employee to understand cybersecurity because implementing the SETA program requires participation and motivation (Caballero, 2017).

The SETA program in its application consists of three stages which are a series of training, namely the level of awareness (awerness), the level of training (training), and the level of education (education). The implementation of the SETA Program begins with a basic level that is general to all users in this case all existing employees with the aim of building awareness so as to be able to create a culture of cybersecurity awareness throughout the organization and needs to be conveyed to all users focusing on individual accountability.

Ultimately, the higher the level of risk managed by individuals, the higher the level of awareness and training they should get.

The cybersecurity education level is usually implemented in a formal education built to teach all the basic concepts necessary to build a career in information security. Already many among universities and colleges have begun to create curricula that offer bachelor's and master's degrees on information security.

### **Training Needs Analysis**

Training needs analysis is an early stage in the training process and involves mechanisms to determine whether training will indeed be able to overcome previously identified problems (Bansal & Prakash Tripathi, 2017). Basically, the purpose of training can be defined if the analysis of training needs is carried out systematically related to development in the organization that is carried out professionally. Therefore, the analysis of training needs begins by defining the gap between what employees know and can do and what they and organizations expect to be able to do, which can be filled with training (Ludwikowska, 2018). Training activities are ensured from the analysis of training needs in order to get the relevance of the target participants and to improve the quality of their performance based on the skills or types of skills needed (Bansal & Prakash Tripathi, 2017).

According to (Khan & Masrek, 2017), each training activity requires an analysis of training needs to recognize what, where, how, as well as when it will be implemented. Success.

### **Extension Challenges in Disseminating Information Technology.**

Farmers in Indonesia are generally in the lower middle class, with socio-cultural conditions that are still firmly held, especially those who live in rural areas. The characteristics of farmers who are still strongly holding culture require a slower process of receiving innovation. This

remains a challenge for agricultural extension workers in delivering new technologies. Soekartawi (1988) stated that smallholder farmers generally have a risk averter nature, they are the ones who will bear the risk of what happens by implementing an innovation. Once they are sure of the results that will be obtained if the technology is adopted then the next step is the application of technology. The level of education of elderly farmers is currently relatively low, and most of them are still active in their farming business.

Narrow land ownership is a determining factor for consideration to face risks. The high number of smallholder farmers is a challenge that must be considered in disseminating a new technology. The Function of Extension Workers in Effective and Efficient Dissemination The principle of agricultural extension is to communicate properly, correctly and effectively. Working in the world of counseling must have good communication skills.

Communication is not only in verbal form, but non-verbally by means of codes or lambing. Communication in a language that is easy to understand so that the message or information conveyed can be easily understood. The gestures of the recipient of the information can be a clue as to whether an information is acceptable, for example, facial expression with a blank look or shaking your head or nodding indicates a lack of understanding with the information being heard. Information that is conveyed prolongedly with the expression of uncommon terms, causes the listener of the information to feel tired and become unfocused. They will chat on their own, no longer concentrating on listening.

Agricultural extension activities must be effectively able to organize counseling with methods that are in accordance with the target, time, place, object (material) and subject (participant). The material presented is in accordance with information needs, this

requires initial communication before carrying out counseling. Support counseling media such as posters, videos including using electronic social media that can support conveying information quickly.

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### **Institutional and Agricultural Extension Systems**

Sejak berlakunya otonomi daerah dengan Full authority in the district/city government to make changes to the extension institutions that are united with the Agriculture Office, resulting in the implementation of agricultural extension services stagnating. The extension system consists of methods, approaches and institutions or organizations. The macro extension system consists of two parts, namely the delivery system and the receiving/adoption system (Badan Litbang Pertanian, 2001).

Institutional counseling is an important factor in the extension system; without the institution of counseling, the implementation of counseling cannot run. The position and role of extension institutions is to organize extension programs by disseminating technology from technology sources to users (farmers) or clients in the social system. Therefore, extension institutions starting from the central, provincial, district/city, sub-district and village levels must establish a relationship of coordination, integration and synchronization of programs, both functionally and operationally in the implementation of agricultural extension

According to Axinn (1985), the agricultural extension system consists of two main categories, namely the delivery system and the acquisition system. The delivery system is the delivery of technological information to farmers based on the needs and goals of the organization. Meanwhile, the acquisition system in agricultural extension is very different. The main idea is that groups of farmers, can organize in any way, so that they can reach out outside their villages to obtain the necessary information.

These organizations are generally smaller, such as farmer associations, small farmer groups, or cooperation groups in the village. For the extension system to be successful, it must be controlled by the target group, by influencing the agricultural research agenda and the policies of the central government.

The development of today's agriculture, especially with regard to counseling clients, no longer distinguishes based on the specific category of farmer groups targeted, but must reach all layers of farmers; ranging from small farmers, farm workers/farmers who do not own land, peasant women and young peasants (Campbell and Baker in FAO, 1997). According to Swanson, Roling and Jiggins (1984) in FAO (1997), explained that there are four main factors that need to be considered in finding or providing an extension framework for the development of technology that suits the needs of the target group and clients. These factors are zone-agroecology, access to resources, gender, age of farmers and tribal groups.

Zne-agroecology is an important factor that needs to be identified such as bio-physical, land type, soil fertility, rainfall patterns, slope and altitude of the place will affect the development of location-specific technology. Such bio-physical factors can influence the adoption of technology. Therefore, in client system counseling, these indicators need to be considered in the delivery of information on technological innovations.

The access to resources factor is to explain the socioeconomic factors that distinguish the access of one farmer from another to other farmers to production factors such as land tenure status (area, owner, trapper, tenant, pawn), capital (source of capital, loan, credit, how to obtain credit, how to grow capital), labor (family labor, outside the family / wages, availability of costs, communal), inputs (availability of seeds, fertilizers and medicines), market (place, price, warehouse, transportation, distance), ability to use technology and information (availability of extension services, suitability of technology) (Swanson, et al, 1984, in FAO, 1997).

### **Human Resources of Agricultural Extension Workers Who Compete In The Digital Age**

Based on Law No.16 of 2006, extension workers are distinguished in 3 (three) categories, namely (1) Civil Servant Extension Officers; (2) Private extension workers ; (3) Self-help extension workers. In general, the three categories of extension workers have no different functions. As a delivery of information on innovative technology to assist farmers in technology escorts, so that it becomes an understanding of the application stages. Being an extension worker with a higher level of education than a farmer does not mean that he is greater than a farmer. The basic principle of agricultural extension is to learn together to solve problems in farming, our big role is to facilitate farmers to get technological information, as well as its application.

Access to information on social media in the modern era as it is now is more diverse and varied. The Internet is accessible to all walks of life, wide open to various information. Digital technology that continues to develop, provides the widest opportunities for us to be able to take advantage of both obtaining information and disseminating information

quickly in an unlimited space. This facility can be used for extension workers in carrying out the role and function of extension workers to become a learning medium and help solve problems. As an extension worker in charge of BPTP, he is required to always strive to increase capacity to face such rapid technological developments. In the digital era that has various conveniences.

The government continues to facilitate the improvement of the human resource capacity of Agricultural Extension Workers in order to carry out their duties properly. With the provision of knowledge, extension workers must also cultivate creativity and ideas that can provide solutions to agricultural problems in the field. The experience of extension workers in the field combined with the results of research or assessment will provide the right solution and have a positive impact. Digital Products That Can Be Utilized by Extension Workers The basic principle of counseling is efficient and effective communication, the use of communication media is very supportive in disseminating information technology in the digital era.

The use of digital products or the internet in conveying and disseminating technological information more effectively and efficiently by utilizing social media such as Twitter, Facebook, Instagram, Youtube, Google, Whatsapp, Telegram, LinkedIn, Line and various other types of social media. The creation of effective and efficient counseling media has been equipped with a variety that is easy to download either through an Android smartphone or on a laptop or notebook. The trend of counseling that follows the current current digital developments that are classic such as radio broadcasts can already use applications via the internet.

Video clips or films of short duration can be used as a form of media that has a wide spectrum, meaning that it can be easily

understood by viewers of various age and education levels. Making it is currently relatively easy because many menu menus are easy to operate because they already use symbols in the form of images. Recording a video clip does not have to use a special camera. Communication equipment such as smartphones have been equipped with photo camera features and video cameras. The editing process can be done easily just by using the application that can be downloaded.

The challenge for extension workers in this digital era is the ability to keep pace with technological developments, which have changed in a relatively short period of time. As an extension worker, you have to read a lot and study the changes that occur. Change is usually the cause of the emergence of new problems, because the existence of information systems that are no longer limited by time and space, can cause unexpected impacts. As an agricultural extension officer who carries out the task of disseminating agricultural technology, conveying new information to farmers. Creativity is needed to face problems for which there is no solution based on the results of research and studies. Of course, it needs to be supported by the knowledge of extension workers, experience in the field, level of education, hard work and discipline.

A communication process certainly needs to run effectively so that the content of the message is conveyed properly and the purpose of the process can be achieved. Likewise with the agricultural communication process, efforts need to be made so that the process runs effectively. The process of conveying messages in agricultural communication needs to pay attention to various aspects such as attitudes, thoughts, and feelings of the recipient of the message to be able to equalize meaning.

Basically, the process of agricultural communication (especially in agricultural extension) has several stages, namely: 1)

Creating awareness, that is, efforts made to attract attention and raise awareness of the recipients of the message (farmers) regarding the existence of something new. 2) Evocative of feelings, that is, an attempt to cause a feeling of opening up in the farmer of something new, which was already realized at the previous stage. So that the farmers have the willingness to know and learn more. 3) Arouse desire, that is, an effort to cultivate a desire in farmers to do new things that are conveyed in agricultural extension activities. 4) Convincing, that is, an attempt to convince the farmers to be sure, not to hesitate, and not to be afraid to do new things. 5) Mobilizing, that is, efforts made to encourage farmers to do new ways or things that are taught, and be able to practice them in a sustainable manner.

Setelah menjalani tahapan dalam Agricultural communication, it is necessary to pay further attention to how the approach is carried out so that the communication process runs effectively. Here are the approach methods that can be done to make agricultural communication run effectively: Group approach method, which is a method of providing agricultural counseling by grouping farmers based on the location of their residence, or paddy fields. (Also read: Philosophy of Communication) Mass approach method, which is a method of providing counseling that is carried out mass and can reach a wider target by using mass media such as television, newspapers, and so forth. (Also read: Gender Communication) The individual approach method, which is a method of approach by communicating directly to the target such as dialogue with farmers. That way, the information conveyed is more targeted and directed even though it cannot immediately reach many people.give importance that they really.

## 5. Conclusion

era digital is appropriate for agricultural farmers to be able to use digital media as a medium for the innovative dissemination of agriculture on social media. The extension system is a system of delivering innovations from technological sources to users (farmers) using various existing approaches and methods that are in accordance with client conditions and social systems, so that innovation can be utilized by users to increase income and welfare. The main components of the extension system consist of three sub-systems, namely the client sub-system, the change sub-system and the research sub-system. The research sub-system does not play a direct role in seeding technological innovations but as a supplier of technology (generating system).

The extension approach in the future is no longer designed as a partial concept but concerns all aspects of rural agribusiness activities, but must be able to be realized in operational activities carried out thoroughly, integrated and coordinated from all development actors.

Agricultural extension systems can use the approaches of: (1) agro-ecosystems; (2) territory; (3) agribusiness; (4) institutional; and (5) welfare. The extension system approach is more directed at the growth of the regional economy (local economy) so that it can reach all client life activities in the social system.

## 6. Recommendations

- Karakteristik petani yang masih kuat memegang budaya memerlukan proses yang lebih lamban dalam menerima inovasi. Ini masih menjadi tantangan bagi penyuluh pertanian dalam menyampaikan teknologi baru. Soekartawi (1988) menyatakan bahwa petani kecil umumnya mempunyai sifat menolak resiko (risk averter), merekalah yang akan menanggung resiko apa yang terjadi dengan menerapkan suatu inovasi menuju Menuju digitalisasi pertanian era revolusi industri 4.0,
- Penerapan teknologi. Tingkat pendidikan petani berusia lanjut saat ini relative rendahnya, dan sebagian besar masih aktif pada usahataniannya.
- Kepemilikan lahan yang sempit merupakan faktor penentu pertimbangan untuk menghadapi resiko. Masih tingginya jumlah petani gurem merupakan tantangan yang harus diperhatikan dalam mendiseminasikan suatu teknologi baru.

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## **PREDICTION OF CALORIFIC VALUES OF WHEAT STRAW FROM PROXIMATE & ULTIMATE VARIABLES**

**Abstract:** *Agro-crop residues for energy applications are paid impressive attention worldwide in the recent decades. As 850 kg of wheat straw generate per every tonne of wheat produced, globally 660.28 million tonnes of wheat straw was estimated for 2021-22. Wheat straw (WS) considered as a primary energy source despite of its utilization in soil enhancer, animal fodder supplement, frost prevention in horticulture, ingredient in mushroom production substrate and traditional building materials. Higher heating value (HHV) is considered as the energy indicator of fuel substances and thus this study mainly focused on construction of single and multivariate linear regression models to determine HHV of WS using proximate and ultimate parameters. 54 different WS data considered and stratified based on available attributes. WS samples found with the mean values of 67.95, 15.47 and 5.96 % of volatiles, fixed carbon and ash contents respectively besides the mean HHV of 16.86 MJ/kg. Further, one-way ANOVA study revealed that items considered for the study are highly significant. In addition, Pearson's correlations ensured that HHV has comparatively stronger linear relations with moisture and volatile matters apart from active relations with carbon and oxygen compositions. Moreover, multivariate linear models of HHV, expressed as function of proximate variables and a function of ultimate parameters along with ash content have proven to be more efficient predictions with the estimated  $R^2$  values of 0.777 and 0.8 respectively. Nevertheless, most of the developed models have demonstrated their coexistence with other reported models.*

**Keywords:** *Wheat Straw, Proximate and Ultimate Analysis, Statistical Measures, HHV Prediction, Single and Multivariate Linear Regression Model.*

### **1. Introduction**

Agro based biomass resources for energy application are paid impressive attention worldwide in the recent decades due to the fact that the replenishing of fossil fuels takes longer time. Despite the utilization of crop residues as fodder to animals, major portion

remains in the fields [Harmandeep et al 2013]. Crop residues have been applied as a biofuel feedstock and the significance of such sources rising in many countries because of increasing prices and depleting reserves of fossil fuels. In other words, CO<sub>2</sub> released from the burning of any biomass can be captured back by the plants while grow-up and thus it holds the carbon neutral

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character, which ensure biomass as a renewable and sustainable energy resource.

Wheat is one of the major stable crops in the world and estimated the production of 776.8 million tonnes in 2021-22 [Food Outlook 2022]. Wheat is primarily grown in moderate and Mediterranean climates. The stalks remain following the removal of the grain during the grain harvesting process, often known as wheat straw. Main producers of wheat are located in Southern Asia, Eastern Europe, Northern America and Eastern and Central Asia. As 850 kg of wheat straw generate per every tonne of wheat produced [NL Agency 2013], globally 660.28 million tonnes of wheat straw was estimated for 2021-22. Wheat straw is a lignocellulosic biomass which relatively contains high amounts of inorganic components and ash. However, straw is considered as a major feedstock for the bio-based economy and combustion of straw remained the most common application so far [NL Agency 2013]. Current uses of straw include soil enhancer, animal fodder supplement, frost prevention in horticulture, ingredient in mushroom production substrate, traditional building materials and energy. In addition, wheat straw is co-fired in coal-fired power plants.

Fuel characteristics such as gross calorific value (GCV) or higher heating value (HHV) of a biomass is considered as a primary energy indicator and the effect of physicochemical compositions of biomass material on HHV studied experimentally or empirically by several researchers [Abdul et al 2013, Ayese Serdar 2016, Harmandeep et al 2013]. Heating value or calorific value of a fuel substance is defined as the energy liberated from the combustion under specific applied conditions. HHV is the total amount of heat energy available in the fuel including energy embodied in water vapour whereas lower heating value (LHV) accounts for only dry components. Heating values can be determined experimentally with the aid of a

Bomb calorimeter. Other words, LHV can be assessed from HHV using  $LHV = HHV - 24.42(AM + 8.94H)10^{-3}$  MJ/kg [Szymajda et al, 2021].

Abdul et al., have applied multiple linear regression models and simple linear models to predict GCV of lignocellulosic biomass materials using proximate variables. Experimental values of proximate parameters of any biomass can be easily obtained from a simple ordinary lab using an oven to measure moisture (M) content and a muffle furnace for measuring volatile (V) and ash (A) contents. And the fixed carbon (FC) can be determined by a simple relationship,  $FC = 100 - (M + V + A)$ . Determination of HHV in the range of 1.469 and 1.493 MJ/kg of biomass using proximate analysis with a statistical parameter  $R^2$  in the range of 0.812-0.837 reported by Ayese and Serdar. In another study by Harmandeep et al., ultimate and proximate variables considered to develop relevant equations for HHV prediction of biomass materials. In addition to many earlier studies focused on calorific value dependency on proximate and ultimate variable, Sunyong et al., have studied interdependency of proximate and ultimate variables [Sunyong et al 2022].

Integration of several varieties of biomass materials and predicting models in a more general way definitely causes to high uncertainty in the results as every type of biomass has shown random variations in their physicochemical compositions. Moreover, soil type and climatic conditions affects significantly the biomass compositions. Therefore, this study mainly focused on assessing the correlations among proximate and ultimate variables, and the development of models to predict higher heating value of wheat straw, a specific significant crop residue using simple linear relations and multivariate linear regression models.

## 2. Data Collection and Methods of Analysis

### 2.1. Data Collection and Stratification for the analysis

Proximate and ultimate analysis reports of 54 wheat straw (WS) samples in as received (ar) condition were acquired from PHYLLIS, Netherlands database in the month of March, 2023. Further, the data of WS samples provided with associated higher heating values (HHV). However, the data was stratified according to the available information such as proximate analysis (PA), ultimate analysis (UA), complete analysis(CA), and the data with HHV provision as shown in figure 1. Out of 54, total number of samples 20 samples has proximate reports (Table 1), 35 samples provided ultimate variables along with gross calorific values (HHV) as given in the table 2, and complete analysis (Table 3) for 14 samples which includes P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O, and excluding proximate analysis that has provided in the Table 1 along with others.

### 2.2 Estimation of Statistical Measures [Kothari C.R 2004]

Measure of central tendency, also known as statistical average or mean tell us the point about which items have a tendency to cluster and it represent a figure for the entire sample data. In general, statistical mean of  $n$  items is given by,

$$\bar{X} = \frac{\sum X_i}{n} = \frac{X_1 + X_2 + X_3 \dots + X_n}{n}$$

Further, in order to measure the scatter behaviour of samples, statistical devices called measures of dispersion such as range, and deviation are calculated. Range is the difference between the extreme values of the items, whereas the standard deviation ( $\sigma$ ) is the square-root of the average of squares of deviations and it is given by,

$$\sigma = \sqrt{\frac{\sum(X_i - \bar{X})^2}{n}}$$

Thus mean, range and standard deviations of all proximate, ultimate and calorific values are determined for further understanding of their distributions.

### 2.2 ANOVA Performance and Determination of Pearson's Correlations [Kothari C.R 2004]

Analysis of variance (ANOVA) is essentially a procedure for testing the difference among different groups of data for homogeneity. In brief, ANOVA methods includes the estimation of population variances (PV) based on inter sample variance (SV) and intra sample variances and they are compared with  $F - test$  and given by,

$$F = \frac{\text{Estimate of PV based on Inter SV}}{\text{Estimate of PV based on Intra SV}}$$

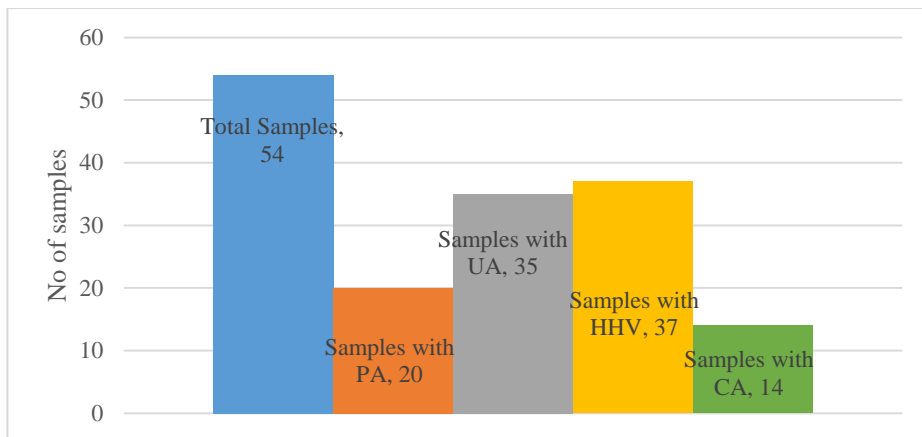
Thus the value of  $F$  provides a qualitative mean of sample significance referred to a given  $F - limit$  for a specific degrees of freedom.

One-way (or single factor) ANOVA test performed in Microsoft EXCEL® for all data groups provided through Table1 to Table 3 to understand their deviations and significance of the samples.

There are several methods of determining the relationship between variables such as bivariate and multivariate correlations to understand their association or correlation and to determine the degree and direction. Karl Pearson has proposed a coefficient ( $r$ ), most widely used method of measuring the degree of relationship between two variables and is given by,

$$r = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum(X_i - \bar{X})^2} \sqrt{\sum(Y_i - \bar{Y})^2}}$$

Using a simple function, *PEARSON* (*y* variable, *x* variable) in EXCEL® correlation coefficients between the proximate, ultimate and HHV variables are established.



**Figure 1.** Stratification of WS data for different types of analysis

**Table 1.** Data Set of Proximate variables and corresponding HHV values of WS

S.NO	M (%)	V (%)	F (%)	A (%)	HHV (MJ/kg)
1	15.1	62.32	14.98	7.6	14.99
2	12.9	66.02	14.98	6.1	15.4
3	13.01	61.86	16.82	8.31	14.64
4	9.19	68.6	14.73	7.48	16.05
5	9.74	71.05	13.96	5.25	16.77
6	17.41	67.09	12.29	3.21	15.19
7	10.5	70.53	15.92	3.05	17.87
8	10	69.57	14.67	5.76	17.19
9	17.41	67.1	12.28	3.21	15.19
10	9.89	70.84	15.37	3.89	16.64
11	7.04	69.97	16.46	6.53	16.68
12	6	71.25	17.01	5.73	17.32
13	11.1	66.59	16	6.31	16.44
14	11.1	66.59	15.91	6.4	16.43
15	11.1	66.59	16.36	5.96	16.43
16	6.5	71.06	15.43	7.01	17.68
17	8.3	71.34	15.59	4.77	16.26
18	8.45	65.55	18.45	7.55	16.02
19	10.25	69.74	15.79	4.23	17
20	7.32	65.38	16.47	10.83	16.27

**Table 2.** Data Set of Ultimate Analysis and the associated HHV values of WS

S.No	C	H	O	N	S	HHV (MJ/kg)
1	46.02	5.5	41.44	1.65	0.1	17.21
2	48.28	5.08	38.32	0.47	0.07	17.05
3	45.96	5.5	41.47	1.54	0.11	17.23
4	48.11	5.64	42.67	0.28	0.03	17.84
5	47.82	5.29	41.59	0.47	0.08	17.72
6	46.73	5.17	39.86	0.37	0.06	17.28
7	46.44	5.24	40.64	0.51	0.06	17.12
8	47.53	3.1	45.58	0.65	0.08	15.05
9	37.29	4.69	34.29	0.62	0.19	13.6
10	40.29	5.13	34.47	0.86	0.14	13.96
11	46.95	6.02	43.83	0.53	0.11	14.81
12	47.62	6.11	42.54	0.62	0.11	14.8
13	45.6	5.55	40.71	0.36	0.21	16.54
14	42.94	5.22	39.45	0.57	0.35	15.64
15	45.25	5.4	40.69	0.89	0.19	16.92
16	37.32	4.45	34.41	0.46	0.25	13.35
17	40.88	5.14	36.07	0.83	0.17	14.7
18	42.19	5.17	36.68	0.64	0.1	15.4
19	39.27	4.84	34.57	0.48	0.08	13.7
20	41.14	5.17	39.51	0.49	0.11	16.49
21	42.48	5.22	35.6	0.63	0.15	15.81
22	39.27	4.84	34.56	0.49	0.07	13.7
23	42.32	5.13	38.09	0.39	0.17	15.28
24	41.76	5.08	38.83	0.41	0.15	15.4
25	43.33	5.26	38.85	0.47	0.08	16.02
26	40.72	5.3	35.68	0.4	0.14	15.01
27	40.72	5.3	35.59	0.4	0.14	15.01
28	40.72	5.3	36.03	0.4	0.14	15.01
29	40.45	5.15	38.47	0.72	0.08	15.57
30	37.87	4.41	34.46	0.54	0.09	13.49
31	40.86	4.75	39.36	0.74	0.4	16.49
32	43.21	5.3	36.86	0.43	0.17	14.9
33	42.45	5.27	37.24	0.52	0.06	15.59
34	41.75	4.85	34.49	0.6	0.16	15.02
35	41.6	5.32	37.08	0.65	0.11	15.59

**Table 3.** Data Set of Wheat Straw with Complete Analysis

S.No	C (%)	H (%)	S (%)	N (%)	P <sub>2</sub> O <sub>5</sub> (%)	K <sub>2</sub> O (%)
1	37.29	4.69	0.19	0.62	0.19	13.6
2	40.29	5.13	0.14	0.86	0.14	13.96
3	40.88	5.14	0.17	0.83	0.17	14.7
4	42.19	5.17	0.1	0.64	0.1	15.4
5	39.27	4.84	0.08	0.48	0.08	13.7
6	41.14	5.17	0.11	0.49	0.11	16.49
7	42.48	5.22	0.15	0.63	0.15	15.81
8	39.27	4.84	0.07	0.49	0.07	13.7
9	42.32	5.13	0.17	0.39	0.17	15.28
10	41.76	5.08	0.15	0.41	0.15	15.4
11	40.72	5.3	0.14	0.4	0.14	15.01
12	40.72	5.3	0.14	0.4	0.14	15.01
13	40.72	5.3	0.14	0.4	0.14	15.01
14	42.45	5.27	0.06	0.52	0.06	15.59

**2.3 Single and Multivariate Linear Model Constructions and Validations** [Kothari C.R 2004]

Simple linear regression models developed for the assessment of HHV values as a function of proximate and ultimate variables using single and multivariate linear regressions. Regression interpret what exist physically between independent variable (X) and dependent variable (HHV) and a single linear regression is given by,

$$HHV = a + bX$$

where X is an independent variable such as proximate or ultimate parameter and a, b are the regressions coefficients, which will give the best possible fit through original X and HHV and they are determined by simple least-square method as follows,

$$b = \frac{\sum x_i y_i}{\sum x_i^2} \text{ and } a = HHV - bX$$

and a multiple linear regression can be described by,

$$HHV = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_k x_k + \varepsilon$$

where HHV is the dependent variable and  $X = \{x_1, x_2, \dots, x_k\}$  are the independent variables as describe above and  $\varepsilon$  is the corresponding residual error. If the expected error,  $\varepsilon$  assumed as zero, the set of arbitrary coefficients (b) can be described as,

$$b = \{\beta_0, \beta_1, \beta_2 \dots \beta_k\}$$

and it can be evaluated by the least square method as,

$$b = (X^T X)^{-1} X^T HHV$$

Regressions equations obtained from the above cited methods are evaluated based on coefficient of multiple determinations (R<sup>2</sup>), which is a comprehensive parameter to understand the precision of the relation usually dwells in the range of  $0 < R^2 < 1$  and it is given by [Abdul.R.S et al 2013],

$$R^2 = 1 - \frac{\sum_{i=1}^n (Y_i - \bar{Y})^2}{\sum_{i=1}^n (X_i - \bar{X})^2}$$

Thus the developed single and multivariate linear models using EXCEL® and POLYMATH® are compared with earlier reported models [Ayse et al 2019, Ivan et al



2022] for the determination HHV as a function of proximate and ultimate variables. Further the models developed for the evaluation of carbon and hydrogen using proximate parameters are validated with M. aliyu et al 2020.

### 3. Results and Discussion

#### 3.1 Significance and Variance of the WS Properties

Wheat straw has shown greater dispersion in terms of their proximate and ultimate variables as provided in Table 4. Moisture content and carbon compositions have noticed with higher variances than any other parameters. Nevertheless, the moisture content majorly depends on sample received conditions and the state of dryness of the samples analyzed. Further, volatile matter and oxygen compositions also recorded huge variances similar to the moisture and carbon contents. Volatiles refer to volatile carbon, combined water, net hydrogen, nitrogen and sulphur, which are first driven off during combustion and thus higher volatiles favors in rapid combustion. Wheat straw attributed with greater volatile contents ranging from 61.86-71.34 %, which is comparatively higher than many other biomass sources. Other words, of the proximate components, fixed carbon varied with less interval of 6.17 varied between 12.28 to 18.45 and a mean value of 15.47 % (weight) whereas rice straw ranging from 11.1 to 16.75% (Van Hung et al 2020). Additionally, higher fixed carbon content favors in higher char yields which can be burned as fuel. Ash content of the studied samples have varied between 3.05 to 10.83 and it has a mean value of 5.96%. The ash content of wheat straw analyzed found substantially lower than rice straw for which it is reported as 18% (NL agency report 2013). Sulphur and Nitrogen elemental compositions in wheat straw found very less magnitude and subsequently have shown least variance. In addition, wheat

straw samples possess higher compositions of carbon and oxygen and their associated variances. Higher heating values of wheat straw samples have shown comparatively less variances with a mean value of 16.86 MJ/kg which is remarkably higher against 14.59 MJ/kg for rice straw (Van Hung et al 2020).

One-way ANOVA results of wheat straw revealed that the samples considered for the analysis has potentially higher significance as their F-test values exceeds F-critical values as shown in tables 5 and 6. Thus the hypothesis test between dependent and independent variables will be more vital to establish. HHV of wheat straw has been considered as an objective variable to understand the corresponding functions in terms of proximate and ultimate parameters. Further the development of single and multivariate linear regression relations is simple, easy to construct and saves bountiful time with adequate results.

#### 3.2 Correlations among Ultimate, Proximate and HHV variables of WS

In general Pearson's coefficient alters between -1 and 1 to determine how closely two variables are related. Pearson's correlation coefficients are evaluated as shown in Table 7 between proximate, ultimate and HHV values of wheat straw. HHV has comparatively stronger linear relations with proximate variables of moisture and volatile contents besides the active relations with carbon and oxygen compositions. Nitrogen holds very weak affiliation with many other elements and HHV as well. Among the proximate variables, moisture adheres better with fixed carbon content while carbon bears the strongest linear alliance with volatiles and moisture components. In addition, in wheat straw samples analyzed, carbon also holds the strongest relation with hydrogen composition.

**Table 4.** Range, Mean and Variances of Proximate and ultimate reports of WS

Parameter (%)	Minimum	Maximum	Interval	Mean	Variance
M	6	17.41	11.41	10.61	10.52
V	61.86	71.34	9.48	67.95	8.362
F	12.28	18.45	6.17	15.47	2.152
A	3.05	10.83	7.78	5.96	3.758
C	37.29	48.28	10.99	42.95	10.528
H	3.1	6.11	3.01	5.14	0.250
O	34.29	45.58	11.29	38.29	9.334
N	0.28	1.65	1.37	0.60	0.083
S	0.03	0.4	0.37	0.13	0.006
HHV	14.64	19.08	4.40	16.86	1.408

**Table 5.** One-way ANOVA results of Ultimate variables & HHV of WS

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	63688.16	5	12737.63	3537.149	5.1E-196	2.258342
Within Groups	734.6246	204	3.601101			

**Table 6.** One-way ANOVA results of Proximate parameters & HHV of WS

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	51306.69	4	12826.67	2506.334	2.38E-95	2.467494
Within Groups	486.1817	95	5.117702			

**Table 7.** Pearson's correlations between proximate, ultimate and HHV values of WS

	M	V	F	A	C	H	O	N	S	HHV
M	1									
V	-0.533	1								
F	-0.666	-0.111	1							
A	-0.374	-0.516	0.523	1						
C	-0.704	0.855	0.170	-0.212	1					
H	-0.335	0.600	0.058	-0.380	0.753	1				
O	-0.678	0.650	0.485	-0.202	0.504	0.237	1			
N	0.014	0.014	-0.327	0.248	-0.064	-0.130	-0.241	1		
S	-0.276	-0.069	0.161	0.444	-0.217	-0.435	0.090	0.321	1	
HHV	-0.710	0.789	0.275	-0.196	0.758	0.565	0.736	-0.030	0.073	1

**Table 8.** Models for the prediction of HHV using proximate variables

Eq. No	Model	R <sup>2</sup>	Variance
1	$HHV = -0.2005 + 0.243V$	0.622	0.317
2	$HHV = 18.396 - 0.195M$	0.504	0.415
3	$HHV = 5.504 - 0.111M + 0.1766V$	0.739	0.231
4	$HHV = -4.515 + 0.256V + 0.223F$	0.755	0.217
5	$HHV = 15.525 - 0.168M + 0.392V + 0.03F$	0.758	0.228
6	$HHV = -5.135 + 0.267V + 0.201F + 0.036A$	0.758	0.227
7	$HHV = -2759.27 + 27.532M + 27.812V + 27.732F + 27.576A$	0.777	0.224

**Table 9.** Models for the Prediction of HHV using Ultimate analysis

Eq. No	Model	R <sup>2</sup>	Variance
8	$HHV = 5.108 + 0.274C$	0.560	0.637
9	$HHV = -0.213 + 0.407C - 0.034H + 0.105N$	0.588	0.635
10	$HHV = 8.846 + 11.801C - 5.264H + 62.893O + 105.166N - 33.576S$	0.590	0.674
11	$HHV = -5.194 - 0.0152A - 0.183C + 1.005H + 0.23O + 0.52N + 2.535S$	0.800	0.232

**Table 10.** Prediction of C and H using Proximate Parameters

Eq. No	Model	R <sup>2</sup>	Variance
12	$C = 15.524 - 0.168M + 0.392V + 0.0327F$	0.805	0.653
13	$H = -1211.83 + 12.131M + 12.18V + 12.172F + 12.103A$	0.455	0.043

### 3.3 Prediction of HHV using Proximate Analysis

Many different models constructed to determine the HHV values in a more precised way using proximate and ultimate reports of wheat straw samples. In the primary approach, single and multivariate linear regressions established in terms of proximate variables and the best models are reported in the table 8. The most complex model that expressed as equation (7) has provided the highest statistical comprehensive variable (R<sup>2</sup>) of 0.777 along with the least variance. Further, the contribution of ash content in the HHV

modeling has witnessed with improved R<sup>2</sup> values when compared with equation (5), which excludes the ash content. The regression equations (2 and 3) for HHV developed as a function of moisture showed poor performance in terms of R<sup>2</sup> whereas the models (1 and 4) that excludes moisture and considers volatiles provided enhanced R<sup>2</sup>.

### 3.4 Prediction of HHV using Ultimate Analysis

The prediction of HHV as a function of elemental composition is crucial to provide a

**Table 11.** Verification of reported models

Eq. No	Model	R <sup>2</sup>	Variance	Reference
14	$HHV = 25.19 - 0.0503V - 0.044F$	0.755	0.217	Ayşe et al 2019
15	$HHV = 5.63 + 0.1679V$	0.622	0.317	Ayşe et al 2019
16	$HHV = -857.09 + 7.9M + 8.8V + 8.9F + 8.62A$	0.777	0.224	Ayşe et al 2019
17	$HHV = 13.6 - 0.655M + 0.171V - \left(\frac{61.1}{F}\right)$	0.767	0.219	Ayşe et al 2019
18	$HHV = -1.89 + 0.3357V + 0.055A - \left(\frac{94.12}{F}\right)$	0.768	0.218	Ayşe et al 2019
19	$HHV = 19.63 - 0.894M + 0.0538V$	0.739	0.231	Ayşe et al 2019
20	$HHV = 0.349C + 1.178H + 0.1005S - 0.1034O - 0.015N - 0.0211A$	0.762	0.256	Ivan M et al 2022
21	$HHV = 32.7934 + 0.0053C^2 - 0.5321C - 2.8769H + 0.0608CH - 0.2401N$	0.588	0.478	Ivan M et al 2022
22	$C(\%) = [(0.97FC) + 0.7(VM - 0.1) - M(0.6 - 0.01)]$	0.796	0.682	Aliyu et al 2020
23	$H(\%) = [(0.036 FC) + 0.086 (VM - 0.1 A) - (0.0035 M^2) (1 - 0.02 M)]$	0.572	0.038	Aliyu et al 2020

better model. Hence, the feasibility of constructing relevant models to gain high accuracy is verified and eventually attained four significant relations expressed in the table 9. Amongst the equations 8 to 11, the model (11) which incorporated with ash content beside all ultimate parameters has provide the R<sup>2</sup> value of 0.8 than any other models. Otherwise, in equation 10, HHV is described as a function of all ultimate variables (C,H,O,N,S) resulted with an R<sup>2</sup> value of 0.59, which is substantially poor when compared with equation 11 and thus it tells us the role of ash content is more prominent in HHV determination. Since the carbon found with best Pearson’s coefficient of 0.758 compared with other ultimate variables, a single variable linear regression between HHV and carbon established with an R<sup>2</sup> of 0.56

The generation of proximate analysis is quite simple than ultimate analysis as it doesn’t need any advanced experimental facilities and it could be easily accessible from any basic laboratory. Instead, ultimate analysis need sophisticated and advanced devices, thus the development of models that

facilitate the assessment of elemental composition based on proximate variable gaining more prominence in many developing countries. In context of that, this study accomplished two different models (12 and 13) for the evaluation of carbon and hydrogen, two imperative elements in terms of proximate parameters as provided in the table 10. Equation 12 displays the accuracy of carbon expressed as a function of M, V and F in terms of best R<sup>2</sup> value of 0.805 while equation 13 provide a model for hydrogen assessment with comparatively poor R<sup>2</sup> but with least variance.

### 3.5 Validation of the Models

Out of 13 different developed models, 10 models are validated with other reported models from the literature and their estimated statistical comprehensive parameter R<sup>2</sup> values along with variances are provided in the Table 11. Except the equations 21 and 23, all compared models are linear multivariate regressions in similar with the proposed models whereas predicted models 9 and 13 are validated with non-

linear multivariate models expressed by 21 and 23. However, all the predicted models are competitive and provides the substitution to the earlier reported models. Although Ayse et al. have proposed models to predict HHV values of 39 different biomass components based on their proximate reports excluding wheat straw, the models developed in this study for wheat straw coexist with their results. Further, Ivan et al has developed the models for the assessment of HHV of coal samples based on elemental analysis, therefore the current work has considered their models to compare the HHV prediction models that relate elemental compositions and proved that the proposed models are highly relevant.

## 4. Conclusion

Agro-crop residues contribute significantly in bio-waste generation worldwide, wheat straw in particular estimated at a rate of 776.8 million tonnes in 2021-22. Straw is considered as a major feedstock for the bio-based economy and combustion of straw remained the most common application so far. 54 different WS data considered and stratified based on available attributes. WS samples found with the mean values of 67.95, 15.47 and 5.96 % of volatiles, fixed

carbon and ash contents respectively besides the mean HHV of 16.86 MJ/kg. Further, Calorific value of fuels substances is considered as the key energy indicator and its determination in terms of fundamental analytical reports such as proximate and ultimate analysis aids to prevent the additional lab facilities. Additionally, one-way ANOVA study revealed that items considered for the study are highly significant. Else, Pearson's correlations ensured that HHV has comparatively stronger linear relations with moisture and volatile matters apart from active relations with carbon and oxygen compositions. Moreover, multivariate linear models of HHV, expressed as function of proximate variables and a function of ultimate parameters along with ash content have proven to be more efficient predictions with the estimated  $R^2$  values of 0.777 and 0.8 respectively. Validation of proposed models with formerly reported equations have proven their coexistence.

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## COMMODIFICATION OF FOOD CULTURE: A STUDY OF THE BODO COMMUNITY, WITH SPECIAL REFERENCE TO THE CHARIDUAR AREA OF THE SONITPUR DISTRICT

**Abstract:** Food, which is a basic requirement for a healthy life and survival, has broadened its scope. In a nutshell, it states that, aside from being a necessary component of survival, It has also evolved into a commodity for commerce and financial gain. The North-East of India, particularly Assam, is home to a diverse range of ethnic and other linguistic groups, each with its own distinct personality, resulting in a vibrant and colourful landscape. Every town has its own traditional foods, as well as a particular style of preparing, presenting, and exhibiting its cultural identity. This paper provides an outline of food commodification. Indigenous foods, which were previously primarily conserved and limited within the four walls of a community, are now being shared on global platforms and among other communities for economic gain, community representation, and man and woman empowerment to improve lifestyle and culture. The study area is comprised of six villages and sub-urban areas in Sonitpur District, Assam, India, primarily in the Chariduar area, where the majority of the population is from the Bodo community. The data and facts for the preparation and conservation of the Bodos' local traditional ethnic foods were gathered through discussions with families, commercial outlets such as ethnic restaurants, local markets, and other people involved in the process of preparing and selling the unique dishes on a commercial scale. The report also considers the chances for continued development of Assam's ethnic cuisine industry.

**Keywords:** Ethnic Food Commodification, Bodo community, Entrepreneurial Prospects, Chariduar area of Sonitpur District, Assam

### 1. Introduction

Simply put, commodification is the process of converting something into a commodity. When there is a mutual desire and trade understandings between members of a society and outsiders, a thing becomes a commodity. When these things are turned into commodities, they provide a source of

money for the community, allowing them to maintain their lifestyle and way of life. Commodification not only contributes to economic empowerment, but it also aids in the good depiction of the community at national and international levels, resulting in the creation of an identity as well as a food identifier or identification tag for that community. Culture is fluid and ever-

evolving. Food is such a vital part of any culture that it is easy to mould with minor variations. As a result, it is simpler for a group to acculturate its eating customs, and as a result, it has a wider reach and penetrates more easily into diverse cultures. As a result of this penetration, fusion food is created, and oicotypification begins. With time, food culture may accept certain changes, resulting in the emergence of variation in its aura while maintaining the core elements. As a result, it is not possible to claim that there is a loss of aura, but rather that there is a change in aura. Commodification is the transformation of an object into a commodity and market product, which is tied to capitalism. Food, like commodification, is a market product that goes through a mobilisation process in the global business era, resulting in new business opportunities. A lot of interest is currently being generated by research into the commodification, authenticity, and long-term survivability of cultural culinary legacies in the global market period. There is a significant debate in the global economic era over the monetization of traditional cuisine's legacy. Because it is tied to consumerism, commodification has become a prominent subject and a hot problem in today's global society. Every part of culture, whether tangible commodities like clothing or intangible ones like traditions and customs, has been transformed into a commodity in today's world for its monetary exchange value. On the other hand, the commercial side must not completely obscure the cultural components. As a result, a war between culture and commerce has erupted, with a dynamic relationship distinguished by interdependencies. On the one hand, the commercialization process should aid in the preservation of culture. The practise of trade, on the other hand, is only feasible because of the existence of culture.

Cuisine is an intangible cultural heritage that symbolises cultural identity and is passed

down from generation to generation, and its presence indicates a community's cultural diversity. This sacred cultural treasure has now become a commodity of trade as a result of commercialization throughout the global market age. The purpose of cuisine is to provide nourishment. Every aspect of people's life, as well as the range and complexity of their cultural arts, reveals their cultural ideals. Culinary heritage is seen as a global asset as well as a local resource that may be exploited to build a historical narrative based on social, environmental, economic, and political variables.

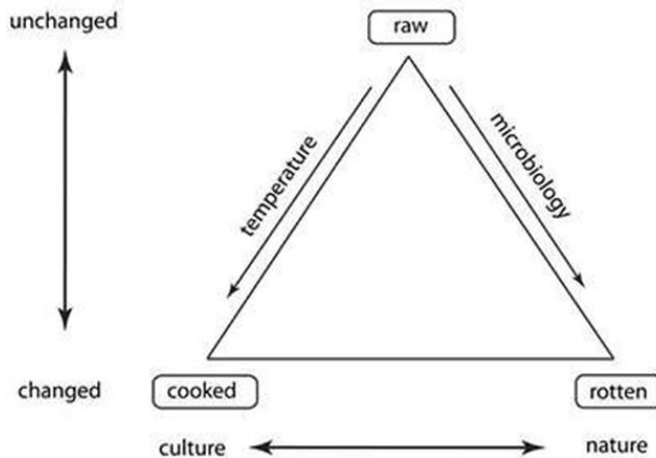
According to gastronomy, traditional cuisine is a culinary product that has not been modified and has been passed down from a previous age and is still in use now. Traditional food is regarded to have a relatively high inherent quality due to its historical relevance. It's a traditional cuisine that's known for eliciting intense emotions, sensuality, and sentiments.

Food preferences, according to researchers four decades ago, are a social interaction indicator, a representation of social caste, class, and hierarchy, and a metaphor for establishing a culture's ethnicity and identity. Food also functions as a marker of identification for individuals and groups of people because it can transmit classes, community, and ethnicity.

## **1.1 The Culinary Triangle, Claude- Levi Strauss**

Claude-Levi Strauss (1908-2009), a French anthropologist, examined the eating habits of North and South American tribes in the twentieth century. He deduced that all societies had a three-phase classification system for food, with raw, cooked, and rotten being the most common. Levi-Strauss noticed that, just as each culture has its own language, each culture cooks its food in a unique way. He came up with the concept of "The Culinary Triangle" as a result of this.





**Figure 1.** Triangle

Source: <https://www.thesmartset.com/article07181301/>

Raw, cooked, and rotting are the three points of the triangle. When looking at the triangle with "raw" at the top, the other two points can be seen as the results of several procedures. The following is Levi-Strauss' explanation for the triangle:

- Raw food straddles the line between cultural and natural forms. This implies that it should be free of human interference and degradation. True raw food, for example, would be carrots grown on a farm before being washed or peeled for human consumption; cooked food, on the other hand, is raw food that has been processed by culture. Potatoes, for example, can be boiled before being used in a meal.
- Finally, rotting food is raw food that has been altered by natural processes. Fruits that have been stored for a long time, for example, may turn rotten and begin to degrade. If the triangle is turned on its side and the word "cooked" is placed at the top, the other two points can be interpreted as distinct categories of inedibility (Davis 2013).
- Levi-Strauss developed the culinary triangle not only as a classification of foodstuffs, but also as a means of cultural difference. Cooking, he claims, is the

primary difference between other animals and humans since animals eat raw food, whereas all human societies heat food in some way. Once a newborn has been weaned from their mother's milk, societal norms determine what is and is not acceptable to consume. As a result, Levi-Strauss claimed that each society's cuisine is similar to an unconscious language that structures individuals' daily life. Each culture places a premium on eating at a specific time, which foods are appropriate for which social occasions, and which animals are socially acceptable to eat. Many wild animals, such as snails, bats, and songbirds, are offered in Chinese restaurants. The majority of the rest of the world frowns on such eating habits. Due to the implementation and strengthening of numerous laws on eating wild animals, the recent COVID-19 epidemic played a significant effect in modifying the food choices of many Chinese people. As a result, Levi-Strauss underlined the importance of gastronomy in determining the culture of a civilization and vice versa.

### 1.2 McDonalization of Society

Society Has Been McDonalized The McDonalization of Society, written by George Ritzer in 1993, was the first book to establish the concept of McDonalization. Since then, the notion has been increasingly important in the area of sociology, particularly in the field of globalisation sociology. McDonalization of society is a phenomena that occurs when society, its institutions, and its organisations adopt the same qualities as fast-food restaurants. Efficiency, calculability, predictability and uniformity, and control are among them. Ritzer's McDonalization theory is an update on Max Weber's famous sociological theory of how scientific reason spawned bureaucracy, which became the fundamental organising force of contemporary society for much of the twentieth century. The modern bureaucracy, according to Weber, was characterised by hierarchical roles, compartmentalised information and duties, a perceived merit-based system of hiring and development, and the rule of law's legal-rationality authority. These qualities could (and still may) be seen in a wide range of communities around the world. Changes in science, economy, and culture, according to Ritzer, have changed nations away from Weber's bureaucracy and toward a new social structure and order known as McDonalization. This new economic and social order is defined by four important features, as he discusses in his book of the same name. 1. Efficiency is defined as a managerial focus on reducing the time it takes to accomplish individual jobs as well as the time it takes to complete the entire production and distribution process. 2. Calculability is defined as an emphasis on objective that can be measured (counting things) rather than subjective aims (evaluation of quality). 3. Predictability and standardisation can be seen in repeated and routinized production or service delivery

processes, as well as in the consistent output of same or nearly equal products or experiences (predictability of the consumer experience). 4. Finally, management wields control throughout McDonalization to ensure that workers appear and perform the same from moment to moment and day to day. It also refers to the employment of robotics and technology to lessen or eliminate the need for human employees. These traits, according to Ritzer, are not only visible in production, work, and the customer experience, but that their defining presence in these sectors has rippling effects across society. Our beliefs, interests, objectives, and worldviews, as well as our identities and social interactions, are all influenced by McDonalization. Furthermore, sociologists acknowledge that McDonalization is a global phenomena fueled by Western businesses, economic power, and cultural supremacy, and that it leads to a global uniformity of economic and social life.

### 1.3 Globalization and its Impact on Bodo Food Culture

Globalization has increased the pace with which people, goods, and services, capital, technologies, and cultural traditions are moved and exchanged around the world. Human nature is responsible for the global phenomenon. Globalization, according to some, began around 60,000 years ago, at the dawn of human history. Different civilizations have created commercial trade routes and experienced cultural exchanges throughout history. It has occurred throughout history, but especially after the second half of the twentieth century, when world trade sped to such an extent and at such rates that the term 'globalisation' became widely used. Globalization began long before European explorers set sail across the huge Atlantic Ocean on voyages that would eventually expose the existence

of the Americans— and even before the term "globalisation" was invented. 1 Globalization, according to Nayan Chanda, is a process that has been going on for millennia without being given a name. 2 Globalization is defined by the Oxford dictionary as "the process of developing or operating on a global scale." As a result of globalisation, a community or culture adopts the values, beliefs, and clothing of other civilizations, losing its identity in favour of a single globalized supra-culture. Globalization has had an impact on every community in the globe, and the Bodo community is one of them. The Bodos, like other groups around the world, have consciously or unknowingly participated in the Globalization process. There have been many changes in their culture since the early nineteenth century, and they are still happening today, and the impact of Globalization will be felt in the future. Globalization has had an impact on many Indigenous communities throughout the world. Furthermore, the Bodo is a transnational Indigenous community that has been impacted by globalisation. For a long time, we have witnessed the development of globalisation in many political, economic, cultural, and religious contexts. This effect or impact is now felt in Bodos as well. As a result, there is no way to stop globalisation in any way. Many different types of changes have occurred in many cultural communities around the world as a result of globalisation or the impact of globalisation, such as in their way of life, thought process, clothing, eating habits, religion, festivals, belief system, and many other aspects of their culture. As a result, they are transitioning into an other cultural dimension, and their original cultural identities are being lost. Many Indian cultural communities, including the Bodo, are knowingly or unknowingly accepting, following, or influenced by westernised culture, and they are attempting to blend into their ideologies by going hand

in hand or following the influential westernised thoughts, methods of thinking, and trying to blend into their ideologies. It would not be inaccurate to state that they are mixing their overall culture with other civilizations and on their way to developing a new globalised culture in which cultural variety is diminishing. They are gradually losing their pure cultural qualities, originality, and originalities under this environment. Many cultural communities have abandoned traditional cultural aspects of their societies. Because of the phenomenon of globalisation, significant changes have been noticed in the Bodo people in every aspect of their culture. These changes or repercussions of globalisation have primarily been observed since the 19th century, and they are altering Bodo people's thoughts, living styles, livelihoods, and all other aspects of their lives. This has an impact on their ability to transition their culture to a new one. As a result, their religious activities, such as festivals, rites, and rituals, are changing, with old traditional practises and rituals being abandoned or lost. Again, nowadays, it is fashionable to discuss modernism in social science. Modernity, on the other hand, cannot be defined by a single concept. Modernity can be viewed from a variety of angles. Modernity is defined as a way of life and a manner of experiencing a new way of existence. New beliefs have produced new habits and actions, which are referred to as modernity. The term "modernity" refers to the ability to think rationally. Progress, science, optimism, and universality are valued in modernity. Modernity entails a transformation of ideals and institutional structures. Changes in conceptions of space and time, as well as the speed with which information is exchanged, are referred to as modernity. Traditional views of society are discouraged in modern culture. Modernity entails increased production mechanisation, a transition from agricultural to industry, and an increase in

urbanisation. Industrialization and capitalism are associated with modernity. Modernity brought about changes in people's minds, societies, and cultures. It alludes to a progressive mindset. Furthermore, modernity attempts to ruin what we have and puts an element of uncertainty, risk, and confusion into our lives. The desire for absolute knowledge in science and technology, society and politics, and the concept that attaining knowledge of the true self was the essential foundation for all other knowledge and rationality are all connected with modernity. Modernity has a profound influence on social structures and cultural institutions all across the world. Traditions have been steadily weakened as a result of modernity. Modernity dealt the first blow to religion and religious customs.

#### **1.4 Commodification and Bodo Food**

Traditional meals are part of the Bodo people's cultural inheritance. Traditional food is a cultural product of ancestral labour that needs to be preserved, developed, and incorporated into the philosophy it represents. Traditional cuisines are being maintained so that they can always be enjoyed and meet the cultural demands of modern society. Traditional cuisine, on the other hand, is more complicated than modern cookery. The practise of eating traditional meals is declining as a result of people's changing consumption patterns. People nowadays prefer to eat fast food or other modern forms of meals in order to save time on cooking and consumption. As a result, commercialisation of traditional food has been ingrained in Bodo society. Local values can inspire local culture, which is born out of living values and gives life meaning. Culture is typically commodified with the goal of generating cash from a certain cultural feature, such as art, cuisine, heritage and archaeology, tourism, and so on. The Ethnic Bodo Cuisine is categorically chosen as a

study area in this research work to interpret the commodification of the culinary element of the Bodo Culture and to reflect how commodification is helping to enhance the community's distinct identity factor in the face of a dynamic and globalised world. Currently, in the case of Bodo ethnic cuisine, the issue of commodification of traditional food leading to commercialization and modernization is being investigated from the perspective of socio-economic empowerment and community well-being, which will result in commodification of the community's food culture as an important facet of cultural representation.

Prospects for commodification of ethnic foods will result in new sources of income not only for producers but also for active bearers of each ethnic community, which will have a positive long-term impact on the community's socio-economic growth and establishment as an empowered community pursuing progressive growth and as a distinct ethnic identity for society in general and the world at large.

## **2. Objectives of the Study**

The study is an attempt to examine the Commodification aspect of the Bodo Ethnic Food of Assam with particular respect to the Chariduar area of Sonitpur District of Assam. The following are the objectives of the study:

1. To find out how commodification of ethnic food can impact the Bodo Community of Assam and thereby representing its cultural identity as a whole.
2. To examine whether the change of food servings of the foresaid community has created an impact in the lifestyle of the new generation.

### 2.1 Research Questions

Keeping consonance with the objectives, the following research queries have been developed. The above research objectives are expected to meet by answering the following questions.

1. Defining the Commodification of Ethnic Food. How can these sale of the ethnic foods contribute to the social upliftment of the community?
2. Is there any change in the lifestyle of the new generation as a result of food commodification?

## 3. Research Methodology

### 3.1 Type of Research

The present study is both qualitative and quantitative in nature as it consists of both numerical values as well as case study. It is exploratory and descriptive too. The researcher has used both the primary and secondary sources of data. For the intended study qualitative data will be collected using –Interview method and Case Study. Face to Face Interview and Controlled Observation method will be used for quantitative data collection. The data is collected using unstructured interviews, survey schedules and by taking field notes.

For Secondary Sources the researcher has gone through Census Data 2011, read articles and books and gone through various journals, research papers, Government Records and magazines to get a detailed understanding of the arena of work.

### 3.2 Sampling Unit

The respondents will consist of population both male and female who are involved in the Commodification of Bodo ethnic food cuisines from all the selected six villages,

where the maximum number of Bodo residence is found.

### 3.2 Sampling Method

A purposive, convenient and stratified sampling technique is applied to select a total of 316 respondents as a sample size for the study as the interviewee with relevant knowledge may not be found everywhere or might not be willing to share their views.

The respondents are stratified into the following categories consisting of-

- Sellers
- Producers
- Individuals who are both Sellers and Producers.

### 3.3 Sample Size

According to the Census of India record 2011, the total population of Chariduar 343749, out of which male 176589 and female 167160. The total number of people residing in Rural area is 94.6% and the urban population consists of 5.4%. The total number of schedule tribes in the entire area is 50,996 out of which 25,695 are male and 25301 are female i.e. 14.8% consists Schedule Tribe out of the entire population.

The villages selected for the study:

1. Bakola Gaon has a population of 2366 out of which 669 are Schedule Tribes.
2. Amloga 1 has a population of 813 out of which 314 are Schedule Tribes.
3. Amloga 2 has a population of 769 out of which 666 are Schedule Tribes.
4. Chengelimari has a population of 594 out of which 173 are Schedule Tribes.

5. Chapaguri has a population of 692 out of which 264 are Schedule Tribes.
6. Jogi Basti has population of 485 out of which 258 are Schedule Tribes.

The Total Population is 5719, out of which 2344 consists of the schedule tribe. Among the 2344 schedule tribes, the Bodo population is 1758. The sample size is taken to be 316 keeping the confidence level 95% and margin of error to be 5%. So, as per the data the sample size is determined at 316 respondents.

#### 4. Discussion and Analysis

The study has been conducted under selected six(6) villages of the Chariduar area of Sonitpur district of Assam where Bodo population is found to be in majority and were commodification of Ethnic Food has seen to be on a large scale.

Out of the total sample size of 50 respondents, in this six monthly progress from the field report conducted, following observations have been made.:

In the study there are 6 numbers of villages have been selected and randomly survey has been conducted to collect the primary data related to ethnic food among the Bodo tribes in Assam. There are all total 50 (fifty) numbers of people has been surveyed from the locality and accordingly data analyses have been made.

**Table 1. Sample Villages**

Sl. No	Sample Villages	Sample Size
1	Bakola Gaon	7
2	Amloga No.2	10
3	Amloga No.1	8
4	Chapaguri	12
5	Jogi Basti	5
6	Chengelimari	8
	<b>Total =</b>	<b>50</b>

From the above table, it could be determined that from Chapaguri village, 12 respondents were selected for survey who are directly or indirectly associated with the commodification process followed by Amloga No. 2 with 10 respondents, Amolga No. 1 with 8 respondents, Chengelimari with 8 respondents and finally Jogi Basti with 5 respondents.

**Table 2. Respondents' gender type**

Sl. No.	Gender	Numbers	% Of Total
1	Female	23	46%
2	Male	27	54%
	<b>Total</b>	<b>50</b>	<b>100.00%</b>

From the above table, it could be seen that out of 50 respondents selected under the area of study, Female stands to 23 and Male stands to 27 in number, when it comes to the engagement in the commodification of the Bodo Ethnic Food.

**Table 3. Respondents' Age Group**

Sl No	Age Group	Sample Size	% of Total
1	Below 20 Years	7	14%
2	20 to 40 Years	22	44%
3	40 to 60 Years	15	30%
4	Above 60 Years	6	12%
	<b>Total =</b>	<b>50</b>	<b>100%</b>

From the above table, it could be inferred that more than half of the respondents are from the age-group of 20-40 years who are mostly the producing generation engaged in commodification of Bodo Ethnic Food, whereas the next highest respondents are from the age-group of 40-60 years and respondents from below 20 years of age not at a vast difference from the previous age-group and the respondents from above 60 years are the least persons who are involved in the process of Bodo Food Commodification under the selected area of study.

**Table 4.** Respondents commodification rank on selective ethnic food

Rank /Food	RiceBeer	Pork	Silkworm	Mushroom	Tekeli Pitha	Total
<b>1st Rank</b>	6	35	3	2	4	50
<b>2nd Rank</b>	37	5	0	0	8	50
<b>3rd Rank</b>	5	4	3	36	2	50
<b>4th Rank</b>	6	7	30	3	4	50
<b>5th Rank</b>	0	3	3	2	42	50

From the above table, it can be analyzed that from the selected six villages under the area of study, pork has the highest rate of commodification because of the high demand for consumption within the villages and arising of new cuisines with pork as the primary food item and ingredients in the local dishes, because of which its demand has reached out even to the nearby town area daily markets. Followed by pork, the second rank is held by the most popular local beverage, rice beer (traditionally known as Zumai), because of its traditional heritage as a local drink to be consumed mostly on occasions and festivities as well as welcome drink for their guests. A perfect example of commodification of Rice Beer was noticed from the field, where villagers from the selected villages under the area of study sell the rice beer in packed bottles in the local markets and food festivals organized by the Govt. of Assam, which led to a wider prevalence about its specialty amongst the Non-Bodo population as well. Third Place in the preference rank of the respondents for the selected Ethnic Food items is occupied by Tekeli Pitha, where its commodification in the past two- three years has increased manifold in the cities and towns during Bihu, Baisagu, and in the ethnic food festivals. Self Help Groups of the Bodo community has established a supply- chain in the towns and hotels. From the field report, it was enunciated that Silk Worm occupies the fourth preference when it comes to commodification of ethnic food, where it is commodified as food items in the local markets and ethnic food festivals. In case of Mushroom, it still infamous as a

commodified food items but its cultivation and popularity has steadily increased amongst the Bodo Population.

**Table 5.** Respondents response to marketing facility of food products

Sl. No.	Responses	Numbers	% Of Total
1	Agree	27	54%
2	Disagree	12	24%
3	Cannot Determine	11	22%
<b>Total =</b>		<b>50</b>	<b>100.00%</b>

When asked about whether there is any proper marketing or supply-chain management with regard to the popular ethnic foods under the area of study, it was known that 27 number of respondents agreed to having marketing the food products they produce for commodification, whereas 12disagreed to the same when asked. And around 11 respondents were not sure regarding what was asked and its status.

**Table 6.** Respondents' Responses to Food Commodification Culture as a source of Livelihood

Sl. No.	Responses	Numbers	% Of Total
1	Agree	36	72%
2	Disagree	6	12%
3	Cannot Determine	8	16%
<b>Total =</b>		<b>50</b>	<b>100.00%</b>

The above table represents the responses of the respondents with respect to Commodification of Food Culture as a source

of livelihood of their commodified ethnic foods were it was seen that out of the total of 50 respondents under the selected villages for study, 36 agreed, 6 disagreed and 8 said they cannot determine a proper answer to the question being asked or they could not understand the concept of food commodification as a source of livelihood at all.

## **5. Results of the Study**

Some of the impact and effect of Commodification of Ethnic Bodo Food on the Surveyed Areas are discussed below:

1. Under the surveyed areas of this research paper, the aspect of commodification of Bodo Ethnic Foods has brought to light the various vegetarian and non vegetarian foods of the Bodo Community, which will be useful in representing this community in the world stage with their unique customs and traditions.
2. The commodification of Bodo ethnic cuisine has inundated their local market places, contributing to the community's socioeconomic development and instilling in the youths an entrepreneurial spirit that would help them become financially stable.
3. The commodification of Bodo ethnic cuisines has aided in the economic upliftment of both male and female producers and merchants, empowering them to a large extent.
4. The Bodos' traditional dishes have their own distinct and identical taste and cultural representation. In this scenario, commercialization has allowed ample opportunity to sample the flavour of Bodo meals in general.
5. The need for the government to preserve, patent, and grow the ethnic food industry on a large scale is urgent, and there is plenty of opportunity to do so with the expansion of food processing industries and

the provision of patenting rights to ethnic foods so that they can be marketed in the country in particular and globally in the Asian/South East Asian market in general to generate revenue for the government and community empowerment in particular. This will allow for cross-cultural contacts, as well as contribute to peace and brotherhood among neighbouring countries.

## **6. Conclusion and Suggestions**

The Bodos' rich traditional culinary habits depict the society's socio-cultural aspect as a whole. The rising demand for traditional ethnic foods of the Bodos in local communities' markets as a result of commodification of ethnic food culture, as well as in Bodo ethnic festivals like the 'Dwijing festival,' which represents the ethnic identity of the Bodos, and the growing up of retail and commercial outlets and ethnic Bodo restaurants (albeit few in number) is acting as a boon for the community to establish its ethnic identity. Although the scope of this study is limited to a few Bodo villages in the Chariduar area of the Sonitpur district of Assam, India, the evidence presented here shows that the trend of commodification of Bodo foods, which eventually leads to commercialization, is increasing day by day, even though within the local and nearby markets of the study's focus areas, it can be inferred that the rise in commodification of these foods is accelerating. The government should increase seed capital with a low rate of interest for Bodo youths interested in commercialization of these ethnic foods, and food processing research of Bodo foods should be enhanced to scientifically determine the aspects for patenting so that these foods can be sold not only in Assam and other states of India, but also in foreign countries. Food chains have sprouted up in practically every aspect of the world's



countries as a result of Globalization and McDonalidization. Punjabi food, Gujarati food, Bengali food, and other Indian popular food chains have practically occupied many food restaurants abroad as a result of

Globalization. This is also conceivable for Ethnic Bodo cuisines with good planning and measures by the government at the correct moment, which is a must.

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## QUALITY ASSESSMENT OF ALID VOLCANIC ROCKS FOR THE POTENTIAL FERTILIZER APPLICATIONS

**Abstract:** Eritrea is one of the developing countries having a GDP that rely on agriculture. Though the agricultural industry is not well structured yet, the Ministry of Agriculture (MoA) assists farmers on a regular basis and provides them with all necessary utilities. Fertilizers are amongst them. However, the MoA is on the verge of prohibiting conventional fertilizers due to their adverse effects on soil, water and biological species. Nowadays, volcanic ashes have been applied as natural fertilizers in many parts of the world. Hence, on this study, the quality of Alid Volcanic Rocks (AVR) found in Eritrea were examined using an XRF study, and compared with earlier local baseline reports. Besides, a comparison with other international sites was also considered for the potential use of fertilizers. Statistical studies in association with simple linear and polynomial model of AVR compositions showed that P<sub>2</sub>O<sub>5</sub> serves as a useful means of evaluating other components of AVR samples with improved R<sup>2</sup> values. The study also revealed that AVR composed of higher Si/Al of 5.52 and Fe of 4.943% help in soil fertilizing and conditioning. Furthermore, the studied samples possess greater K/P values of 17 on average and thus serve as a potassium supplement to the plants. In addition, cations (K, Na, Ca, Mg) concentrations are higher than many of the other sites in the world and it is vital to note that the AVR serve as a good soil enhancer.

**Keywords:** Alid Volcanic Rocks, Volcanic Ash Fertilizer, Quality of Volcanic Rocks, Statistical Model Construction, Mineral Compositions of Volcanic Rocks

### 1. Introduction

The rise in world population has driven the improved food with increased rates of production in the recent decades and consequently posed the threat of infertile and degraded soil. Soils contribute significantly in life cycle of many essential nutrients that directly or indirectly support biological species on earth. Unfortunately, climate crisis in the form of global warming, loss of

biodiversity and improperly organized land use practices have put the soils into more risk. From the 18 essential plant nutrients 15 are supplied by a healthy soil. Nevertheless, one third of soils worldwide are already degraded and the loss of soil fertility resulted in the production cereals, vegetables and fruits with reduced content of vitamins and nutrients as they were 70 years ago. (FAO Report, 2022).

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Eritrea is a country virtually bisected by a branch of the east African rift valley. It has a fertile land to the west, descending to desert in the east making it a semi desert land. The highlands of the country have a temperate climate throughout the year while the climate of most of the lowlands are; arid and semi-arid causing the distribution of rainfall and vegetation types of the country to vary markedly throughout the year (Wikipedia, 2022). Since Eritrea is a developing country the agricultural industry is not well structured yet. The country's agricultural input is mostly dependent on local farmers and seasonal rainfall. Ministry of agriculture (MOA) is responsible to provide the farmers with all the necessary utilities such as fertilizers, equipment and livestock. The Government of Eritrea considers the development of agriculture as one of the prospering projects in the country, this project focused on finding an effective fertilizer in terms of providing prominent nutrients necessary for the plant growth and economic viability for the ample supply.

Fertilizers hold vital role in countries where the economy depends on local agricultural products. Though the conventional chemical fertilizers proven to be more effective in terms of productivity, with time, these have noticed to be disadvantageous as they caused many different problems such as soil, water, air pollutions and biomagnification issues as well. On top of this, the microorganisms in the soil have vanished because of the chemicals present in the fertilizers. In response, Eritrean government has put efforts on facilitating farmers with necessary utilities to achieve potential growth in agricultural sector. As a part of that, the MOA has recently prohibited using conventional fertilizer and started to find an ecofriendly substitute for them.

Alid volcanic area center, Eritrea, lies along the axis of the Danakil Depression, the graben trace of a crustal spreading center that radiates north-northwest from a plate-

tectonic triple junction within a complexly rifted and faulted basaltic lowland called the Afar Triangle. Alid has long been recognized as a potential geothermal resource of electrical grade because it is the focus of geologically young rhyolitic volcanism within a background of spreading-related basaltic volcanism and it is the site of many fumaroles (Michael A. et al, 2005). The Danakil Depression is a subaerial segment of the spreading system that is opening to form the Red Sea. Crustal spreading along the axis of the Red Sea is transferred to spreading along the Danakil segment in a right-stepping echelon pattern. The Danakil segment shows increased opening southeastward to the Afar triple junction (Michael A. et al, 2005).

Rock minerals are essential for plant growth, but not all rocks are the same. Basalts; which are igneous rocks from volcanos, have the highest mineral content (Rosaria et al, 2022). This means that they provide the biggest benefit for a soil. Volcanic rock dust is a great organic supplement to prepare a super soil. Volcanic rocks tend to break down faster than other rocks and its higher quartz content makes it more accessible to plant, at a faster rate (Claudeta GR. et al, 2017). For this reason, it is no coincidence that civilizations have been setting near volcanoes for thousands of years. Some of the most fertile soil in all the world can be found at the base of active volcanoes. These igneous rocks are full of beneficial minerals. Coming from the center of the earth, the minerals work well for aiding plant growth.

Volcanic activities push igneous rocks out of the earth and onto the surface where they broke down by plant roots. Because these rocks have not been worn down or weathered on the surface before this point, their trace elements and micro-nutrients have not leached out. This means that powdered volcanic rock can be an ideal fertilizer. Once added to a soil, volcanic rock tends to break down faster than other forms of rock. With a

higher quartz content, it makes more of it accessible to plants more quickly.

Volcanic ash contains both magmatic and non-magmatic minerals and has two major effects on the human eco-system, one on soil and the other on climate [El-Desoky et al 2018]. Primary use of volcanic ash as a soil enricher have been studied by several researchers (Rosaria et al 2022, Lalita V. et al 2022, Damasus et al 2022, El-Desoky et al 2018, Nitisapto et al 2018, Claudette GR et al 2016, B. Langmann et al 2010, Marta et al 2006, Marta AV et al 2006, Sadao et al 1975). One research illustrates that volcanic ash is a multi-nutrient mineral fertilizer that replenishes the trace metals necessary to soil bacterial enzymes for the efficient biogeochemical cycling of key elements such as N, C, K, P and S, ensuring use of relatively small amounts to fertilize large soil surfaces. The experimental results showed that the seeds growing in the stimulated soil created with two different compositions of volcanic ash had higher germination rates, higher growth rates, and produced plants that were healthier in appearance than the soil made from peat mixed with quartz sand (Rosaria et al., 2022).

A field trail conducted in Cairo, Egypt suggested that cation exchange capacity of infertile soils may possibly be boosted by using volcanic ashes. In addition, volcanic rocks are considered as a source of soil fertility due to their moderately fast rate of releasing their contained nutrients (El-Doseky et al., 2018). Another study done in Indonesia which is a country susceptible to volcanic eruptions, observed the volcanic ash's feasibility to be used as vegetable planting media, especially for curly lettuce, based on the improvement of physical and chemical volcanic ash characteristics with charcoal husk (so as to reduce its hardening property when exposed to water) (Nitisapto et al., 2018). While a 1975 research on volcanic ash's chemical composition indicated the

presence of the important elements vital to plant growth (Sadao et al 1975), another one supported by a field experiment confirmed that the potato yield increased by 31-63% relative to the background, 47% on average.

Fulfilling the key principle of the emerging circular economy to reuse materials previously considered waste, the use of readily available and overabundant volcanic ash as agricultural fertilizer is a significant economic opportunity for both farmers and populations living nearby active volcanoes, affording also important environmental advantages. Providing a unified picture, this study will hopefully accelerate such progress.

## 2. Materials and Methods

### 2.1. Volcanic Rock Sample and their Preparation

A volcanic rock sample of 20 cm diameter, which has a weight of 3.75 kg collected from Alid volcanic area and brought to a construction laboratory, Mai-Nefhi College of Engineering and Technology (MCOETEC) for further size reduction. Part of the rock approximated to 100g separated by breaking, packed in a polyethylene bag and sent to Bisha Assay laboratory for elemental analysis. The remaining rock was crushed by an automatic compression strength device until an ash that is 75 $\mu$ m sieve size was obtained.

### 2.2. Characterization of Volcanic Rock

The CS230 Carbon/Sulfur Determinate is a microprocessor based, software driven instrument for measurement of carbon and sulfur content in metals, ores, ceramics, and other inorganic materials. The CS230 uses an induction furnace and measures carbon and sulfur by infrared absorption. Analysis begins by weighing out a sample (1 g

nominal) into a ceramic crucible on a balance. Accelerator material is added, the crucible is placed on the loading pedestal, and the analyze key is pressed. Furnace closure is performed automatically, and then the combustion chamber is purged with oxygen to drive off residual atmospheric gases. After purging, oxygen flow through the system is restored and the induction furnace is turned on. The inductive elements of the sample and accelerator couple with the high frequency field of the furnace. The pure oxygen environment and the heat generated by this coupling cause the sample to combust. During combustion, carbon bearing elements are reduced, releasing the carbon, which immediately binds with the oxygen to form CO and CO<sub>2</sub>, the majority being CO<sub>2</sub>. Also, sulfur-bearing elements are reduced, releasing sulfur, which binds with oxygen to form SO<sub>2</sub>. Sample gases are swept into the carrier stream. Sulfur is measured as sulfur dioxide in the first IR cell. A small amount of carbon monoxide is converted to carbon dioxide in the catalytic heater assembly; SO<sub>2</sub> is converted to SO<sub>3</sub>, while sulfur trioxide is removed from the system in a cellulose filter.

The detailed chemical elements including trace components were determined using an Inductively Coupled plasma- optical emission spectroscopy (ICP-OES). ICP-OES is an analytical technique that can be used to measure elements at trace level. Its principle relies on those excited atoms releasing light at specific wavelength as they transition to a lower energy level. Generally, each sample was a 0.25g weighed accurately using a 4-decimal-place analytical balance and placed in a 20ml digestive test tube. The samples were initially digested with concentrated HNO<sub>3</sub> (2mL) at 85 0 C water bath for around 15min. 7mL HCl was added to dissolve most of the base metals present in the samples and the mixture was heated at 85 0 C for 45min.

The mixture is allowed to cool to keep hygroscopic nature of elements might present in the mixture. The resulting mixture was diluted suitably with ultrapure deionized water to a total volume of 20mL. Samples are then shaken and transferred to ICP-OES for instrumental analysis.

### 2.3. Stastical Evaluation of Alid Volcanic Rock Composition

The variance among different sample locations were estimated using one-way ANOVA study performed on Microsoft EXCEL®. Statistical Mean values were also determined for the chemical compounds presented in the volcanic rock samples. Arithmetic mean or average were estimated by (Kothari C.R, 2004)

$$\bar{X} = \frac{\sum X_i}{n} = \frac{X_1 + X_2 + X_3 \dots + X_n}{n}$$

And standard deviation ( $\sigma$ ) or variance is given by;

$$\sigma = \sqrt{\frac{\sum(X_i - \bar{X})^2}{n}}$$

Karl Pearson's coefficient of correlations evaluated between the Alid volcanic rock compositions to understand the dependence of one on the other variables. The degree of correlation between two populations can be analyzed using the Pearson correlation coefficient, which is expressed in the following Equation [Sunyong et al., 2002).

$$r = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum(X_i - \bar{X})^2} \sqrt{\sum(Y_i - \bar{Y})^2}}$$

In addition, data regression analysis was carried out in POLYMATH® to assess the functional relations among the variables. Determination of relationship between two or more variables is known as regression. A simple regression applied to obtain potential linear equation such as  $Y = a + bX$  of all dependent variables ( $Y$ ) by considering a low variant component as an independent variable ( $X$ ). Regressions equations obtained from the analysis evaluated based on

coefficient of multiple determinations ( $R^2$ ), which is a comprehensive parameter to understand the precision of the relation usually dwells in the range of  $0 < R^2 < 1$  and it is given by [Abdul.R.S et al 2013]

$$R^2 = 1 - \frac{\sum_{i=1}^n (Y_i - \bar{Y})^2}{\sum_{i=1}^n (X_i - \bar{X})^2}$$

Further, linear polynomial fitting applied for the better predictions of some special cases.

### 3. Results and Discussion

#### 3.1. Volcanic Rock Composition and Their Correlations

Alid volcanic place is a 700 m tall mountain in Eritrea, and it is 7 km x 5 km structural dome and doming was assumed that due to the intrusion of relatively low density silicic magma into the upper crust. In addition to major chemical analysis of volcanic ash rocks performed in this study, a summarized report by Clynne et al. 2005 provide more detailed elemental analysis of approximately 40 different kind of volcanic rock samples in Alid region. Average values of different components of all tested samples are compared against many other reported samples from Alid area (Clynne et al., 2005) as shown in Tables 1 & 2, to understand the variations among the chemical compositions in addition to the petrography.

Statisticians usually adopt the following method for a better study, suggested by H.A. Sturges (Kothari C. R., 2004), determining the minimum size of the group ( $i$ ) in terms of range ( $R$ ) and number of samples ( $N$ ) for a better analysis.

$$i = \frac{R}{(1 + 3.3 \log N)}$$

The rounded values of minimum size of the component groups for SiO<sub>2</sub> (6), Al<sub>2</sub>O<sub>3</sub> (3), Fe (3), MgO (2), CaO (3), Na<sub>2</sub>O (1), K<sub>2</sub>O (1), TiO<sub>2</sub> (1) and P<sub>2</sub>O<sub>5</sub> (1) were determined as shown in Table 2, thus group size of 9 different components with a sample count of 10 in each case considered for better understanding of the statistical parameters such as their range, mean and variances, estimated using One-way ANOVA study as shown in Table 2. The sum of average values of 9 selected compounds is estimated as more than 96 % of the total rock composition, majorly dominated by SiO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub>. The P content in the form of P<sub>2</sub>O<sub>5</sub> is smaller than the other 8 components and it is also noticed that it has a low variance and thus it could be a better independent candidate for the comparative study between the group variables. Since the F values of the groups higher than the critical and P values are too smaller than 0.05 between the groups as shown in Table 3, the study considered as a significant statistical analysis.

**Table 1.** Elemental Composition of Alid Volcanic Rock Samples (Clynne et al. 2005)

Components (%)	This work	ES96-10	ES96-8	EC96-43	EC96-25	ED96-6	EC96-31	ED96-11
SiO <sub>2</sub>	73.45	73.37	71.93	73.14	73.63	51.81	51.53	50.8
Al <sub>2</sub> O <sub>3</sub>	6.24	13.95	13.8	13.33	13.2	15.81	16.78	15.09
Fe	2.14	1.88	3.25	2.57	2.47	11.07	10.75	11.03
MgO	0.24	0.19	0.14	0.18	0.16	5.76	4.75	6.88
CaO	0.976	0.7	1.21	0.95	0.98	9.88	10.15	10.05
Na <sub>2</sub> O	NA	4.68	4.83	4.77	4.54	2.87	2.95	2.82
K <sub>2</sub> O	0.966	4.71	4.4	4.73	4.69	0.75	0.96	1.04
TiO <sub>2</sub>	0.5	0.41	0.28	0.23	0.23	1.53	1.6	1.71
P <sub>2</sub> O <sub>5</sub>	0.06	0.06	0.05	0.04	0.04	0.34	0.35	0.37
MnO	596(ppm)	0.05	0.12	0.07	0.06	0.18	0.18	0.19

**Table 2.** Range, Mean and Variance values of Alid Volcanic Rock Compositions

Components	Minimum Size of the Group ( <i>i</i> )	Values (weight %)				
		Minimum	Maximum	Interval	Average	Variance
SiO <sub>2</sub>	5.31	50.8	73.63	22.83	66.657	111.426
Al <sub>2</sub> O <sub>3</sub>	2.45	6.24	16.78	10.54	12.068	17.407
Fe	2.13	1.88	11.07	9.19	4.943	17.326
MgO	1.57	0.14	6.88	6.74	1.878	7.566
CaO	2.19	0.70	10.15	9.45	3.685	19.169
Na <sub>2</sub> O	0.47	2.82	4.83	2.01	3.921	0.640
K <sub>2</sub> O	0.92	0.75	4.73	3.98	2.418	3.646
TiO <sub>2</sub>	0.14	0.23	1.71	1.48	0.614	0.490
P <sub>2</sub> O <sub>5</sub>	0.08	0.04	0.37	0.33	0.143	0.021

**Table 3.** Results of ANOVA Study

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	36209.62	8	4526.203	229.2479	2.62E-52	2.054882
Within Groups	1599.24	81	19.7437			

**3.2. Correlations of Chemical Compounds in Alid Volcanic Rock Samples**

Pearson’s coefficient of correlations among the group variables are evaluated as shown in Table 3. The range of coefficients is in between -1 and 1. Further, positive and negative values are considered as proportional or inverse relations between the parameters. The linearity of the relationship depends on closeness of the coefficients to -1 or 1. As the approaches to zero, they depart highly from the linearity. It is lucid from the Table 3, the SiO<sub>2</sub> an inverse relations with all parameters except with Na<sub>2</sub>O and K<sub>2</sub>O. In most of the cases, Al<sub>2</sub>O<sub>3</sub> and K<sub>2</sub>O components are poorly associated with each other and even with other populations. CaO and MgO possessed similar kind of relations with other components while P<sub>2</sub>O<sub>5</sub> holds better linearity with others than any other component in the group.

Different mathematical models as shown in Table 4. constructed in POLYMATH® for the better prediction of Alid volcanic rock compositions by treating P<sub>2</sub>O<sub>5</sub> as an independent component. P<sub>2</sub>O<sub>5</sub> has a positive linearity with SiO<sub>2</sub>, Fe, MgO, CaO, and

TiO<sub>2</sub> except Na<sub>2</sub>O with high R<sup>2</sup> values whereas Al<sub>2</sub>O<sub>3</sub> and K<sub>2</sub>O adjudged to a 3rd order polynomial equations. Further these models may help in determining the composition of volcanic rocks with relatively high precision if only P<sub>2</sub>O<sub>5</sub> composition is given.

Experimental values are compared with model predictions for all components as depicted by the Figures 1(a) to 1(h) and their relevance measured by R<sup>2</sup> values provided in the Table 5. Sadaoe et al has correlated SiO<sub>2</sub> with other volcanic rock compositions and confirmed that it has a very poor linearity with K<sub>2</sub>O, TiO<sub>2</sub> and MnO with R<sup>2</sup> values of 0.351, 0.546, and 0.571 respectively, whereas in the present study, all the predicted models possess higher R<sup>2</sup> values of minimum 0.644 and hence P<sub>2</sub>O<sub>5</sub> serves as a useful means of predicting all other components of Alid volcanic rock samples.

**3.3. Comparison of Alid Volcanic Rock with Other Reported Samples**

Volcanic rock contains many different minerals and they are varied greatly and in



general, silica and alumina represented the major components in all volcanic rock samples compared in the Table 6. Moreover, volcanic rocks are classified in to basaltic (45-53.5%), andesitic (53.5-62%), dacitic (62-70%) and rhyolitic (70-100%) based on the SiO<sub>2</sub> content and thus based on the average composition, most of the Alid samples belongs to deictic family. The composition of Alid samples also observed as more relevant with Shibecha site samples of Japan (Sadae et al, 2012) except K<sub>2</sub>O which found significantly higher in Alid

samples.

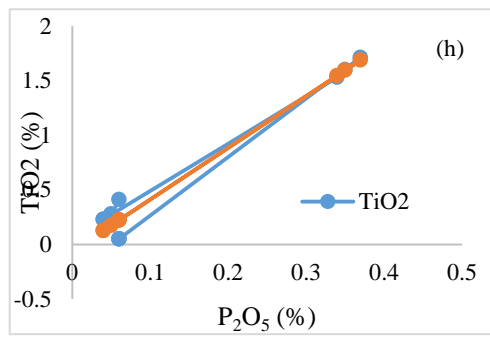
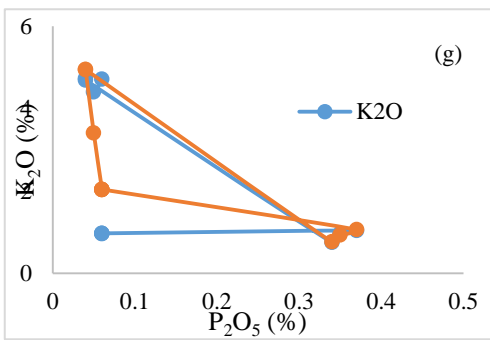
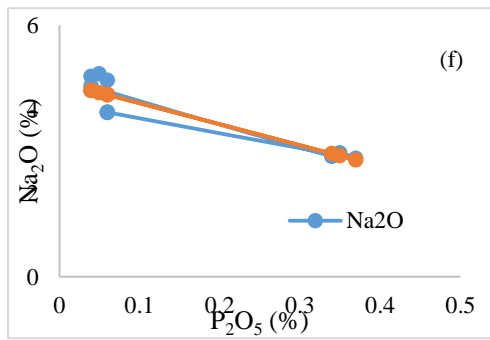
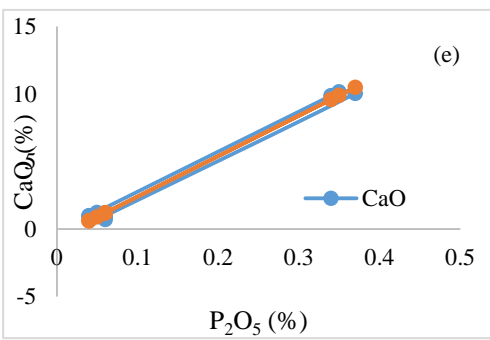
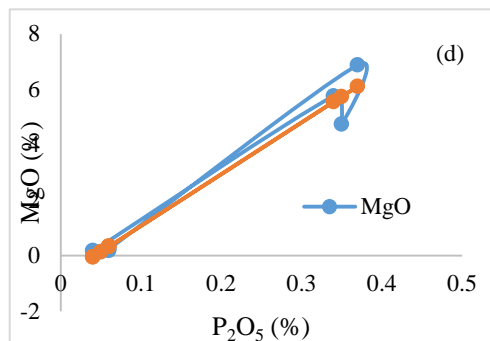
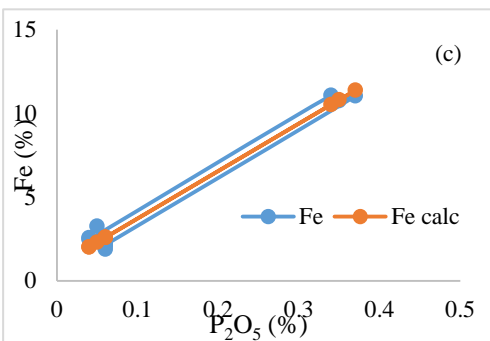
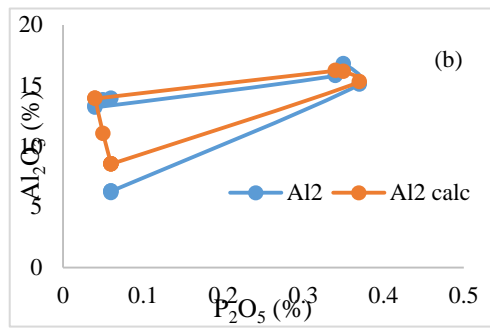
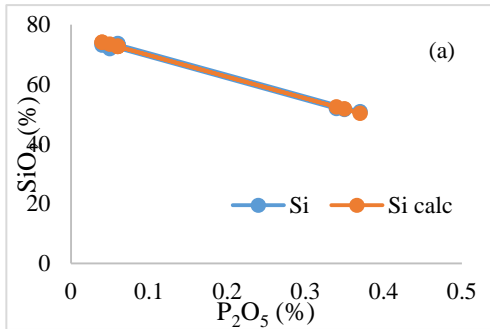
Despite of greater K/P values, Alid volcanic samples noted of higher silica and higher Si/Al ratio of 5.5 than other sites except Mount Kelud East Java of Indonesia. From another comparison with volcanic rock samples of Papandayan Mountain of Egypt (El-Desokey et al., 2018), K<sub>2</sub>O, TiO<sub>2</sub> and P<sub>2</sub>O<sub>5</sub> compositions are identified as very close to the Alid mountain samples of Eritrea.

**Table 4.** Results of Pearson Correlation Between Chemical Components of Alid Volcanic Rocks

	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe	MgO	CaO	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>
SiO <sub>2</sub>	1	-0.645	-0.998	-0.985	-0.999	0.886	0.528	-0.987	-0.997
Al <sub>2</sub> O <sub>3</sub>	-0.645	1	0.661	0.596	0.6315	-0.232	0.298	0.736	0.601
Fe	-0.998	0.661	1	0.981	0.995	-0.87	-0.507	0.981	0.988
MgO	-0.985	0.596	0.981	1	0.982	-0.894	-0.541	0.973	0.987
CaO	-0.999	0.631	0.997	0.982	1	-0.896	-0.544	0.983	0.997
Na <sub>2</sub> O	0.886	-0.232	-0.872	-0.894	-0.896	1	0.844	-0.821	-0.911
K <sub>2</sub> O	0.528	0.298	-0.51	-0.54	-0.544	0.844	1	-0.408	-0.571
TiO <sub>2</sub>	-0.987	0.736	0.983	0.973	0.983	-0.821	-0.408	1	0.982
P <sub>2</sub> O <sub>5</sub>	-0.997	0.601	0.99	0.987	0.997	-0.911	-0.571	0.982	1

**Table 5.** Mathematical equations proposed for the prediction of Alid volcanic rock compositions

S.No	Proposed Model	R <sup>2</sup>	RMSD
1	$SiO_2 = 0.939424 + 4.726157P_2O_5$	0.9936	0.2530
2	$Al_2O_3 = 29.9955 - 498.4847P_2O_5 + 2560.29P_2O_5^2 - 3568.616P_2O_5^3$	0.6534	0.7369
3	$Fe = 0.8914884 + 28.33225 P_2O_5$	0.9812	0.1711
4	$MgO = -0.7899129 + 18.65673 P_2O_5$	0.9744	0.1321
5	$CaO = -0.603387 + 29.98872P_2O_5$	0.9936	0.1051
6	$Na_2O = 4.637936 - 5.013535P_2O_5$	0.8310	0.0987
7	$K_2O = 12.9333 - 239.0302P_2O_5 + 1033.459P_2O_5^2 - 1281.53 P_2O_5^3$	0.6440	0.3417
8	$TiO_2 = -0.0618609 + 4.7263 P_2O_5$	0.9644	0.0396



El-Doseky also pointed that high alumina content and low Si/Al ratio (less than 4) such as the sample cases of Kuchinash, Bibi and Hatano sites in Japan (Sadaoe et al., 2012) are considered as a hydrophilic soil conditioner. In the same study when they

compared volcanic ash with soil, cations (K, Na, Ca, Mg) concentrations were high and since the current study contain similar concentrations of rock it is vital to say that Alid volcanic rocks are good soil enhancers.

**Table 6.** Comparison of Eritrean Volcanic Rocks with Others

Chemical Components	Eritrean volcanic Rock (Sample of Alid area)	(Sample of Mount Kelud East Java) [S.Hardinata et al. 2015]	(Sample of Mountain Papandayan) [El-Desokey et al. 2018]	[Sadaoe et al. 2012]			
				Pumice Sample of Shibecha	Pumice Sample of Kuchinash	Scoria Sample of Bibi	Scoria Sample of Hatano
SiO <sub>2</sub>	66.657	34.270	48.00	69.66	61.85	54.29	51.71
Al <sub>2</sub> O <sub>3</sub>	12.068	1.000	14.00	13.81	16.19	19.46	16.65
Fe	4.943	0.057	9.05	4.28	6.80	8.67	11.73
MgO	1.878	0.120	1.13	1.03	2.56	3.67	5.11
CaO	3.685	3.260	1.50	4.31	6.63	8.67	9.07
Na <sub>2</sub> O	3.921		3.24	4.08	3.12	2.61	2.89
K <sub>2</sub> O	2.418	0.120	2.45	0.61	1.21	0.57	0.84
TiO <sub>2</sub>	0.614		0.63	0.64	0.56	0.69	1.19
P <sub>2</sub> O <sub>5</sub>	0.143		0.13	-	-	-	-
MnO	0.106			0.14	0.14	0.14	0.17
C	0.260	0.430		-	-	-	-
S	0.120			-	-	-	-
Cu	0.020			-	-	-	-
Zn	0.020			-	-	-	-

### 3.4. Potential of Alid Volcanic Rocks for Fertilizer Application

The results of this study on the availability of micronutrients and macronutrients showed a suitable potential for the application of volcanic rock as a natural fertilizer. These volcanic rock released several nutrients from the solid structure to the acidic solutions as shown in Table 6. It is relevant to emphasize on some of the components which imparts greater benefits to be used as potential natural fertilizer. For instance, though Si is not conventionally considered as an essential element, it has proven to have a positive influence in plant growth and yield, in particular under stressful environments and enhances plant

resistance to fungal and bacterial diseases and insect pest damage conditions (Rosaria et al., 2022; T. Balakhnina, A. Borkowska, 2013). Thus, the Si content from this study shows that the Eritrean volcanic rock sample has a great potential for fertilizing and conditioning damaged soil bodies.

A study by A.I. El-Desoky et al, in 2018 revealed the immediate relevance of essential elements like Ca, Mg and K which are found in CaO, MgO, and K<sub>2</sub>O respectively to agriculture by using Indonesia's Papandayan volcano to fertilize potato tuber. In line with this study, the considerable amount of these compounds in Eritrean volcanic rock sample would make it a potential substitution for conventional

fertilizer. Fe which is a micronutrient plants constitutes 4.943% of the volcanic rock sample is an average if we compare it with a different study (S. Hardinata et al. 2015; El-Desokey et al., 2018; Sadaoe et al. 2012). However, it is sufficient enough to aid a plant to synthesize chlorophyll and accepting and donate electrons as part of the electron transport chains of photosynthesis and respiration. However, the Na in the form of Na<sub>2</sub>O causes sodicity (excess salinity of soils), detrimentally affect plants (MAFRD, 2022). On the other hand, the low concentrations of potentially toxic elements such as As (< 100 ppm), Pb (< 0.02 %), Cd (< 10 ppm), and Li (18 ppm), among others, do not represent environmental risk to soil bodies or the ambient environment itself.

The results of analysis by LECO method (CSA06V), and ICP-OES demonstrates that the volcanic rock sample was characterized by a series of macronutrients and micronutrients described in this study. These facts have proved that this volcanic rock powder will be a promising natural organic fertilizer for application in agriculture.

#### 4. Conclusion

Volcanic ashes in the world have been applied as potential fertilizer in many parts of the world. In the context of that volcanic rock samples from Alid area of Eritrea are examined using an XRF study. One-way ANOVA study performed among nine (SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Fe, MaO, CaO, Na<sub>2</sub>O, K<sub>2</sub>O, TiO<sub>2</sub> and P<sub>2</sub>O<sub>5</sub>) significant components of samples tested. Range, Mean and Variances were compared and P<sub>2</sub>O<sub>5</sub> compositions recognized with a less variance of 0.0212 while SiO<sub>2</sub> possess highest deviation of 111.43. In addition, mineral compositions of

samples correlated using Pearson's coefficients and found P<sub>2</sub>O<sub>5</sub> positively hold a linear relationship with most of the components except Al<sub>2</sub>O<sub>3</sub> and K<sub>2</sub>O. Therefore, composition of P<sub>2</sub>O<sub>5</sub> considered as an independent variable and model equations developed for the prediction of other variables using linear and polynomial regressions. Statistical comprehensive parameter R<sup>2</sup> estimated for all models is better than the earlier proposed model (Sadaoe et al., 2012) and thus P<sub>2</sub>O<sub>5</sub> serves as a useful means of predicting all other components of Alid volcanic rock samples than SiO<sub>2</sub>. Despite of greater K/P values, Alid volcanic samples noted of higher silica and higher Si/Al ratio of 5.5. Though Si is not conventionally considered as an essential element, it has proven to have a positive influence in plant growth and yield, in particular under stressful environments and enhances plant resistance to fungal and bacterial diseases and insect pest damage conditions. Cations (K, Na, Ca, Mg) concentrations are higher than many other sites in the world and it is vital to note that the Alid volcanic rocks are good soil enhancers. In response to the adverse effects of using chemical fertilizers, MoA of Eritrea is trying to prohibit them and in search of finding a better substitute to boost agriculture in the country. Hence the present study could make the relevant researchers or local officials to understand the quality of local volcanic sources and potential of using Alid volcanic rocks as a natural fertilizer.

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## **SIMULATION AND PARAMETRIC STUDY OF ETHANOL DISTILLATION PLANT FOR ASMARA BREWERY**

**Abstract:** Globally ethanol has a key role in food and beverage industry with a substantial contribution of 17% of its total production. As the young nation Eritrea started to grow, the demand of alcoholic drinks such as AREQI, GINN, COGNAC etc., and the need of change in terms of production scale besides the purity of ethanol have become inevitable in the Asmara Brewery company. Consequently, a preliminary study performed on the development of a new ethanol distillation plant with a capacity 6500 lit/day to replace the currently existing and inefficient bubble cap column of 2000 lit/day. Atmospheric (ADS) and multi pressure distillation system (MPDS) for ethanol separation of 96.4 % (volume) purity using locally available fermented wine must of 7 % (volume) alcohol are evaluated in Aspen HYSYS®, an industrial plant simulation tool. The effect of changing feed location, number of stages, and minimum reflux ratio for ADS and MPDS studied primarily by adopting shortcut column models. However, a three column-ADS recorded with 30% excess energy consumption than MPDS that permits first column to operate at 10 kPa and the other two columns at atmospheric conditions. Further, a facility adopted in MPDS to recover 68% of energy from the condensers has reduced the specific energy consumption to a currently competitive levels of 2.4 kWh per liter of ethanol from 7.01 kWh/lit without any energy recovery.

**Keywords:** Ethanol Rectification, Multi-Pressure Distillation System, Beverage Alcohol, Process Simulation, Aspen HYSYS®

### **1. Introduction**

Ethanol is a simple liquid alcohol that formed from the fermentation of sugars in their natural occurrences or by the conversion of starch and lignocellulosic substances. Ethanol used as disinfectant, an organic solvent, a chemical feedstock, transportation fuel and a beverage (Hoang and Nghiem 2021). Ethanol production has

grown about 33% globally, over the last 10 years due to its significant role as renewable fuel to mitigate the climate change issues levitated from the combustion of fossil fuels. The unprecedented spread of COVID-19 has triggered the demand of ethanol to the lower bounds for fuel applications while increasing consumption in beverages to the peak, disinfectant and personal care and the trend expected to continue for 2 to 3 years. Ethanol beverages earlier considered a

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premium offering and now slowly turned into an essential product found in the majority of the households globally despite of the fact that the alcohol consumption causes the damage of liver, an important organ that helps in removal of toxins from the human body. In 2019, the sales of premium alcoholic beverages grew at a rate of 5 to 6%. However, fuel ethanol has driven down the global ethanol market size from 110 billion liters to 98.6 billion liters in 2020 due to the pandemic (Hoang and Nghiem, 2021) but it was anticipated to register a compound annual growth rate (CAGR) of 4.8% from 2020 to 2027 (Market Report, 2022).

Alcoholic beverages classified into beers, wines and spirits, which are distilled beverages such as whisky, rum, gin, vodka etc. Distilled alcoholic beverages contains 40-60 % (vol) of ethanol and produced using distilled ethanol from the fermentation of grains, fruits and vegetables. During the fermentation process, the yeast *S. cerevisiae* produces the enzyme invertase and uses it to convert sucrose to glucose and fructose and subsequently converted to ethanol and carbon dioxide. The maximum theoretical yield of ethanol is 0.511g per 1g of glucose; however, the actual yield is always lower as entire glucose cannot be converted to ethanol (Hoang and Nghiem, 2021). Many other investigators have studied on the production of ethanol using various raw materials (Pramanik and Rao, 2005). Singh and Jain (1995) studied on the production of ethanol by batch fermentation of cane molasses. Green and Shelef (1989) used municipal solid waste in ethanol production while agricultural waste was tried by Schugerl (1994). The fruit wastes like papaya (Akin-Osanaiye et al., 2008), mangoes (Reddy and Reddy, 2007), banana peels (Joshi et al., 2001), pineapple and grapes (Pramanik and Rao, 2005; Asli, 2010) were used in the production of ethanol. Depending upon the various attributes such as cultivar, stage of

ripening of fruits, chemical composition of juice, use of additives to the must, vinification techniques and ageing of wine, the alcohol and sugar content, the wines are classified as natural wines (9-14 % alcohol) and dessert and appetizer wines (15-21 % alcohol).

Distillation column is one of the prominent devices in the process industry, it uses difference in relative volatility to separate two or more components. Today, the distillation columns widely used in chemical industries are tray towers and packed towers (Tarikh Azis et al.2019). Ethanol has the most outstanding role in the liquor industries as it is the main component. In connection, there are different types of distillation systems like atmospheric and multi-pressure distillations practiced for optimization of energy consumption. In multi-pressure distillation system (MPDS) the energy requirement is less when compared to atmospheric distillation (ADS) whereas the water required for cooling is higher in ADS than in MPDS. (Nilesh PP, Vilas S.P,2016).

Advanced System for Process Engineering (ASPEN) is one of the virtual simulation software used to simulate the chemical processes. A generalized computer procedure for individual trays and complex tray columns yields the optimum design for the tray parameters, has a desirable degree of operating flexibility, and allows accurate estimation of performance. In this study Aspen HYSYS® is used in particular to develop a model and simulate the atmospheric as well as the multi pressure distillation columns. Design of distillation columns is always challenging because of their high energy inputs, which must be optimized through finding the best operating variables such as feed composition, feed stage location, number of stages in the column and actual reflux ratio. Therefore, it is necessary to study and determine the various parameters that can affect the distillation column for the optimal ethanol



production, with high purity and less energy consumptions while protecting environment. For this study, the case of Asmara Breweries has been considered as it plans to expand its existing capacity of alcohol production unit. It started way above half a century ago in Asmara Brewery (originally known as MELOTTI Beer Factory), the production of ethanol has started as one of the main products and since then it has been filling the demand in liquor production as its main objective to produce AREQI, GINN, and COGNAC. However, now a day the distillation has been facing many problems such as low capacity and less efficiencies. In the context of that, the requirement for better efficiency and higher capacity are in greater demand as ever (personal communication). The existing bubble cap column has a capacity of 2000 lit.day at Asmara Brewery company, but the demand is discovered to be much higher in the survey done recently by the company and it was estimated about 5000lit/day.

## 2. Methodology

### 2.1. Feedstock selection and its composition

Currently Asmara Brewery doesn't have any specific feed in their plan. As the country produces wine from locally cultivated grapes in Anseba region of Eritrea for this study, a wine based fermented broth is proposed as the feed for the ethanol rectification process. Based on the information provided by the Hagaz Wine Factory, Eritrea, the fermented broth presumed as a binary solution of 7%(vol) ethanol and 93% of water.

### 2.2. Process Development

The grapes are first collected from the vineyard and washed before sent to the juice extractor. The sugar contained in the pulp of grape comprised of fructose & glucose.

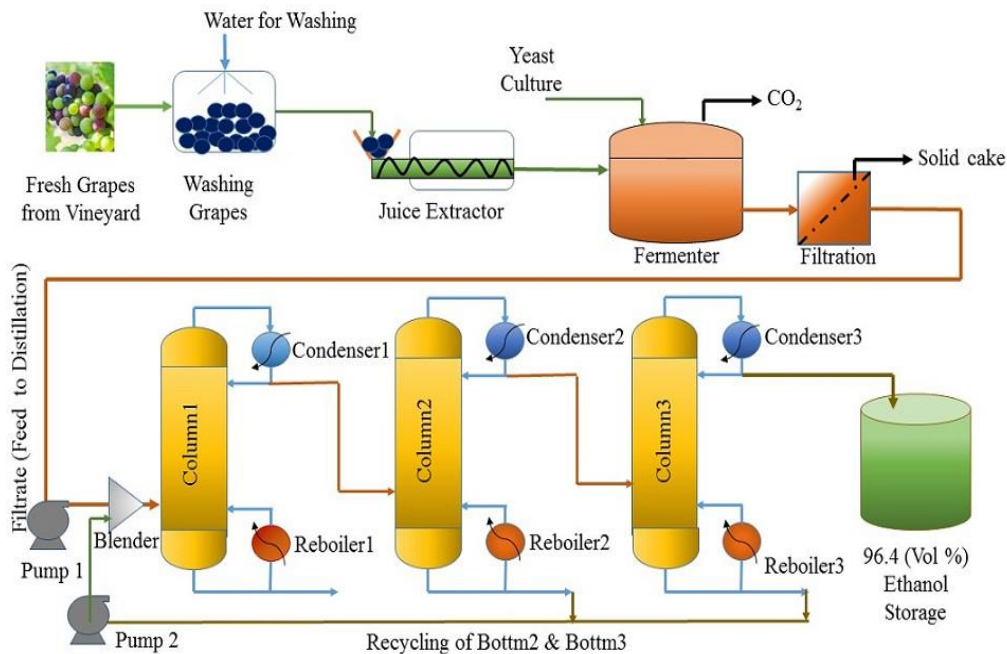
During fermentation, enzymes from yeast convert the sugars into ethyl alcohol and carbon dioxide. The fermentation temperature begins about 20°C, but temperature may rise to 30°C to 32°C. Yeast ceases to work if the temperature rises above approximately 35°C. From fermentation tank, a fermented broth that contains 7% of alcohol is filtered and centrifuged before it is fed to the distillation column. After a series of three consecutive distillation columns, 6500 liters of 96.45% beverage grade alcohol can be obtained from the 3<sup>rd</sup> column as showed in figure 1. The bottoms of the 2<sup>nd</sup> and 3<sup>rd</sup> columns contain appreciable amounts of alcohol which must be recycled through a blender along with fresh feed to the first column.

### 2.3. HYSYS® Simulation of Ethanol Rectification Plant

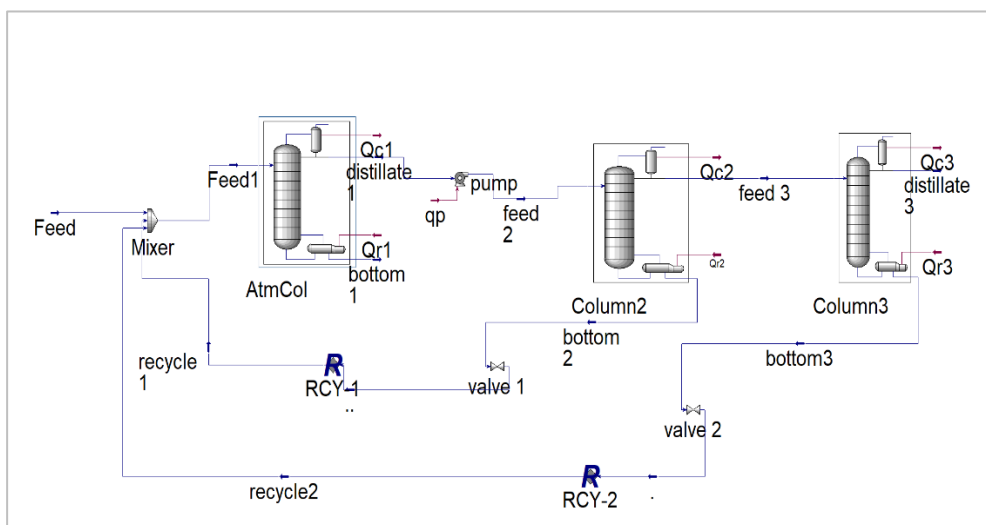
Aspen HYSYS® (or simply HYSYS) is a chemical process simulator currently maintained by Aspen Technology, Inc., USA, used to model chemical processes, from unit operations to complete chemical plants and refineries. HYSYS is able to perform many of the core calculations of chemical engineering, including those concerned with mass balance, energy balance, vapor-liquid equilibrium, heat transfer, mass transfer, chemical kinetics, fractionation, and pressure drop. HYSYS, V8.8 is used extensively in industry and academia for steady-state and dynamic simulation, process design, performance modelling, and optimization. As a primary step in a new case, Ethanol (C<sub>2</sub>H<sub>5</sub>OH) and Water (H<sub>2</sub>O) added as Conventional Components. The choice of appropriate thermodynamic model and the accuracy of parameters are crucial for the reliability of design. The Non-random Two-Liquid (NRTL) model equation of state for thermophysical properties has been selected as fluid package (base method) in Aspen HYSYS®

steady-state simulation. NRTL model is generally suggested for highly non-ideal chemical systems and can be used for both

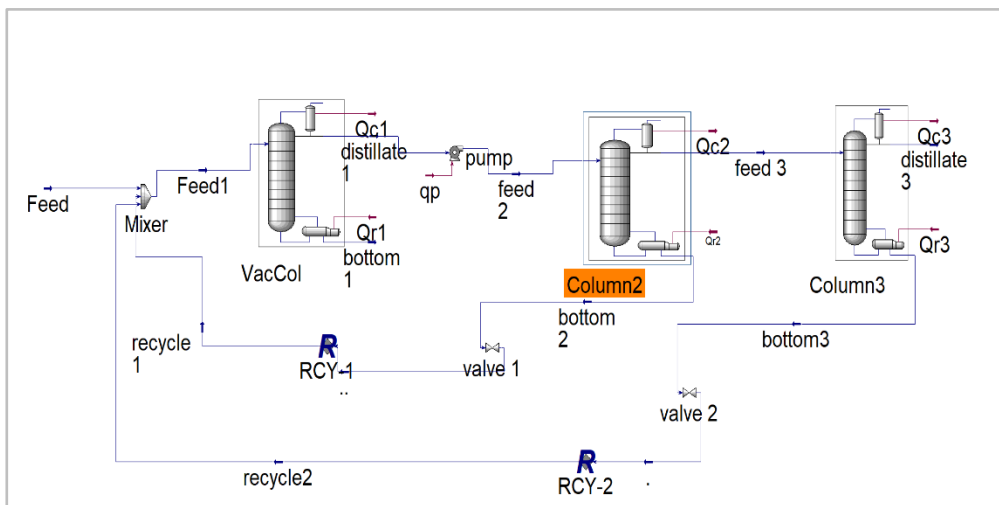
VLE and LLE applications (Syed AT et al) 2016).



**Figure 1.** Schematic Process flow diagram for Ethanol Rectification from wine based fermented broth



**Figure 2.** Steady state simulation model for atmospheric ethanol rectification in HYSYS®



**Figure 3.** Steady state simulation model for vacuum separation of ethanol in HYSYS®

**Table 1.** HYSYS models used in simulation.

Unit	HYSYS® model	Purpose
VAC COL or ATM COL	Rigorous Distillation Column	Separation of Ethanol from Water
Column2	Rigorous Distillation Column	Separation of Ethanol from Water
Column3	Rigorous Distillation Column	Separation of Ethanol from Water
Pump	Pump	To elevate the pressure of the feed to Column2
Mixer	Mixer	To blend the recycle streams with fresh feed
Valve1, Valve2	Control Valve	To reduce the pressure of the recycle streams
Distillation column	Short cut Distillation	To evaluate minimum reflux ratio and minimum number of trays

**Table 2.** Operating Conditions Distillation Columns

Units	Number of stages	Feed stage	Molar composition of Distillate	Top pressure (kPa)	Bottom pressure (kPa)
Atm Col	11	7	0.78	101.3	106.4
Vac Col	11	7	0.78	5	10
Column 2	12	8	0.85	101.3	106.4
Column 3	15	11	0.8945	101.3	106.4

As ethanol-water, system forms azeotropes at atmospheric pressure, vapor-liquid equilibria (VLE) study of a binary system of ethanol-water studied at different column operating pressures to identify their

azeotropic compositions prior to proceed for further steady state simulation. Later, a steady state simulation of ethanol rectification developed for an atmospheric column or a vacuum column coupled with

two more additional atmospheric columns using the models mentioned in the Table 1 at different operating conditions as shown in Figure 2 and Figure 3 according to the specifications provided in Table 2. In addition, a pump and two valves included in the process to compensate the stream pressures to the specific column conditions.

Simulation studies performed on model to minimize the specific energy demand for the desired product composition through univariate approach. A shortcut column design approach utilized to decide number of stages and minimum reflux ratio required for the specific product composition in each column model applied in the study. Later effective variables such as feed composition in terms of alcohol content ranging from 5 to 10 % (by volume), feed stage location varied in between 6<sup>th</sup> to 12<sup>th</sup> stages and a range of operating reflux ratios 1.1 to 1.5R<sub>min</sub> have been applied to optimize the minimum energy requirement per liter of 96.4%(vol) ethanol.

### 3. Results and Discussion

#### 3.1. Equilibrium study of Ethanol-Water System

The separation of ethanol-water, a binary system studied in terms of its equilibrium conditions. For the phases to be in equilibrium, essential criteria are their temperature, pressure and fugacities of all the components in both the phases must be same. The T-x-y diagram of the binary solution of ethanol and water at atmospheric pressure of 101.3kPa has showed an azeotropic composition of 88.34 % (mol) at a minimum boiling point of 77.88°C as displayed in figure 4, whereas the minimum boiling point of azeotropic composition for a vacuum pressure of 10 kPa has upgraded to 90.16% (mol) while lowering the temperature to 29.42°C as depicted by figure 5. In other words, under atmospheric

pressure ethanol-water system forms an azeotrope at 89.4% (mol) of ethanol at 78.4°C provided by the previous reports (K.V Narayanan,2009), which was slightly deviated from the current study as it depends on selected thermodynamic property method. VLE study of ethanol-water system has revealed that the vacuum operation at 10 kPa facilitate the desired composition of beverage grade alcohol with 89.45% (mol) of ethanol.

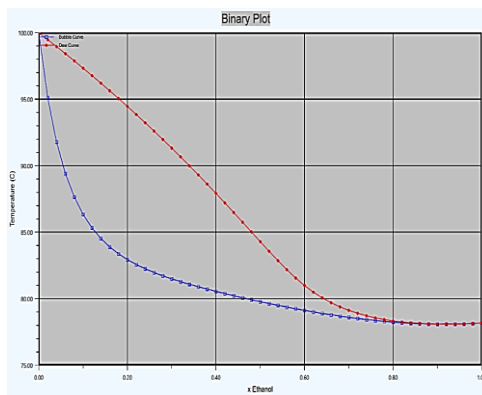


Figure 4. VLE diagram at 101.3 kPa

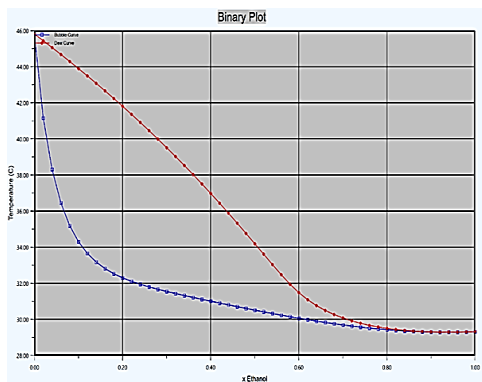


Figure 5. VLE diagram at 10 kPa

#### 3.2. Atmospheric Distillation versus Multi-Pressure Distillation

The optimum conditions such as feed location, number of stages, and minimum reflux ratio for atmospheric distillation

systems to achieve the desired composition of ethanol as shown in table 3 studied by using a shortcut column in HYSYS® prior to

the development of atmospheric separation model.

**Table 3.** Atmospheric distillation operating conditions

Column	$R_{min}$	$R_{actual}$	Number of stages	Feed location	Heat required by Reboilers (kW)	Heat removed in Condensers (kW)
Atm Col	2.231	2.97	11	7	1766	1768
Column 2	1.937	2.63	12	8	518.6	515.2
Column 3	4.794	6.7	16	13	414.4	401.2

**Table 4.** Multi pressure distillation operating conditions

Column	$R_{min}$	$R_{actual}$	Number of stages	Feed location	Heat required by Reboiler (kW)	Heat removed in Condenser (kW)
Vac Col	1.596	2.23	11	7	1026	1033
Column 2	1.947	2.63	12	8	486.5	439.2
Column 3	4.912	6.8	15	11	402.6	402.2

**Table 5.** Effect of Reflux Ratio on Distillate Composition

Operating Reflux Ratio	Molar Composition of Distillate		
	Column 1	Column 2	Column 3
$1.1R_{min}$	0.7862	0.8548	0.8926
$1.2R_{min}$	0.7898	0.8568	0.8936
$1.3R_{min}$	0.793	0.8587	0.8943
$1.4R_{min}$	0.793	0.8594	0.8945
$1.5R_{min}$	0.793	0.8594	0.8945

Atmospheric distillation model applied for the production of ethanol from fermented wash in a distillery. In this process all the columns set to operate at atmospheric pressures. Reboilers of each column supplied with saturated steam of 1 atm pressure to meet its heat requirement. The vapor coming out from the top of each column get condensed in a condenser facilitated with cooling water supply. Since the current study not focused on heat integration, the energy consumption in the process noticed as quite high. In this study three consecutive columns used to operate at atmospheric pressure as shown in figure 4 to achieve the desired composition of distillate. The first

atmospheric column set to recover 78% (mol) ethanol from a fresh must of 7% alcohol, which has noticed with an energy consumption of 1312 kW per 207.2 kmol/h of feed at 25°C of operating temperature. Actual reflux ratios of all columns fixed at  $1.38R_{min}$  which is within the acceptable limits of reflux ratio ranging from 1.1 to 1.5  $R_{min}$  for the commercial operations (Coulson and Richardson, 2004).

Multi-pressure distillation is a latest technique employed in the ethanol production. The energy consumption in this process is quite low compared to that of atmospheric distillation process (Patil et al 2016). In this study three columns applied

with the first one operating at vacuum pressures of 10 kPa and 5kPa at the top and bottoms respectively while the others set at atmospheric conditions. In addition, all three

columns are specified at the operating reflux ratios of 1.38 $R_{min}$ .

**Table 6.** Effect of feed composition on distillate

Feed composition (volume %)	Distillate Composition (mole fraction)		
	Column 1	Column 2	Column 3
5%	0.76	0.85	0.892
6%	0.76	0.85	0.8924
7%	0.78	0.856	0.8935
8%	0.78	0.855	0.8935
9%	0.78	0.855	0.8935
10%	0.79	0.858	0.894

**Table 7.** Effect of feed stage on Ethanol composition

Feed Location	Column 1	Column 2	Column 3
6	0.791	0.8558	0.8912
7	0.793	0.8593	0.8923
8	0.793	0.8594	0.8932
9	0.793	0.8594	0.8941
10	0.793	0.8594	0.8943
11	0.793	0.8594	0.8945
12	0.793	0.8594	0.8945

To achieve a distillate composition similar to that obtained from ADS, MPDS utilized about 40.93% less energy. Further, the effect of change in reflux ratio on distillate compositions in each column has noted as shown in table 5. The corresponding distillate compositions have altered in each separation column while actual reflux varied between 1.1 $R_{min}$  to 1.4 $R_{min}$  and remained static thereafter.

### 3.3. Effect of feed composition on distillate

The intention of this sensitivity analysis is to analyze the performance of the distillation column at different feed composition. Since the fermentation may yield different amount of concentration ranging from (5%-10%), the distillation should perform with consistency. And the required amount of yield using different concentration is about

96.4 (v/v) % because the potable alcohol should be up to the maximum possible purity and beyond that ethanol and water shows azeotropic property. And at the expense of extensive energy the desired amount of composition can be achieved. As per the required purity of the alcohol by the Asmara Brewery company, this work focused on achieving the result of above 6000 lit/day at 7% feed composition. However, the change in feed composition from 7 to 9% of alcohol hasn't shown any effective variation in the products from all three columns. Further, a minute alteration noted corresponding to a feed composition that contains 10% of alcohol.

### 3.4. Feed location and its impact on product composition

The feed tray position of the distillation

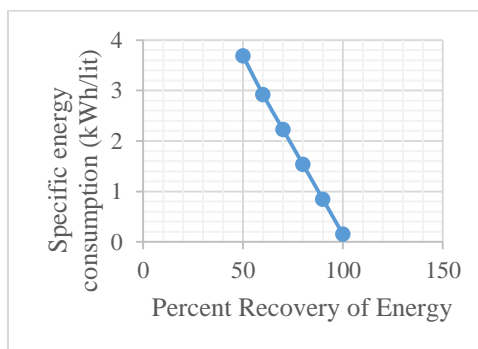
column was varied from 6 to 8 for the first column, from 7 to 9 for the second, from 10 to 12 for the last column, by keeping all other parameters constant. As shown in table 7, when the feeding of the column was altered from 6 to 7 stages, an increasing of recovery of ethanol of 0.20 % (mol) was obtained for the first column while the feed stage of the column 2 altered from 6 to 8 stages shown an increase of recovery of 0.42% (mol) ethanol. Further, the feeding of column 3 was altered from 6<sup>th</sup> to 11<sup>th</sup> stages resulting an increase of 0.33 % (mol) ethanol recovery.

### 3.5. Specific Energy Consumption and The effect of Energy Recovery in MPDS

The production of ethanol of 96.4% (vol) purity at a rate of 4.779 kmol/hr subjecting 38 stages comprising of all three columns in MPDS system measured with a specific energy consumption of 7.017 kWh/litre for a feed flow rate of 207.2 kmol/hr that contains 7 % (mol) of alcohol. Further, distillation process is always energy intensive which makes it more challenging for commercial adaption. However, implementation of innovative technologies to recover partially the energy spent on distillation will support the system in commercial way. Diverting Process water to condensers as cooling media prior to its conversion into steam in the reboilers will decrease the energy demand by the boilers.

In other words, the selection of suitable design for better heat transfer in condensers and in reboilers will improve the heat transfer area and helps in dissipation of energy in a better way. Applications of advanced thermodynamic cycles such as ORC (Organic Rankine cycle) for the conversion of waste heat recovery into electricity would support the system for economical operation. As it is depicted by the figure 6, energy savings and reduction in

specific energy consumptions assessed at various energy recovery schemes. If the plant is assumed at least 50% recovery of energy from the condensers, the specific energy reduces to 3.6 kWh per liter of ethanol. In other words, if the plant is designed to recover about 68%, it will achieve an energy consumption of 2.4kWh per liter.



**Figure 6.** Specific energy consumption versus percent recovery of energy

## 4. Conclusion

Ethanol production has grown about 33% globally, over the last 10 years due to its significant role as renewable fuel to mitigate the climate change issues levitated from the combustion of fossil fuels. In Asmara Brewery company the existing bubble cup column with a capacity of 2000lit/day is not meeting the demand discovered by the recent market study organized by the company and it was estimated about 5000lit/day to produce alcoholic beverages such as AREQI, GINN, COGNAC etc., Therefore, in this work, an ethanol separation plant with a capacity of 4.779 kmol/hr of 96.4% (vol) purity developed in Aspen HYSYS® simulation tool. An Atmospheric distillation system and a multi-pressure distillation system were compared and found that MPDS has saved the specific energy of 40.93%. Minimum reflux ratios of 1.596,

1.947 and 4.912 were determined for first, second and third distillation columns of totally 38 stages in MPDS system. An actual reflux ratio of 1.38R<sub>min</sub> found that as an optimum operating conditions in all three columns to achieve the desired distillate composition. Further, suggested that if the MPDS provided with 68 % of waste heat energy recovery from the condenser, it could meet a globally competitive specific

electricity requirement of 2.4 kWh per liter of ethanol production.

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## QUALITATIVE AND QUANTITATIVE EVALUATION ON PERFORMANCE OF LOCAL HOPS (GESHO) IN BEER PRODUCTION

**Abstract:** *Rhamnus prinoides* (Gesho) is a medicinal plant practiced as a bittering agent in the preparation of local alcoholic beverage known as 'Suwa' in Eritrea. Due to lack of scientific analysis application of Gesho constrained to limited areas and no earlier reports available on quantity of bittering agents, essential oils, and antioxidants of this plant. Therefore, the objective of this research is set to assess the Gesho plant and determine the bitterness, essential oils, and antioxidants. Leaves and stems of the Gesho plant were taken separately for the experimental study. Results revealed that leaves of local hops contains 16.54% total resins, 10.615% soft resins, 5.925% hard resins. Further, 3.37mg/l of alpha acids, 2.26 mg/l iso-alpha acids, 3.93 mg/l beta acids, 7.74% (weight) essential oils, 24% (weight) flavonoids, and 2.3 mg/l polyphenols were measured in the leaves. Stems of local Hops have shown relatively poor results and approximately a 10% drop observed in all contents compared to leaves. Leaves of *R. prinoides* are found as a good source of bittering agents, essential oils, antioxidants and meeting the requirements on comparing with contents of currently used imported Hops in Beer Production. Moreover, *R. prinoides* is economically favorable substitute for commercial hops used in the breweries, and Gesho leaves acts as a bittering agent, source of aroma and flavor, and also antioxidant for beer and other alcoholic beverages.

**Keywords:** *Rhamnus prinoides* (Gesho), Local Hops, Titrimetry of Gesho, Beer production, Qualitative analysis of Gesho

### 1. Introduction

Beer is the most consumed alcoholic beverage in the world, and is the most popular beverage behind water and tea (Nelson, 2005). Most often beer is produced from malted barley, hops, yeast, and water, yet simple changes in the formulation has created 25,000 to 35,000 varieties of beer worldwide. It is produced by the brewing and fermentation of starches, mainly derived from cereal grains—most commonly from malted barley, though wheat, maize (corn),

rice, and oats are also used. During the brewing process, fermentation of the starch sugars in the wort produces ethanol and carbonation in the resulting beer (Wikipedia). Beer is measured and assessed by bitterness, by strength and by colour. The perceived bitterness is measured by the International Bitterness Units scale (IBU), defined in co-operation between the American Society of Brewing Chemists and the European Brewery Convention.

Hops are known to be one of the most essential and characteristic ingredients in

beer production as they make several contributions to the final product. Hop plant has been in a continuous use for centuries or even a millennium mostly as an ingredient of beer, although some of its medicinal properties have been known as well. Hops are used in beer brewing to impart both its distinct aroma and bitter taste (Kovačević and Kač, 2002). It is also used as bacteriostatic activity to inhibit the growth of most microorganisms (Simpson and Smith, 1992). Beer that is made from hops or hop products of certain breeding varieties, varies considerably in the nature of bitterness, taste and aroma. This is due to the peculiarity of the biochemical composition of bitter substances, polyphenolic compounds and essential oil of hop of aromatic and bitter varieties (Lidia Protsenko 2017). There are currently many varieties of hops, but they can be divided into bittering hops [that is, those with high bitter acids, humulone, cohumulone, lupulone, and colupulone (Ting and Goldstein, 1996)] and finishing or aroma-giving hops (Hornsey, 1999). Finishing hops are generally added to the wort at the end of the boiling process (last 1-2 min) to provide volatile aroma components to the beer (Papazian, 2003). Most modern beer is brewed with hops, which add bitterness and other flavours and act as a natural preservative and stabilizing agent. Other flavouring agents such as gruit, herbs, or fruits may be included or used instead of hops (Wikipedia). After the introduction of hops into England from Flanders in the 15th century, "ale" referred to an unhopped fermented drink, "beer" being used to describe a brew with an infusion of hops. Thus, there are different types of drinks worldwide today, such as real ale, pale ale, stout, mild ale and wheat beer. The strength of beer is usually around 4 to 6% alcohol by volume (Ebneht and Theuvesn, 2005).

There are two fundamental limits to any history of beer brewing. First, the unambiguous definition of its object, namely

beer. A consideration of hopped beer only would be too selective, and would ignore the fundamental roots of brewing technology and beer culture. The dissemination of European/American beer culture all over the world and the recent trend towards globalization generates new variants of beer-like beverages that follow regional and traditions preferences. A second difficulty arises from the availability and reliability of resources. In the world there are five top hop producing countries in. Although Eritrea is not one of the top growing countries in the world, but because it can be grown within most places the imported hops can be easily replaced with our own local hop.

Nowadays, beer is produced in Eritrea with imported hop as bittering agent. Since it is imported, it creates a pressure on its foreign currency. *Rhamnusprinoïdes* (Gesho) is a cultivated indigenous shrub which is also known to occur far west as Cameroon and as far south as South Africa, Eritrea and Ethiopia. It has a potential use as a commercial hopping agent in the beer industry. The leaves and stems of this plant are essential ingredients in the traditional fermented Ethiopian beverages, local beer. In Eritrea, the plant parts are used to impart the characteristic bitter flavor for the traditional beverage and it was estimated that over 5 million people consume these beverages every day. However, the role of this plant in the fermentation process of beer or beer production is not clearly established. Gesho is a new potential substitute for imported hops which can be used as an alternative substrate and also raise economic benefits through import substitution. With the continued increase in Eritrea and western African population great emphasis has been placed throughout the region on increasing the production of beer, improving their nutritional qualities. Thus, this project mainly focused on scientific analysis of Gesho plant leaves and stems for understanding its aptness to substitute

imported hops in local beer production industries and in other traditional beverages.

## 1.1. Gesho (*Rhamnusprinoides*) Plant

*Rhamnusprinoides*, the shiny-leaf buckthorn, is an African shrub or small tree in the family *Rhamnaceae*. Commonly referred to as "gesho". It was first scientifically described by French botanist Charles Louis L'Héritier de Brutelle in 1789. *Rhamnusprinoides* occur from Eritrea to South Africa at medium to high altitudes. They grow near streams or along forest margins. The small edible fruits are shiny red and berry-like. It is commonly known as dark blinkblaar, dogwood, and shiny leaf. *R. prinoides* is a dense shrub or small tree which grows up to 6 meters tall. It is one of the two species that represent the genus *Rhamnus* and a widespread plant species in Africa. *R. prinoides* occurs in regions with altitudinal range of 1,400-3,200 m and annual rainfall of 750-2,000 mm. The plant is native to Ethiopia, Eritrea, Botswana, Namibia, Lesotho, Swaziland, South Africa, and Uganda and also exotic to Kenya. It also occurs in Cameroon, Sudan, Angola, and Arabia (Abebe WN et al 2021).

## 2. Materials and Methods

### 2.1. Sample Collection, Preparation and Extraction

The sample used in this study is *Rhamnusprinoides* which was collected from Asmara. The other samples like Barley malts, yeast and water used for brewing which were already produced as wort liquor, collected from the brewing house of the Asmara Brewery factory [ABF]. The fresh plant leaves and stems were harvested from a small garden (vegetation) area and scattered in a wide open area for drying. Drying was done in two phases, initially the moisture of

freshly harvested sample of Gesho leaves measured of 75 -80%. In the first phase, the gesho was left for drying under direct sun light for 2-3 days covered with cambric in order to free the gesho from dusts and other particulate matter. In the second phase, drying performed in an open air protected system for the direct exposure to sunlight for five days to attain a moisture content of 10.4%. The dried materials are ground using a portable coffee grinder. Later, gesho plant samples powdered into a size of 0.75 mm and subjected to extraction (Abebe WN et al 2021).

As methanol dissolves a broader range of hop components and represents a suitable solvent for the extraction of polyphenols, compounds with structural phenolic features, which can be associated with different organic acids and carbohydrates, 90% methanol used to obtain gesho leaf and stem extracts for further analysis. 5% [w/v] of dried gesho stem sample measured as 5g of sample mixed in 100ml of 90% ethanol solution, was taken in extracting funnel and extraction carried out by vigorous shaking for 5hrs and then filtered. The filtrates [extract] show in in the figure 1 were concentrated in a rotary evaporator and the dried crude extracts analyzed further for the presence of phytochemicals following the tests provided in table 1 (Abebe WN et al 2021).



**Figure 1.** Gesho stem(left) and leaf(right) extracts

## **2.2. Qualitative Analysis of Phytochemicals of Rhamnusprinoide's leaves and stems**

Leaves and stems of the Gesho plant containing phytochemicals, which are chemical substances or nutrients derived from plant sources such as alkaloids, saponins, tannins, sterols & triterpenes, phenols, flavonoids & flavones and resins and their functions are explained as follows, Saponins are also referred to selectively as triterpene glycosides, are bitter-tasting that have foamy nature when agitated in water whereas tannins are a class of mild astringent, polyphenolic biomolecules that bind to and precipitate proteins and various other organic compounds including amino acids and alkaloids. In addition to the alpha acids extracted from hops to provide bitterness in beer, condensed tannins are also present. These originate both from malt and hops. In addition, phenols are carboxylic acid is an aromatic organic compound, polyphenols are a large family of naturally occurring organic compounds characterized by multiples of phenol units. Further, alkaloids are a class of basic, naturally occurring organic compounds that contain at least one nitrogen atom. This group also includes some related compounds with neutral and even weakly acidic properties. Additionally, resin is a solid or highly viscous substance of plant or synthetic origin that is typically convertible into polymers. Most plant resins are composed of terpenes, particularly specific components such as alpha-pinene, beta-pinene. Flavonoids and Flavones are a class of polyphenolic secondary metabolites found in plants, and thus commonly consumed in diets. Moreover, the presence of phytochemical components in Gesho stems and leave extracts determined using qualitative tests as shown in table 1.

## **2.3. Detection of bittering agent in Rhamnus Prinoide's samples by Quantitative Analysis**

Extraction of well vented and dried samples of Gesho was performed by soaking in 97% ethanol or methanol as an extracting agent and the aqueous extract prepared as follows. 40g of powdered sample was soaked in aqueous solution of 70 ml methanol and 100 ml water (70 % v/v) then filled in a funnel extractor. The extract was macerated for three days with continual shaking and then filtered using whatman No. 1 filter paper. Filtered extract dried in a water bath evaporator until constant dryness achieved and stored in refrigerator for further analysis following the methods provided in the table 2.

In general, Alpha acids ( $\alpha$  acids) are a class of chemical compounds primarily of importance to the production of beer. They are found in the resin glands of the flowers of the hop plant and are the source of hop bitterness. The alpha acid "rating" on hops indicates the amount of alpha acid as a percentage of total weight of the hop. Hops with a higher alpha acid content will contribute more bitterness than a lower alpha acid hop when using the same amount of hops. High alpha acid varieties of hops are more efficient for producing highly bitter beers. Further, Iso-alpha acids are isomerization form of alpha acid. Iso-alpha acids (iso- $\alpha$ -acids) are typically produced in beer from the addition of hops to the boiling wort. The degree of isomerization and the amount of bitter flavor produced by the addition of hops is highly dependent on the length of time the hops are boiled. Longer boil times will result in isomerization of more alpha acids and thus increased bitterness. But, in case of our local hop (Gesho plant) these iso-alpha acids can be present naturally before isomerization reaction occurs.

**Table 1.** Qualitative testing methods for the detection of phytochemicals in Gesho stem and leaf extracts

Phytochemical Component	Detection Test	Reference
Saponins	0.5g of the sample extract was dissolved in 5ml of distilled water and the mixture was poured in a beaker and shaken for five minutes. If stable frothing occurs on the top of the solution, it is proved that saponins are present	Teklit GA 2015
Tannins	0.5 g of the sample extract was dissolved in 2 ml of distilled water and the solution was filtered using a whatman no-1 filter paper. Ferric chloride was added 2 drops to the filtrate. Finally, if a blue-black precipitate occurs, it indicates the presence of tannins in the plant extract	Teklit GA 2015
Phenols	1mg of sample was taken in a test tube and was added to 2ml of distilled water and then few drops of 10% aqueous ferric chloride. Finally, formation of blue or green colour indicate the presence of phenols	Abebe WN et al 2021
Resins	2mg of plant extract was dissolved in 5 to 10 ml of acetic anhydride by gentle heating. After cooling, 0.5 ml of sulfuric acid was added. Bright purple colour produced indicated the presence of resins	Teklit GA 2015
Alkaloids	0.5g of plant extract was weighed and stirred in 2 ml of 1% aqueous hydrochloric acid and heated in a boiling water bath for 10 minutes. The mixture was filtered while hot and treated with Dragendorff's reagent. Turbidity or precipitation indicate the presence of alkaloids.	Teklit GA 2015
Flavonoids and Flavones	200mg of the extract was dissolved in 4 ml of 50% methanol. The solution was warmed and metal magnesium added. Five drops of concentrated sulfuric acid were then added. Development of a red color indicated the presence of flavonoids and afterwards orange color showed presence of flavones	Teklit GA 2015

**Table 2.** Quantitative methods for the determination of bittering agents of *R. prinoides*

Phytochemical Component	Quantitative Test	Reference
Total Resin	20g of the leaves sample of <i>R. prinoides</i> was dissolved in a 100 ml of cold methanol in a conical bottom flask and agitated vigorously. The mixture was filtered using the whatman No. 1 filter paper. The filtrate containing the resin was dried until constant weight over a water bath. The final weight was calculated as a percentage of the original weight of the sample dissolved in methanol.	Adama K.K et al 2011
Soft and Hard Resin	20g of the sample was dissolved in a 20 ml of n-hexane in a conical bottom flask and agitated. The mixture was filtered using the Whatman No. 1 filter paper. The filtrate containing the soft resin was dried until constant weight over a water bath. The final weight of the soft resins was calculated as a	Okoro and Aina 2007

	percentage of the original weight of the sample dissolved in n-hexane. Hard resin was calculated by subtracting soft resin from total resin.	
$\alpha$ and $\beta$ acids	0.15g of the sample plant (leaf) extract was dropped into 100 ml of cold methanol filled in a flask shaker, then filled in centrifuge tubes. The mixture was centrifuged at 2500 rpm for 20 min. The supernatant of the mixture was decanted from the test tubes and acidified with 0.002N HCl. Finally, using UV-vis spectrophotometer the alpha and beta acid content can be calculated its absorbance at a wavelength of 355,325 and 275 nm.	Abebe WN et al 2021
Iso- $\alpha$ -acid	15g of sample of R. prinoides was dissolved in a 100 ml of distilled water 0.15% (w/v) and boiled for 90 min and cooled, then filtered using whatman No-1 filter paper. 15 ml sample of extract was acidified using 0.5 ml of 6N HCl and then mixed with 15 ml of pure isooctane in a flask shaker. Finally 10 ml of the isooctane extract was washed with 10 ml of a mixture of methanol and 4 N HCl (68: 32, v/v). 5 ml of the washed isooctane layer was diluted with 5 ml of alkaline methanol (60: 40, v/v methanol: 0.5 N NaOH). Finally, using a UV-Vis spectrophotometer the iso-alpha acid content can be calculated as absorbance at wave length of 255 nm.	Abebe WN et al 2021

**Table 3.** Testing methods for the determination of essential oils and antioxidants.

Compounds	Testing Procedure	Reference
Essential Oils	20g of sample is placed inside a thimble & inserted into the inner-tube of the soxhlet extractor. The apparatus is fitted to a round-bottom flask, which contains 200 ml of n-hexane. Reflux condenser was set on the top of the apparatus and extraction time of 120 min at 60°C (boiling point of n-hexane). The mass of the extracted oil was recorded and calculated as a percentage from the original sample.	Adama K.K et al 2011
Flavonoids	10g of the leaves sample of R. prinoides was mixed with 100 ml of 80% aqueous methanol at room temperature. The whole solution was filtered with whatman No. 1 filter paper and the filtrate was transferred into a crucible and then evaporated to a dryness over a water bath. Finally, the evaporated filtrate was weighed to a constant weight.	Edeoga H.O et al 2005
Phenols	5g of leave sample of R. prinoides was boiled with 50 ml of petroleum ether for the extraction of phenolic component for 15 min. 5 ml of the extract was poured into a 50 ml flask then add 10 ml of distilled water. 2 ml of ammonium hydroxide solution and 5 ml of di nitro salicylic acid solution (1%: aqueous solution) was added. The sample was made up to the mark and left for 30 minutes for color development. Finally, using a UV-Vis spectrophotometer the polyphenols content can be calculated as absorbance at wave length of 505 nm.	Damilola O et al 2015



## 2.4. Determination of essential oils and anti-oxidants

Essential oils are volatile oils that present in a hop plant. Especially in the aroma hops (hops which gives flavor & aroma to the finally produced beer). Since these oils are highly volatile, they are inserted to the wort kettle during the end of the boiling. For the extraction of oils, the raw material containing the compound placed inside the thimble. Later, the thimble loaded into the main chamber of the Soxhlet extractor. The extraction solvent to be used placed in a distillation flask. Then the flask placed on the heating mantle. The Soxhlet extractor placed on top of the flask and a reflux condenser attached at top of the extractor. Further, the quantitative details of the sample, solvent and operating conditions are set as shown in Table 3.

Antioxidants such as flavonoids and phenols are the compounds that inhibit oxidation. They are mainly used as food additives to guard against food deterioration. Therefore, these compounds have a great role in beer preservation by means of providing a long-lasting expiry to the beer. The presence of antioxidants in the hops applied exist in the form of flavonoids and polyphenols. So, the content of antioxidants measured according to the methods given in the Table 3.

## 2.5. Beer Brewing using imported Hops and Gesho

Imported hops used in ABF for the beer production are collected and wort liquor prepared using ABF facilities under the similar conditions that are practiced by ABF for the beer production to compare the effect of local hops from the imported ones. After the raw material milling process in ABF, mashing was done in a large mash-tun where 30,000 tons of malted barley and 176 hectoliter of water were boiled for 120 min at 74°C to achieve saccharification, which is the total conversion of starch in to glucose and the completion of saccharification determined by an iodine test. On completion of mashing, HOPS are added and allowed to wort boiling in wort kettle.

Further, the mash was collected from ABF and used to produce beer using Gesho (local HOPS). Followed the methodology adapted by ABF to produce beer with the replacement of imported HOPS by Gesho local HOPS. The collected mash liquor [ of about 5 liters] was added with 12.7g HOPS as the same proportion used in ABF and boiled to 95°C for 90 min to obtain the Wort liquor as shown in figure 2. And finally, after one and half hour, boiling was stopped and allowed the wort to attain 10-12 °C which is favorable temperature for the yeast inoculation for further fermentation process.



**Figure 2.** Wort boiling (a) and Inserting Gesho plant in wort (b)



**Figure 3.** Fermentation process(a) and fermented beer (b)

Moreover, yeast was inoculated into the five-liter jar containing the wort liquor and it was first acclimatized to 10 °C for 6 days and thereafter the temperature increased to 15 °C in order to reduce vicinal di ketones (VDK) which is a metabolic product secreted by the yeasts. After two days, the fermentation was finished when almost 80% of sugar converted into CO<sub>2</sub> and ethanol. Then these wort samples were precipitated for almost 8 days by decanting, with proper pH monitoring and was kept at 12°C in the refrigerator. Later the temperature was dropped to 3 °C for 7 days and then the beer product was characterized.

## 2.6. Characetrization of the beer brewed

Beer analysis from Gesho leaf and stem samples were performed at ABF lab using facilities such as determination of extract, alcohol meter, pH meter, turbidity, color meter, density, specific gravity and characteristic studies such as determination of bittering units, polyphenol and vdk using the methods provided by Getaw and Berhanu, 2022.

Bitterness of the beer determined using adegassed sample without loss of foam by adding 2-4 drops of octanol into the bottle and pouring 5-20 times from one beaker to another or use magnetic stirrer at least of five minutes. If Yeast contained in beer must

be clarified by centrifuging 15minutes at 3000rpm. Further, 10ml of degassed test sample was pipetted into conical flask which was acidified with 1ml of 3N HCl and was filled with 20ml of isooctane (2,2,4-trimethylpentane). Flask was stoppered tightly and placed it in mechanical shaker, shaken vigorously for 15min at room temperature and then decanted for 10 minutes until the supernatant organic phase forms. Absorbance of isooctane at 275nm in cuvette was measured using Isooctane from the batch as the blank. The optical density is expressed in terms of European brewing convention bitterness units as follows.

Bitterness[IBU] = 50 x Absorbance at 275nm  
 Calculation of International Bittering Units

$$IBU = [AAU \times U \times 10] / V$$

Where AAU is Alpha Acid Units and V is the Volume of the boil in liter

$$Utilization [U] = F[G] \times F[T]$$

Where  $F[G] = 1.65 \times 0.000125[G_b - 1]$ , in which G<sub>b</sub>=boil gravity

$$F[T] = [1 - \exp(-0.04X_t)] / 4.15$$

The constant 10 was accounted for the unit conversion and IBU was measured in mg/L.

Polyphenol amount in beer determined using 10ml of degassed test sample was pipetted into volumetric flask (25ml) with glass stopper which was basified with 0.5ml of 25% ammonium solution and 0.5% ferric

reagent and 8ml of CMC/EDTA were added to the solution the blank was run in the parallel except 0.5% ferric reagent to determine polyphenol amount in the beer. The reaction was allowed for 10min. Absorbance was measured at 600nm. The optical density is expressed in terms of European brewing convention bitterness units as follows.

Polyphenol [pphl] = 120 x ABS at 600nm

VDK estimated in 25ml distilled beer, 10ml of the distillate was taken into 50ml flask with glass stopper, 0.5ml % O-phenyldiamine (reagent) was added and kept in the darkness. After adding 2ml 4N HCl (reagent) into the sample, the absorbance was measured at 275nm and expressed in terms of European brewing convention ppm.

VDK[ppm]=2.7 x ABS at 335nm.

### 3. Results and Discussion

#### 3.1. Qualitative Analysis for the presence of phyto-chemical in Rhamnusprinoides

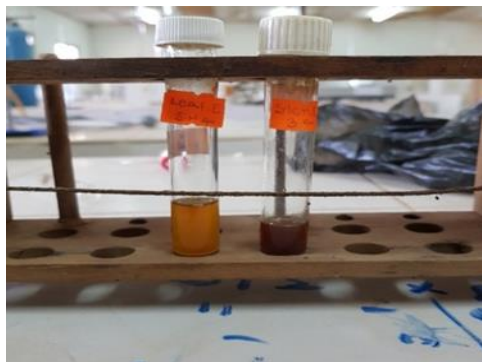
**Saponins:** It was proved that the foam formed after continuous shaking of the sample for five minute and the stable foam persisted for 26 min. This presence of saponins also indicates the protein content in the Gesho plant (RP). Saponins which were present have been used as antioxidant, anticancer, anti-inflammatory. They are also known to have anti-fungal properties and have been implicated as bioactive antibacterial agents of plants.

**Tannins:** The presence of tannin was proved that the formation of blue-black color precipitate by the ferric chloride test. Tannins are also known to possess general antimicrobial and antioxidant activities.

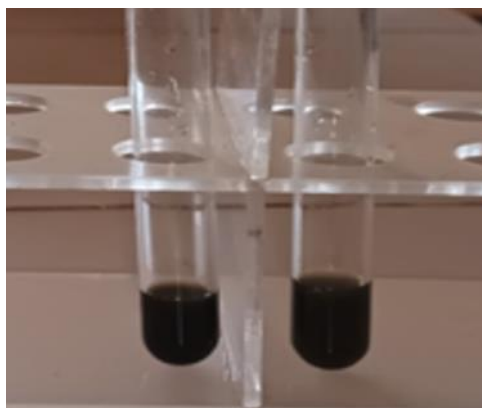
**Phenols:** As per the standard procedure of ferric chloride test, the appearance of green-black color showing the presence of phenol in the Gesho plant. Phenolic phytochemicals

were present and have been reported to have antioxidative, antidiabetic, anticarcinogenic, antimicrobial, antimutagenic and anti-inflammatory activity. Such activities would qualify the plant for use as a medicinal remedy.

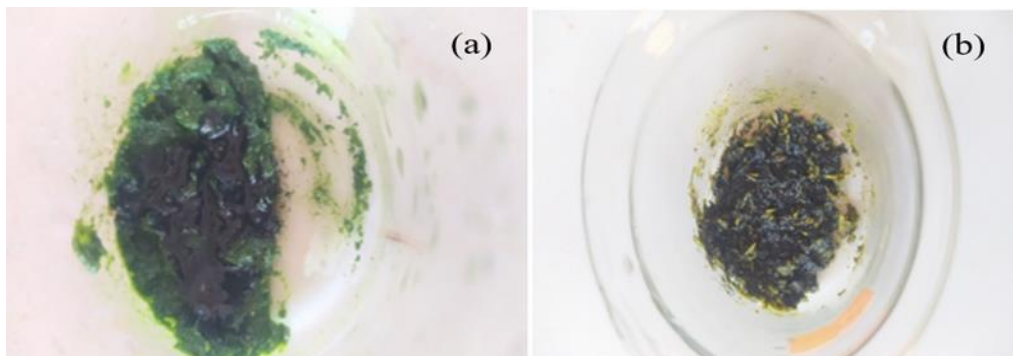
**Resins:** The presence of resins was detected by appearance of bright purple color for the leaf sample very well compared to stem. They are secreted by plants as secondary plant metabolites. A variety of trees produce them and each variety has a slight difference in the resins they secrete. Because of their anti-inflammatory properties' resins have been used in treatment of arthritis as well as in aroma therapy to release stress and anxiety in Africa.



**Figure 4.** Tannin test for leaf(left) and Tanin test for stem(stem)



**Figure 5.** Sample extract of leaf and stem



**Figure 6.** Phenol test for leaf (a) and Phenol test for stem (b)

### 3.2. Quantification of Bittering Agents present in *R. prinoides*

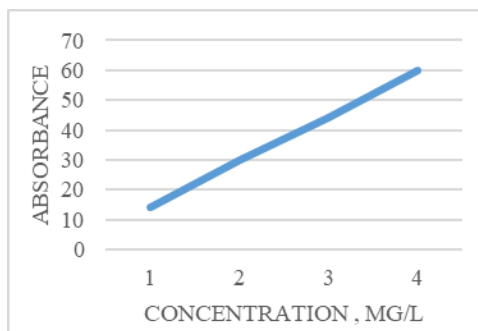
The quantitative values of total resins, soft resins, hard resins,  $\alpha$ -acid, iso- $\alpha$ -acid, and  $\beta$ -acid of *R. prinoides* leaves and stem collected from the small vegetation garden area were determined. In general, the total resins represent the sum of all bitter resins and can be further divided into hard and soft resins. Hard resins are insoluble in hexane, and soft resins are soluble in hexane. In this investigation, the amount of total resin content of *R. prinoides* leaves and stems collected from our garden.

Total resin of the leaf sample estimated as 16.54% on average based on the data obtained from the journal (L.Herit) reported from Amhara Region, Ethiopia. The results of total resins were comparable comparing with the total resin, they ranged from  $16.03 \pm 0.03$  to  $17.05 \pm 0.04$  %. And the amount of soft resins measured for both leaf and stem as an average of 10.615% based on the same journal mentioned above the outcomes of our soft resin were satisfactory and favored the range between  $(10.00 \pm 0.08$  to  $11.23 \pm 0.07)$ %. Further, the hard resin content of *R. prinoides* leaves and stems collected from the small garden area was calculated by the difference of the total resin to soft resin as shown in Table 4.

### 3.3. Determination of alpha, beta, iso-acids and essential oils.

Alpha acid: The mean compositions of  $\alpha$ -acid obtained from the leaves and stem of *R. prinoides* collected from our area were developed in a plot as shown in figure 7. Then with the provided wave length ( $\lambda$  max= 355nm), found the absorbance using the spectrophotometer and based on that absorbance calculated the concentration of the alpha acid through the standard plot.

- Alpha acid absorbance of leaf: 50.8
- Alpha acid absorbance of stem: 43
- Alpha acid concentration of leaf sample: 3.37 mg/L
- Alpha acid concentration of stem sample: 2.9 mg/L



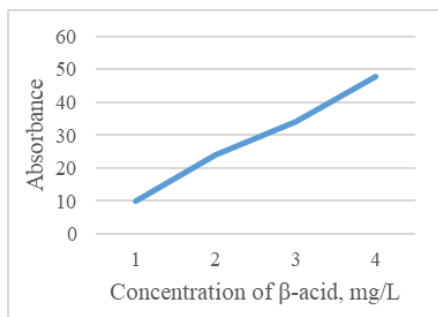
**Figure 7.** Alpha acid test for *R. prinoides* leaf sample absorbance

**Table 4.** Resin Content of the *R. prinoides* leaf and stems

Sample type	Total resin	Soft resin	Hard resin
Leaf sample	16.54%	10.615	5.925
Stem sample	Trace amount	Trace amount	Trace amount

**Beta acid:** The mean values of  $\beta$ -acid obtained from the leaves and stem of *R. prinoides* collected from our area were drawn in a plot as shown in figure 8. Then with the provided wave length ( $\lambda$  max= 323 nm), we found the absorbance using the spectrophotometer and based on that absorbance we calculated the concentration of the beta acid through the standard plot.

- Beta acid absorbance of leaf sample: 47.3
- Beta acid absorbance of stem sample: 38.7
- Beta acid concentration of leaf sample: 3.93 mg/L
- Beta acid concentration of leaf sample: 3.27 mg/L



**Figure 8.** Beta acid test for *R. prinoides* leaf sample absorbance

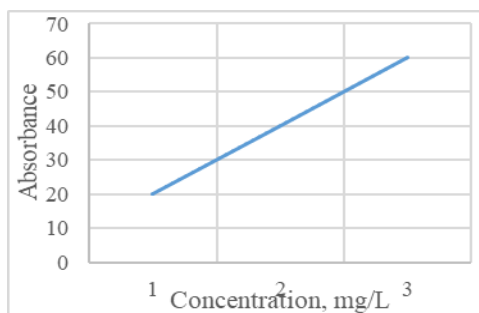
So the values of  $\beta$ -acid of leaves of *R. prinoides* from our sample sites was found to be within the range of  $(2.62 \pm 0.04$  to  $4.29 \pm 0.08$  mg/l) of  $\beta$ -acid values of commercial hops reported in references.

**Iso-alpha acid:** Based on standard method and uv-spectrophotometer absorbance at 345nm it was found that the content of iso-alpha acid was  $2.26 \pm 0.15$  mg/l up to  $4.15 \pm 0.10$  mg/l.

**Essential oils:** Essential oils are the key contributor to aroma and flavor during beer production. Using the standard procedure mentioned in our report, it was found that the content of the essential oil obtained in *R. prinoides* leaves was in the range of  $7.74 \pm 0.11$ – $12.47 \pm 0.13\%$ . It was also proved by our steam distillation experimental results. Therefore, significant amount of essential oils was obtained in this study, indicates that the leaves and stems of our *R. prinoides* can be serving as a good source of aroma and flavor in the production of alcoholic beverages in ABF.

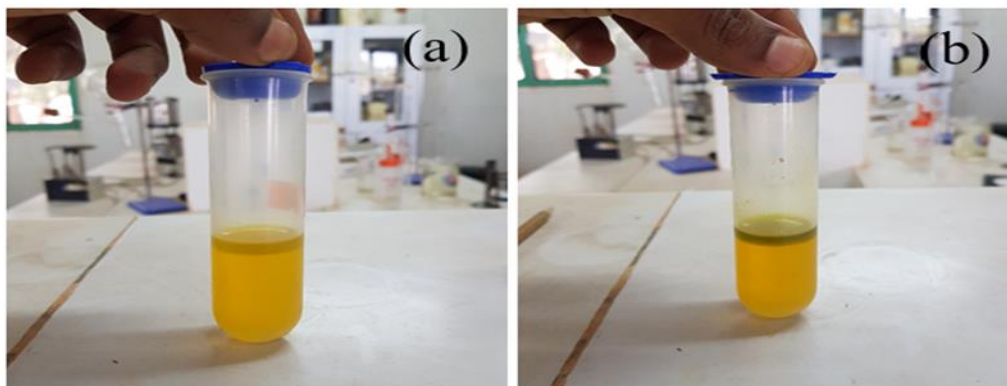
### 3.4. Determination of Antioxidants of *R. prinoides*

Flavonoids of the leaf and stem samples of *R. prinoides* determined as 24.0332 % and 22.8631 % respectively. And the polyphenol content of the *R. prinoides* leaves and stem were reported using the standard plot of uv-spectrophotometer as shown in figure 9.



**Figure 9.** Polyphenol test for *R. prinoides* leaf sample absorbance

Polyphenol absorbance of leaf sample: 45.1  
 Polyphenol absorbance of stem: 42.3  
 Polyphenol content of leaf sample: 2.3 mg/l  
 Polyphenol content of stem sample: 2.13 mg/l



**Figure 10.** Polyphenol test for (a) leaf and for (b) stem

**Table 5.** Comparison of local hops with imported hops in terms of bittering agents, essential oils and antioxidants

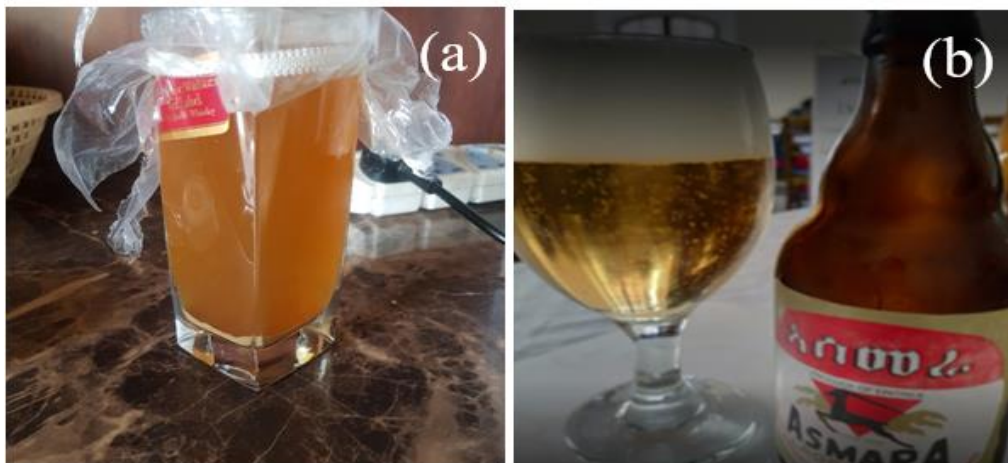
Content		Local hop(leaf)	Local hop(stem)	Imported hop	Typical acceptable Range
Bittering Agents	Total Resin	16.54%	Trace	16.675%	10-20%
	Soft Resin	10.615%	Trace	10 - 18%	8-15%
	Hard Resin	5.925%	Trace	2-4%	1-6.2%
	Iso $\alpha$ -acid	3.205 mg/l	3.21 mg/l	8.52 mg/l	3-9 ppm
	$\alpha$ -acid	3.37 mg/l	2.9 mg/l	9.27 mg/l	3-10 ppm
	$\beta$ -acid	3.93 mg/l	3.27 mg/l	7.64 mg/l	3-8 ppm
Essential oils		2.9%	Trace	1.2%	0.25-3%
Antioxidants	Flavonoids	24.0332%	22.8631%	24.42 $\pm$	20 – 25%
	Polyphenols	2.3 mg/l	2.13 mg/l	0.13% 2-5 mg/l	2 -5 ppm

The result obtained in this study suggests that the *R. prinoides* leaves are a good source of polyphenols, and it may serve as an antioxidant for commercial alcoholic beverages brewing. Further comparisons of bittering agents, essential oils and antioxidants developed in the table 5.

### 3.5. Comparison of Gesho beer with beer produced from imported hops

The sample of beer was prepared by filtering the gesho beer to its final stage with filtration process that includes whatman filter paper and filtration aids. A comparison made between the beer produced from local

hops and imported hops, in terms of color, turbidity and alcohol contents as shown in table 6. The alcohol content was determined by the gas chromatography as 7.57 % (volume), higher than conventional beer that use imported hops. In other words, gesho beer found in golden yellow color and turbidity measured as higher in gesho beer due to lack of effective filtration, the turbidity is slightly higher than ASF beer. Interms of taste and odor, not found any appreciable difference between Gesho beer and ASF beer, except the Gesho beer was showing slightly less sourness than ASF beer due to less presence of alpha, beta and iso-alpha acids.



**Figure 11.** Gesho beer (A) and beer of Asmara brewery factory (B)

**Table 6.** Comparison of the beer produced from local hops and imported hops.

S.No	Parameters	Beer with imported hops	Beer with local hops
1	pH	4.37	4.64
2	Color	9.75 EBC	15 EBC
3	Specific gravity	1.008	1.0096
4	Density	1.008 g/cc	1.0096 g/cc
5	Extract	3.5 g/100ml	3.36 g/100ml
6	Alcohol content	5 % v	7.57 % v
7	Turbidity	0.29 EBC	5.92 EBC
8	Toxicity (VDK)	Not present	Not present

## 4. Conclusions

From the experiments performed, it was observed that the bitter taste and antioxidant activities of Gesho hops are suitable for application in brewing. Resin contents and antioxidants of local Gesho hops were closely approaching imported hops. Essential oils found in local hops are medically valuable compounds are higher than in the imported hops, but the alpha, beta and iso alpha acids are relatively lower than the imported hops. Similar taste and quality was observed except the sourness of beer was

slightly lower [within acceptable range] than the imported hops due to lower alpha, beta and iso-alpha acids. The Gesho beer was found to have a pH of 4.64, alcohol content of 7.5%, and colour of 15EBC are in acceptable range.

The processing methodology of beer [local Gesho hops added] was followed closely with the ASF beer [imported hops containing beer]. Since the taste of the beer was slightly less sour and all other requirements were closely approaching the ASF beer, the local Gesho hops are recommended to ASF. The fermentation efficiency was also showing the

similarities on both the beer. Therefore, incorporating Gesho as a bittering agent gives an advantage to the breweries and the country as well an economic advantage by:

- Increasing profit margin of the brewery
- Reducing import of hop with increasing agricultural inputs to industries
- Creating job opportunities

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## APPLYING ARTIFICIAL INTELLIGENCE TO DETECT RETINAL DISEASES

**Abstract:** Vision and eye health are one of the most crucial things in human life, it needs to be preserved to maintain the life of the individuals. Eye diseases such as CNV, DRUSEN, AMD, DME are mainly caused due to the damages of the retina, and since the retina is damaged and discovered at late stages, there is almost no chance to reverse vision and cure it, which means that the patient will lose the power of vision partially and maybe entirely. Optical Coherence Tomography is an advanced scanning device that can perform non-invasive cross-sectional imaging of internal structures in biological tissues by measuring their optical reflections. which will help the ophthalmologists to take a clear look on the back of the eye and determine at early stages the damage caused to the retina, macula, and optic nerve. The aim of this study is to propose a novel classification model based on deep learning and transfer learning to automatically classify the different retinal diseases using retinal images obtained from Optical Coherence Tomography (OCT) device. We propose a deep CNN architecture and compared the obtained results with pretrained models such as Inception V3 and VGG-16, our proposed CNN architecture gave an accuracy of 98.96% and Inception V3 model gave an accuracy up to 99.27% on the test set.

**Keywords:** Convolutional neural networks, Optical coherence Tomography, Transfer learning, medical imaging, image classification

### 1. Introduction

OCT stands for Optical Coherence Tomography is an advanced scanning device that can perform non-invasive cross-sectional imaging of internal structures in biological tissues by measuring their optical reflections. [1], which will help the ophthalmologists to take a clear look on the back of the eye and determine at early stages the damage caused to the retina, macula, and optic nerve. Diagnosing or predicting these pathologies at early stages can increase the chance of curing the patients and restore vision ability, it has been also proved that eye diseases don't just affect the retina and

the patient's vision, but it has also a relation between heart diseases and hypertension, which means that predicting and diagnosing eye diseases at early stages can also save the health of the patient's heart.

Four main types of eye diseases are treated in this study:

- DME Diabetic Macular Edema is a type of eye disease due to the damage of blood vessels in the retina. When left untreated, DME will cause the build-up of liquid in the macula further leading to a swollen area on the retinal layer and

consequently irreversible eye blindness.

- **AMD** Age-related Macular Degeneration is a damage affects the macula (small area at the center of the retina), leads to center-blind, and it's a blinding disease with no cure at present. This disease doesn't just affect the vision of the patient, but it can also cause heart diseases and hypertension, according to [5]. The number of people living with macular degeneration is expected to reach 196 million worldwide by 2020 and increase to 288 million by 2040 [6]
- **DRUSEN** One of the first signs of AMD pathology are called DRUSEN. Drusen are yellow deposits under the retina, they are not symptoms of eye diseases, but the appearance of large number of them can lead to AMD and vision loss. [16] Ophthalmologists these days use OCT imaging scanning to detect DRUSEN and define their types if they are serious and can lead to AMD, or if they can disappear [9], which gives them the opportunity to make prior decisions.
- **CNV** Choroidal neovascularization is a very common vision-threatening disease that leads to vision loss. involves the growth of new blood vessels that originate from the choroid through a break in the Bruch membrane into the subretinal pigment epithelium or subretinal space. [7] [15] any damage to the Bruch membrane can be complicated by CNV.

## 2. Related works

Machine learning is nowadays used in different fields of medical imaging, computer-aided diagnosis [19], image

segmentation [18] and image-guided therapy, this means that there are multiple areas in medicine, where machine learning methods can be applied to improve patients' health care. Different studies have been proposed to classify OCT images. Md Akter Hussain et al. [31] proposed a classification model based on random forest classifier, with 15-fold cross-validation tests, to detect (AMD) or Diabetic Macular Edema (DME) using retinal features from Spectral

Domain Optical Coherence Tomography (SD-OCT) images. the dataset contained 251 (59 normal, 177 AMD and 15 DME) images, and obtained the accuracy of 95 % while testing and 96 % in train set.

Venhuizen et al. [42] proposed an architecture to detect AMD diseases using Random Forest with a maximum of 100 trees is used for the classifier. The method achieved an AUC of 0.984 with a dataset of 384 (269 AMD, 115 control) OCT volumes. Shenghua He et al. [36] have proposed a very deep CNN network architecture contained 9 CONV blocks and 2 FC layers. 2 max-pooling layers were placed after the 3rd and the 6th CONV blocks, respectively. 1 global pooling layer was placed after the 9th CONV block. The spatial support of the filter in each of the CONV layers was set as 3 x 3 pixels. The number of the filters in the first three Conv layers was set to 32. In order to compensate for the information loss caused by max pooling, the number of filters in 2nd three CONV layers and 3rd three CONV layers were set to 64 and 128, respectively. Two FC layers followed the global pooling layer. The first FC layer included 512 neurons and the second one included 5 neurons. One dropout was set between these two FC layers with a dropout ratio of 0.5 to further avoid overfitting. A softmax layer was placed at the end of the classifier.

The experiments on 269 OCT images showed that the average prediction accuracy of the CNN-based method was 0.866. The

test set accuracy wasn't mentioned in their paper, we believe that such very deep architecture on a few data (269 images) can lead to overfitting. one trick could have been done is to use data augmentation [35] to get more data for training. Muhammad Awais et al. [30] have worked on the classification of SD-OCT images using VGG-16 pretrained model, to detect DME diseases on a dataset consisting of 32 OCT volumes (16 DME and 16 normal cases). Each volume contains 128 Bscans with resolution of 1,024px 512px. They did many experiments on the dataset combining CNN with other classifiers (KNN and Decision trees). the best configuration was obtained 93.5 %. One of their configurations gave 100% accuracy, by setting the  $k = 1$  in KNN classifier, and 2 FCL1, hence this leads also to overfitting cause of the bad choice of parameters. Cecilia S. Lee et al. [33] published a paper on classifying AMD diseases using a modified version of the VGG16 convolutional neural network on a total of 80,839 images (41,074 from AMD, 39,765 from normal) were used for training and 20,163 images (11,616 from AMD, 8,547 from normal) were used for validation. The training was then performed using multiple iterations each with a batch size of 100 images with a starting learning rate of 0.001 with stochastic gradient descent optimization. At each iteration, the loss of the model was recorded, and at every 500 iterations, the performance of the neural network was assessed using cross-validation with

the validation set. The training was stopped when the loss of the model decreased and the accuracy of the validation set decreased. Accuracy in the area under the ROC curve (AUROC) was 92.77 %.

This is a very interesting paper indeed, due to the use of pretrained model and regularization techniques to speed the learning phase and avoid overfitting.

Another paper on classifying OCT images

using deep learning methods by Parmita M. et al. [34] for multilabel multiclass classification for OCT retinal images to diagnose patients who may exhibit multiple pathologies, the dataset consists of 36,150 images, applied data augmentation [35] and modified version of Inception Resnet V2 pre-trained model by removing the output activation layer softmax and replaced it with sigmoid. The goal of their study was to compare transfer learning with CNN from scratch the resulted work is accurate and exact match for transfer learning was 74.5% and 30.14% compared to 85.23% and 64.3% for direct learning. A paper was published recently that used the dataset that we are using in this study published by Kuntoro Adi Nugroho [32] comparison of Handcrafted and Deep Neural Network Feature Extraction for Classifying Optical Coherence Tomography (OCT) Images the deep neural network-based methods outperformed the handcrafted feature with 88% and 89% accuracy for DenseNet and ResNet compared to 50% and 42% for HOG and LBP respectively. The issue with this study is that they have split the dataset into 50% for training and 50% for validation. In this study, we are proposing different split of the data and different approaches

### 3. Proposed approaches

Machine learning approaches: We have trained three classic machine learning classification algorithms, and we compared the results obtained of each algorithm based on the accuracy and training time.

-Decision trees classifier:

Decision trees classifier is one of the most popular machine learning algorithms used all along, we used sklearn python library to fit decision tree classifier, after 38 minutes of training using google colabs GPU we obtained these results:

**Table 1.** Decision trees classifier results

Accuracy	Precision	Recall	F1-score
33,50%	33,25%	33,50%	32,87%

-XGBOOST classifier :

After splitting our dataset and resized the images to have a shape of (224 by 224 ) pixels and converting the images to matrix data, we used sklearn library to fit XGBOOST classifier to our the training data. After 40 minutes of training we obtained the following results :

**Table 2.** XGBOOST classifier results

Accuracy	Precision	Recall	F1-score
52,06%	51,91%	52,06%	51,12%

-SVM classifier:

We used the sklearn library to adapt the SVM classifier to the training data. After 13 minutes of training, the following results were obtained:

**Table 3.** SVM Classifier Results

Accuracy	Precision	Recall	F1-score
40,20%	44,31%	40,20%	40,29%

-Random Forest Classifier :

We used the sklearn library to adapt the Random Forest classifier to the training data. After 15 minutes of training, the following results were obtained:

**Table 4.** Random Forest Classifier Results

Accuracy	Precision	Recall	F1-score
60,30%	62,66%	60,30%	59,47%

Deep learning approaches: In this section we will demonstrate how we applied deep learning to classify and identify the retinal diseases, we focused on the use of

convolution neural networks because they shows a good performance when dealing with images, we done many experiments, we changed the hyperparameters and evaluated the obtained results. We also establish the use of some pretrained models by tuning them to fit our dataset outputs.

- First CNN architecture:

the first CNN experiment architecture is composed of 3 Convolution layers and 3 Max pooling layers and one Dense layer.

We obtained from this experiment an accuracy of 96,97% in validation set and 97,52% when testing on our test set data.

- Second CNN Architecture:

We added to the first CNN architecture one dropout layer and one Batch normalization layers.

We obtained from this experiment an accuracy of 97,20% in validation set and 98,96% when testing on our test set data.

Architecture interpretation: The model is sequential which allows us to create the model layer-by-layer. The architecture consists of convolutional layers, max-pooling layers, dropout layers, and fully connected layers.

The first layer is a convolutional layer with 32 filters each of size 3 x 3. We are also required to specify the input shape in the first layer, which is 224 x 224 x 3 in our case.

We will be using the Rectified linear unit (ReLU) activation function for all the layers except the final output layer. ReLU is the most common choice for activation function in the hidden layers and has shown to work pretty well.

The second layer is a pooling layer. The pooling layers are used to reduce the dimension. Max Pooling with a 4x4 window only considers the maximum value in the 4x4 window. A dropout layer with dropout

[39] rate of 0.1 means 10% of the neurons will be turned off randomly.

This helps prevent overfitting by making all the neurons learn something about the data and not rely on just a few neurons. Randomly dropping neurons during training means other neurons will have to do the work of the turned-off neurons, thus generalizing better and prevent overfitting. The third layer is again a convolutional layer of 512 filters each of size 3 x 3 followed by another max-pooling layer of 3x3 window. Usually, the number of filters in the convolutional layer grows after each layer. The first layers with a lower number of filters learn simple features of the images

whereas the deeper layers learn more complex features. The next layers are again convolutional layers with 32 filter size. followed by a Batch normalization layer. We need to flatten the 3D feature map output from the convolutional layer to 1D feature vectors before adding in the fully connected layers. This is where the flattening layer comes in. The following dense layer (fully connected layer) has 128 neurons. The final output layer is another dense layer that has a number of neurons equal to the number of classes. The activation function is softmax because it is a multi-class classification problem.

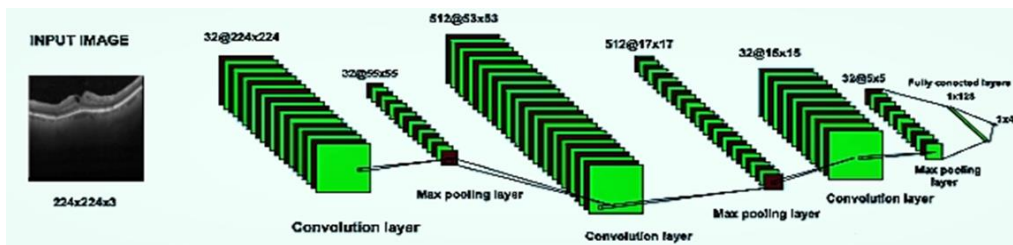


Figure 1. Our proposed CNN architecture

- Inception V3 Model We used Inception V3 pre-trained weights to classify our images, we removed the first three top layers and changing the output layer to have four neurons corresponding to our number of classes.
- VGG-16 Model We used VGG-16 [44] pre-trained weights to classify our images same as we did with Inception V3 model, we removed the first three top layers and changing the output layer to have four neurons corresponding to our number of classes.
- ResNET50 Model We used ResNET50 pre-trained weights to classify our images same as we did with InceptionV3 and VGG16

models, we removed the first three top layers and changing the output layer to have four neurons corresponding to our number of classes.

### Compiling and training the models

All the models are compiled with categorical cross-entropy loss function and the Adam as an optimization algorithm, except the InceptionV3 model where we tried both Adam and rmsprop, the last one gave better results. The accuracy metric is used to evaluate the model. Training the model using a GPU speed up the training process, We set the number of epochs to 15 and use a regularization method Early Stopping [38], In our case, we tell EarlyStopping to monitor

validation-accuracy and if it does not improve for 10 epochs continuously, stop the training process. The model checkpoint is used to save the model.

The monitor parameter allows us to set a metric that we want to keep an eye on. In our

case, we only save the model when the validation accuracy is the max. We save the best model to be used later to make predictions and thus evaluate the models' performance.

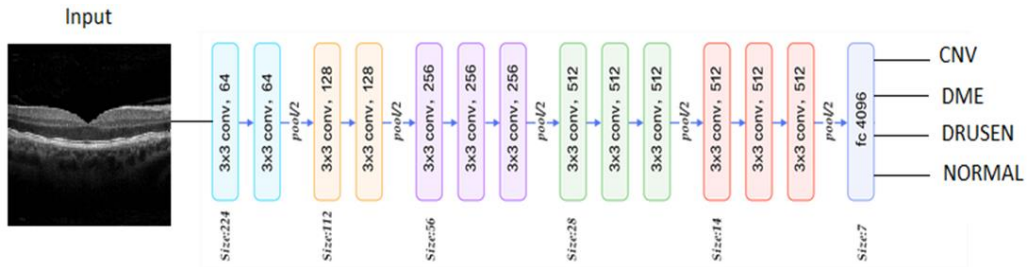


Figure 2. Adapted version of the VGG-16 architecture to match our data

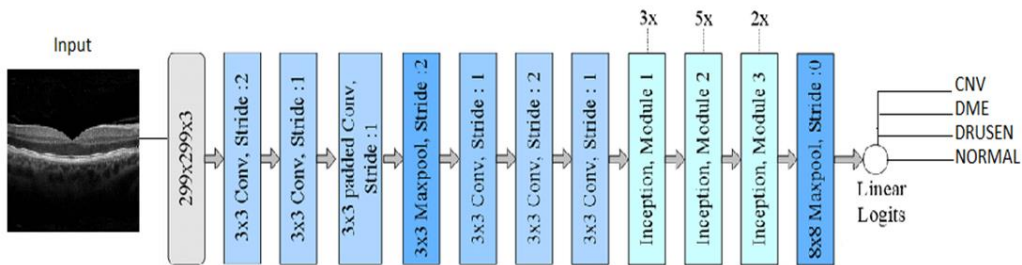


Figure 3. Adapted version of InceptionV3 to match our data

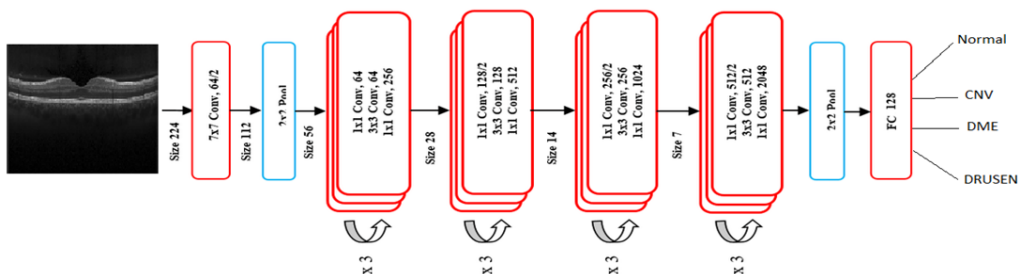


Figure 4. Adapted version of the ResNET50 architecture to match our data

#### Dataset overview and preprocessing

We have used the OCT images dataset from [27], the dataset is organized into 3 folders (train, test, val) and contains subfolders for

each image category (NORMAL, CNV, DME, DRUSEN). There are 84,495 images (JPEG) and 4 categories (NORMAL, CNV, DME, DRUSEN).



Our dataset was taken from different research labs, what makes the sizes of the images varies (496, 768, 3), (496, 1024, 3), (496, 512, 3), (496, 1536, 3), (512, 512, 3) the first two values refers to the width and height of the image, and the third one refers to the image channels, meaning in this case that the images are in RGB.

**Table 5.** Dataset original split

	Training	Testing	Validation	
CNV	37205	242	8	<b>37455</b>
DME	11348	242	8	<b>11598</b>
DRUSEN	8616	242	8	<b>8866</b>
NORMAL	26315	242	8	<b>26565</b>
	<b>83484</b>	<b>968</b>	<b>32</b>	<b>84484</b>

**Table 6.** Dataset distribution after resampling

	Trainin g	Testin g	Validatio n	
CNV	33,03 9	242	4,174	<b>3745 5</b>
DME	7,182	242	4,174	<b>1159 8</b>
DRUSEN	4,450	242	4,174	<b>8866</b>
NORMA L	22,14 9	242	4,174	<b>2656 5</b>
	<b>66,78 8</b>	<b>968</b>	<b>16,696</b>	<b>8448 4</b>

Data Rescaling: Importing the images with the original sizes will lead to use big part of hardware resources and the time of processing the images will highly increase, we reduced the image sizes to 224 X 224 pixels, same as Imagenet [41] dataset images sizes because we aim to do experiment on pretrained models.

Data Resampling: The dataset is splitted into 3 folders as explained in the previous section, with only 8 images per class for validation and 242 images for test and the rest for training. as detailed in table This split is not efficient and can lead to extream overfitting. We made another split of 80% for training , 20% for validation (table 2) and after constructing our model we tested our

model on 968images.

## 4. Results and discussions

After compiling our first CNN architecture we obtained an accuracy of 96,97% in validation set and 97,52% when testing on our test set data.

After the second experiment of our CNN architecture ( after adding the regularization terms )we obtained an accuracy up to 97,29% and accuracy of 98,96% while testing. meaning when we added the two regularization terms the accuracy did enhance for both validation and testing.

Our experiment on the VGG16 model, the training time was 16 minutes per epoch, we obtained an accuracy of 94,75% on validation and in testing the model. the accuracy in the validation part didn't improve the 10 first epochs until early stopping algorithm stopped the training process.

Our experiment on the ResNET50 model, the training time was 20 minutes per epoch, we obtained an accuracy of 95.57% on validation and in testing the model.

The results of our experiment on the InceptionV3 model were exciting, after 15 epochs of training and validation, we obtained an accuracy up to 99.03% in training and 100% in the validation part, and accuracy of 99.27% in 986 testing images. This experiment outperformed all the other results.

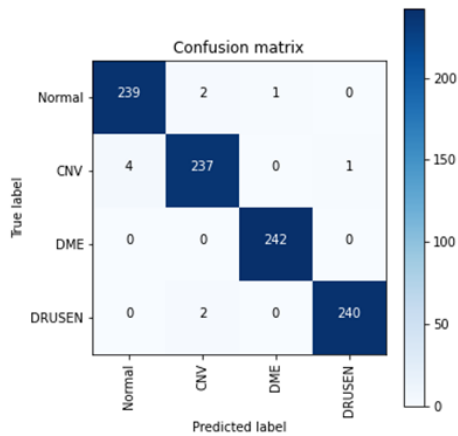
Predictive labels on the X-axes and true labels on the Y-axes, we have used 968 images to test our model, the blue cells shows the correct predicted images meaning the predicted labels matches the actual labels of the images, in this case the model correctly predicted 958 images out of 968 images where the DME images were 100% correctly predicted. and the wight cells show the incorrectly predicted labels which 10 in this case.

CNN architecture - accuracy ON TEST SET : 0.9896694421768188

31/31 [=====] - 1s 19ms/step

	precision	recall	f1-score	support
Normal	0.98	0.99	0.99	242
CNV	0.98	0.98	0.98	242
DME	1.00	1.00	1.00	242
DRUSEN	1.00	0.99	0.99	242
accuracy			0.99	968
macro avg	0.99	0.99	0.99	968
weighted avg	0.99	0.99	0.99	968

**Figure 5.** Matrix showing the precision and recall for each classed obtained by second CNN architecture



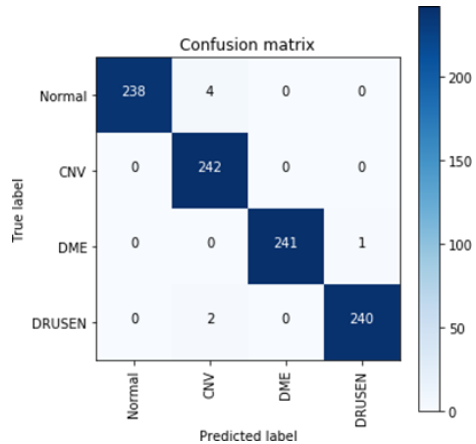
**Figure 6.** Confusion matrix obtained by the second CNN architecture

Inception V3- Rmsprop optimizer - accuracy ON TEST SET : 0.9927685950413223

	precision	recall	f1-score	support
Normal	1.00	0.98	0.99	242
CNV	0.98	1.00	0.99	242
DME	1.00	1.00	1.00	242
DRUSEN	1.00	0.99	0.99	242

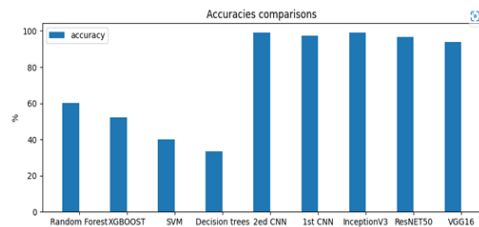
**Figure 7.** Model's accuracy obtained by the Inception model while testing

The performance on the test data is consistent with the performance on the training data. DME , DRUSEN and Normal images have a great precision value of 100%, in all the evaluation metrics. CNV have lower precision value compared to other classes.



**Figure 8.** Confusion matrix obtained by InceptionV3 model

This model was able to correctly predict 961 out of 968 images, meaning only 7 images were incorrectly classified, this shows better results compared to the previous confusion matrix where the 2nd CNN models miss-classified 13 images. The CNV category is better classed here compared to the previous confusion matrix of the 2nd CNN architecture, and the test accuracy improved as well, all the instances of CNV class were correctly classified.

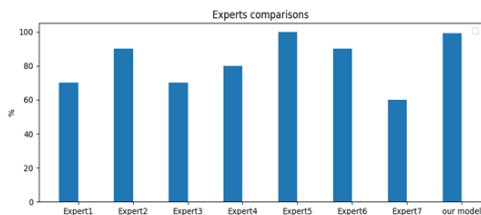


**Figure 9.** Comparisons between the results obtained by our experiments

Convolutional neural nets give better results in term of accuracy and efficiency compared to artificial neural nets and classical Machine learning algorithms. CNN gives good results and inceptions V3 outperforms all the results, 2nd CNN is better than the first one where we added regularization terms.

Comparative study with the diagnosis of OCT experts in order to evaluate our models and see if they give good results compared to OCT radiologists experts, we obtained diagnosis of 7 OCT radiologist, by asking them to label 10 images corresponding to the category.

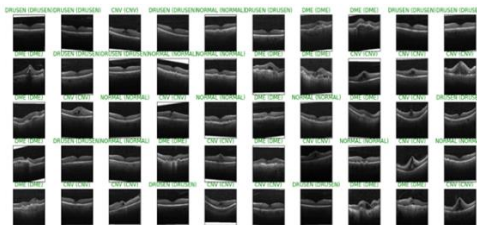
The experts were given the enough time to make their own decision on the images, from all doctors, only one of them accurately classified the 10 images. another thing to notice is that all the doctors have correctly classified the DME and NORMAL images, and some of them struggle to diagnose images that contains CNV.



**Figure 10.** Comparisons between experts and our model

Our model outperformed the diagnosis of 6 out of 7 OCT experts in term of accuracy. It took the model only 3 seconds to predict the 10 images.

Then we tested 50 images on our model, our model successfully classed all the images correctly as illustrated in figure 11.



**Figure 11.** Predictions on 50 randomly chosen images

## 5. Conclusion

This work represents case study and aims to develop and propose a new novel classification model based on deep learning to automatically detect and diagnose retinal images better than the diagnosis of experts in OCT radiology and also previous published papers.

To achieve research objectives we conducted many experiments using classic machine learning classification algorithms and deep convolutional neural nets methods.

As turned out, our proposed CNN model outperformed all other classifiers and approaches, as well as the diagnosis of OCT experts. The results has shown that the use of Convolutional neural networks can give very interesting results in image classification and can be used to asses doctors in medical diagnose and opens up to a new, simple and effective method for early CNV, DME and DRUSEN detection. We have also seen that the use of some pretrained models can enhance the results in time and model effectiveness.

Our approaches shows good results in term of classification performance, yet we didn't trained our models for long epochs due to the hardware limitations, and we haven't test our models in different OCT dataset to see if they can perform as well as they did in this data.

For future , we would study further many related problems and test our models in different datasets to diagnose more retinal diseases. We also aim to integrate our model directly into an OCT scanning device to asses the ophthalmologists in making decisions.

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## HOW TO MAINTAIN A QUALITY ENVIRONMENT IN HOSPITALS

**Abstract:** *The main focus of this paper is on maintaining a high quality environment in hospitals, which is essential for the safety and well-being of patients, staff, and visitors, and to some extent even promotes healing. We have divided the paper into three main sections: Physical Environment, Healing by Design - Comfortable and even Positive Environment, and Socio-emotional Environment.*

**Keywords:** *quality environment, hospital, patients, safety, well-being, Patient-centered*

### 1. Introduction

Maintaining a quality hospital environment is critical to the safety and well-being of patients, staff, and visitors, and to some extent may even aid in the healing process. To promote this quality hospital environment, we must focus our attention on the physical environment, the ability to create a comfortable environment, and the patient's socio-emotional environment. By physical environment we mean: cleanliness, adequate ventilation, sufficient space, waste disposal, hand hygiene. By pleasant environment we mean: Natural light, colors and textures, art and nature, privacy and personalization, comfortable furnishings, clear pathways. And we use the term socio-emotional environment to help patients, staff and visitors have a positive experience, even under difficult circumstances: Empathy, compassion and communication.

### 2. Physical environment

In the Physical Environment section, we listed several factors that contribute to maintaining a quality environment in hospitals, such as cleanliness, adequate ventilation, sufficient space, waste

management, and hand hygiene.

Cleanliness means that regular cleaning and disinfection of all surfaces, equipment and patient rooms is critical to prevent the spread of infection. Ensure cleaning protocols are followed correctly and staff are trained to maintain hygiene standards (Peters et al., 2018).

Adequate ventilation means that good ventilation can help reduce the risk of airborne infections. Ventilation systems in hospitals should be inspected regularly and air filters replaced as needed (Elsaid et al., 2021).

Adequate space means that adequate space for patients and staff can help prevent the spread of infections. Staff must ensure that patient rooms, waiting areas, and other public spaces have adequate space to maintain social distance (CEP et al., 1996; Kader, 2023).

The importance of waste management is that proper waste disposal is essential to maintaining a clean and safe environment. Personnel must ensure that all waste is disposed of properly and that hazardous waste is disposed of in accordance with local regulations (WHO, 2017).

It is important that staff, patients, and visitors practice good hand hygiene. Provide hand sanitizers and hand washing stations throughout the hospital and ensure that staff are trained in proper hand hygiene (Gaubé, Fischer, & Lermer, 2021).

### **3. Healing by Design - Comfortable and even Positive Environments**

In Healing by Design - Comfortable and even Positive Environments, we explain how incorporating natural elements such as natural light, plants, and views of nature into hospital design can have a positive impact on health and well-being. We also mention how the use of colors and textures, art and nature, privacy and personalization, comfortable furniture, and clear wayfinding can help create a warm and welcoming environment for patients. The meaning of Comfortable Environment is that patients should feel as comfortable as possible during their stay in the hospital. This can be achieved by providing comfortable beds, adequate lighting and temperature control, and amenities such as TV, books, or games.

From the perspective of biophilic design theory, we can assume that humans have an innate connection to nature and that incorporating natural elements into design can have a positive impact on health and well-being. This may include the use of natural light, plants, and views of nature in hospital spaces (Wilson, 2000; Heerwagen, 2009; Kellert, 2018).

By the term natural light, we mean a positive effect on mood and well-being. Wherever possible, hospital rooms should be designed to maximize natural light and views to the outdoors (Tekin, Corcoran, & Gutiérrez, 2023).

By the term color and texture, we mean the use of color and texture in hospital spaces that can help create a warm and inviting environment. Use warm colors and natural

materials such as wood or stone to create a calming and comfortable atmosphere (Dalay, 2020).

By art and nature, we mean that incorporating art and nature into hospital spaces can help create a sense of calm and relieve stress. This may include displaying artwork or photographs, creating green spaces or gardens, or providing views of nature (Samir, 2021).

By privacy and personalization, we mean the fact that hospital spaces should be designed to provide privacy and allow patients to personalize their environment. This may include providing private rooms with en-suite bathrooms, allowing patients to bring personal items such as photos or blankets, and providing space for visitors to spend time with patients (Fuchs, 2001; Xiong et al., 2019).

By comfortable furnishings, we mean comfortable and supportive furniture that can provide a sense of comfort and well-being. Provide comfortable chairs, sofas, and beds, as well as pillows and blankets for patients (Olausson et al., 2021).

By clear wayfinding, we mean clear and easy-to-understand wayfinding that can help reduce stress and confusion for patients and visitors. This includes clear signage, maps and directions, and color-coded floors or areas to help patients find their way around the hospital (Chen, Ko, & Hsieh, 2021).

### **4. Socio-emotional environment**

In the section on the socio-emotional environment, we emphasize the importance of empathy and compassion, as well as clear and effective communication in the hospital. We also mention the need to provide patients with a spiritual or cultural space and support. The importance of empathy and compassion is that patients and their families are often in distress and need emotional support. Hospital staff should be trained to show empathy and compassion toward patients



and their families, to listen to them, and to respond to their needs (Su et al., 2020).

Communication means that clear and effective communication is essential in a hospital. Patients and their families should be informed about their care and treatment, and staff should communicate effectively to ensure that patients' needs are met (Hapsari et al., 2022).

Nonetheless, offering spiritual or cultural space and support is part of the process (Saad & de Medeiros, 2016; Kader, 2023).

### 5. Staff support, training and regular inspections

Hospital staff should be supported to provide quality care. This includes access to training and development opportunities, ensuring adequate staffing levels, and promoting staff well-being (Boamah, Read, & Spence-Laschinger, 2017).

We see that at the heart of everything we do to promote a quality hospital environment is not just the physical environment, but also education and training. This means that education and training are critical to maintaining a high-quality hospital environment (Peters et al., 2018). Ensure that staff are trained in infection prevention and control and that patients and visitors are educated on the importance of maintaining a clean and safe environment.

However, we believe that education is not enough and that something always needs to be done. Regular inspections and audits can help identify areas for improvement. This

includes gathering feedback from patients and their families, as well as staff, and using that feedback to identify areas for improvement. Ensure that inspections are conducted regularly and that any issues identified are addressed promptly.

### 6. Conclusion

Positive psychology is a field that focuses on promoting positive emotions, behaviors, and attitudes and has been applied to healthcare (Seligman & Csikszentmihalyi, 2000). Hospital spaces can be designed to promote positive emotions such as serenity and comfort and reduce negative emotions such as stress and anxiety (Ulrich, 2000).

Person-centered design theory is an approach that focuses on the needs and experiences of individuals and seeks to create spaces that are tailored to their needs. This may include designing hospital spaces that are comfortable, private, and allow for personalization (Boissy, 2020).

So, if we are willing to understand that the hospital environment should be customized so much to have a quality environment, we can claim that the key factor is the patient-centered methodology. This means that the care is tailored to the individual needs and preferences of each patient.

And furthermore, there are even heaps of evidence that environment design even improves medical outcomes (Ulrich, 2000; Schweitzer, Gilpin, & Frampton, 2004; Sternberg, 2009, DuBose et al., 2018).

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## METHODICAL ASPECTS OF SIMULATION MODELING OF EMERGENCY INTERACTION OF LIFE SUPPORT FACILITIES

**Abstract:** An important component of the sustainable functioning of urbanized territories are life support systems that provide the main indicators of the quality of life of the population both in normal conditions and in emergency situations of man-made and natural character. Such systems primarily include power supply systems, gas supply, heat supply, water supply, transport, etc. Accidents in life support systems lead to large-scale and long-term negative social, material, financial and environmental consequences. Especially severe consequences are associated with intersystem accidents, when the termination or restriction in functioning affects two or more life support systems. The report discusses methodological issues of simulation of emergency interaction of life support systems, an algorithm and a general scheme for resilient assessing are proposed..

**Keywords:** life support system, accidents, intersystem interaction, negative consequences, general algorithm

### 1. Introduction

An important component of the stable functioning of urbanized territories are life support facilities, which provide the main indicators of the quality of life of the population both in normal conditions and in emergency situations of man-made and natural character. Such facilities include, first of all, power, gas, heat, water, transport and other facilities. Accidents in life support facilities lead to large-scale and long-term negative social, material, financial and ecological consequences. Particularly severe consequences are associated with intersystem accidents (ISA), when the termination or limitation of functioning affects two or more life support facilities (LSF).

The study of intersystem accidents within the framework of risk theory and the concept of adaptive resilience considers the development of such methods and models

that allow to assess not only the risks of intersystem accidents, but also to assess the duration and costs of restoration of life support facilities and territory. The development of mathematical models of emergency interaction of life support facilities is an urgent research area for a number of years. Taking into consideration the difficulties of formal description of the interaction of heterogeneous life support facilities, the focus has been on modeling the emergency behavior of electric power facilities (Dobson et al, 2005; Reducing..., 2011), modeling the interaction of two facilities, for example, electric power and gas supply facilities (Lesnykh et al, 2016), electric power and water supply (Jin-Zhu & Hiba, 2019). There is a number of problems that make it difficult to model the emergency interaction of two or more life support facilities. First of all, it is different dynamics of emergency disturbance propagation in the facilities: in the electric

power facilities the propagation is almost instantaneous, in the gas supply facilities it can reach several hours, and in the heat supply facilities - several days. Another difficulty is related to the formalization of the disturbance transfer function between the facilities. If for the energy facilities the energy equivalent (Lesnykh et al, 2016) can be used, for other facilities the description of such a function requires additional research.

## 2. Modeling the emergency interaction of life support facilities

The main purpose of modeling the emergency interaction of life support facilities is to assess the level of adaptive resilience of LSF to intersystem accidents. The total negative consequences (direct and indirect social, material, financial and environmental damage), the duration and costs of the restoration of LSF to the normal level of functioning can act as criteria of adaptive resilience.

ISA modeling is conducted for the selected territory, to which the structure and categories of consumers, the specified composition and structure of life support facilities correspond. Life support facilities are attached to the main groups of consumers (public utilities, industry, services, etc.).

The most effective method that allows to realize a model of such processes, taking into account the influence of a large number of random factors is simulation modeling. Let us consider sequentially all the main elements of the ISA simulation modeling algorithm. The proposed algorithm is a development of the conceptual model of interaction of life support facilities during intersystem accidents (Lesnykh & Timofeeva, 2021).

**Step 1.** For the given initial data, the modeling of emergency processes begins with the selection of the initiating life support facility. Analysis of statistical data also showed that the most frequent initiating event of intersystem accidents are accidents in electric power facilities, the histogram of the frequency distribution of ISA initiating of life support facilities is shown in Fig. 1. This diagram is converted into a distribution histogram and can be used in the first step of ISA modeling to generate the type of initiating accident facility.

To select the initiating system of intersystem accidents, you can use statistical data for a particular territory and a particular composition of life support facilities. Analysis of the operation of life support facilities revealed the following main causes of accidents (Causes..., 2007):

- dilapidation, poor preparation of engineering infrastructure for the heating season (36%);
- failure to comply with the rules of technical operation of equipment, unskilled actions of maintenance personnel (32%);
- natural factors and natural disasters (21%);
- unauthorized power cuts, gas explosions, fires, etc. (11%)

Statistics on 80,000 accidents and incidents during the year show that 47% occur in water supply facilities and 16% - in heat supply facilities. According to the data collected, repairs last on average 8.5 hours (Over..., 2021).

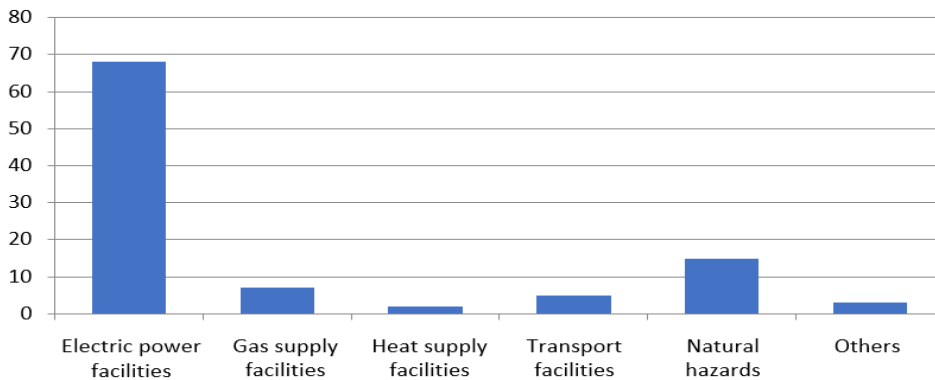
**Step 2.** After determining the initiating ISA facility it is necessary to determine the cause of the accident and identify the emergency element of the life support facility (for example, LSF-1). Determination of the emergency element of the LSF-1 facility is carried out for a given configuration of the facility (composition and number of main elements, types of relationship between the elements) is carried out with Monte Carlo method based on statistical data on the causes and frequency of accidents at LSF-1

objects.

**Step 3.** The next stage of ISA modeling is the selection of the accident development scenario in LSF-1. Complexities of formation of emergency scenarios, especially for a large-scale space distributed life support facility with a large number of equipment elements, lead to the need to form a typical set of scenarios based on a preliminary analysis of statistical data.

**Step 4.** For the chosen scenario of the emergency situation a number of indicators

are assessed: the number of elements of LSF-1 involved, material, social, financial and environmental consequences of the scenario, the duration of elimination of consequences and restoration of normal functioning of LSF-1. The assessment of consequences and duration of restoration is performed both on the basis of data obtained from regulatory documents, and on the basis of probability distributions or expert assessment to generate values of random parameters of the model.



**Figure 1.** Histogram of ISA distribution by triggering event location

The assessment of damage to consumers and the life support facility should be carried out with the possibility of redundancy, such as the use of a second source of electricity or reserve water supplies, which can reduce the amount of possible damage to consumers.

To assess total damage, direct and indirect damage must be determined on the basis of regulatory documents or using statistical data, including the distribution of damage as a random value.

The value of indirect losses in relation to direct losses is not constant, but varies depending on the type of production facility, type of products, scale of production, etc. According to the data (Arkhipets, 2005), this ratio for the main industrial sectors for industrial safety events (accidents, incidents) can vary from 30 to 300%. In this work,

based on the analysis of a number of studies, it was found that between the damage from the failure of industrial equipment and the total losses of the enterprise associated with the restoration of production, downtime and other economic losses, there may be a larger scale ratio of 1:14 to 1:23. That is, indirect damage can exceed direct damage by an order of magnitude or more.

The assessment ratio between direct and indirect damage for labor safety events (fatalities, severe and minor injuries) is also a problem in its own right. This value varies within a fairly wide range. A ratio of 1:6 can be used for preliminary assessments (Timofeev, 2009).

**Step 5.** This element of the algorithm is key in the ISA modeling, because it is associated with the identification of elements of LSF-1,

which may lead to the transfer of emergency perturbations to the interconnected life support facilities.

A formal representation of the interrelations between systems when an ISA occurs is a multidimensional matrix of interactions. This matrix should contain the following information: type of initiating system, number of the considered node; type of "receiving" system, number of the considered node; probability of influence; duration of expected outage; scale of expected consequences. The basic form of the interaction matrix must contain the values of conditional probabilities of transfer

of emergency perturbation from the element of one facility to the element(s) of the other facility(ies).

Table 1 shows an example of an interaction matrix of two life support facilities. Each element of the  $P_{ij}$  matrix represents the conditional probability that an accident that occurred in the  $i$ -th element of the first facility will lead to an accident in the  $j$ -th element of the second facility. The values of the matrix elements are obtained as a result of the analysis of statistical data, or on the basis of expert assessment.

**Table 1.** . Example of an interaction matrix between two life support facilities

Objects of Facility	1	2	3	...	$i$	...	$N$
1	$P_{11}$	$P_{12}$	$P_{13}$	...	$P_{1i}$	...	$P_{1N}$
2	$P_{21}$	$P_{22}$	$P_{23}$	...	$P_{2i}$	...	$P_{2N}$
3	$P_{31}$	$P_{32}$	$P_{33}$	...	$P_{3i}$	...	$P_{3N}$
...	...	...	...	...		...	...
$j$	$P_{j1}$	$P_{j2}$	$P_{j3}$	...	$P_{ji}$	...	$P_{jN}$
...	...	...	...	...		...	
$M$	$P_{M1}$	$P_{M2}$	$P_{M3}$	..	$P_{Mi}$	...	$P_{MN}$

Simulation of occurrence of emergency processes in the interconnected facility takes place in accordance with the values of conditional probability in the interaction matrix. If the modeling shows the possibility of perturbation transfer from LSF-1, for example, to LSF-2, then the type of perturbation function, type and characteristic of interrupted communication (energy or material equivalent), the duration of interruption and other characteristics are determined.

Random processes and quantities which values are random and for the calculation of which Monte Carlo-based statistical testing procedures are used include the following:

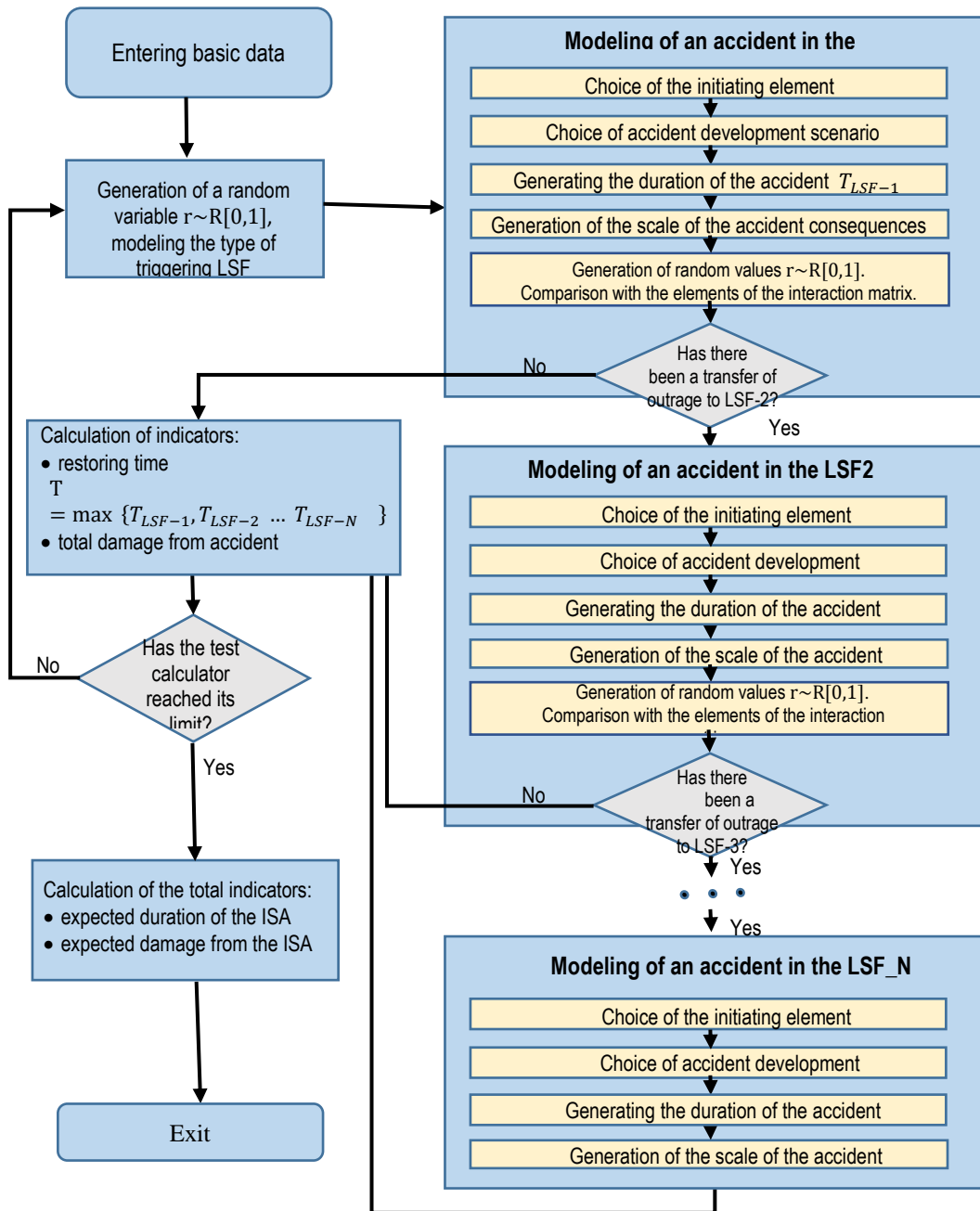
- the cause of the accident;
- emergency element;

- scenario of the development of the emergency process;
- the duration of the elimination of the accident;
- the value of direct and indirect damage;
- the possibility of transferring perturbation to interconnected facilities, etc.

The general scheme of the simulation ISA modeling algorithm is shown in Fig. 2.

The implementation of the above simulation scheme will make it possible to assess the level of adaptive resilience of life support facilities, as well as to identify elements of these facilities that can initiate the intersystem development of emergency situations ("bottlenecks").





**Figure 2.** General scheme of the simulation ISA modeling algorithm

### 3. Conclusion

The work defines a methodical approach to the modeling of emergency interaction of life support facilities, develops the basic provisions and an algorithm for the simulation model describing this process. The ways for further research are outlined.

The most time-consuming task of future research is to develop and implement a system of ISA simulation models. It is advisable to begin this task with small cities or isolated territories, that will allow us to consider interconnected life support facilities in the limited area, as well as a limited

number of possible ISA scenarios. In the future, this experience can be transferred to larger-scale infrastructure-complicated territories.

The main task of future research will focus on finding "bottlenecks" in the interconnected life support facilities that can initiate the intersystem development of emergency situations. Solving this problem with the help of simulation models will make it possible to assess the current level of adaptive resilience of life support facilities and, if necessary, justify the appropriate measures to reduce the risk of ISA.

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## **THE USE OF THE EXCELLENCE EFQM MODEL IN THE HEALTHCARE SECTOR**

***Abstract:** As the healthcare sector is under growing pressure to enhance patient outcomes and reduce costs, quality management systems are becoming increasingly essential to ensure high-quality care and efficient operations. The EFQM (European Foundation for Quality Management) model serves as a framework for assessing an organization's quality management system. This paper provides an overview of the implementation of EFQM in the healthcare sector based on the literature analysis. Findings revealed that the EFQM model is unsuitable for the hospital sector and needs to be customized before it can be used for practical application. In addition, the EFQM model can also be integrated into local, national, or international country-specific models. However, regarding the model's application sector, the EFQM model can be applied to any specialty (emergencies, medical services, primary care services, intensive care services, and so on). To the best of our knowledge, the proposed study is the first that sheds light on the importance of the integration and customization of the EFQM model when it is used in the healthcare sector by various case studies in the literature.*

***Keywords:** Literature review, organizational business excellence, quality management systems, EFQM, healthcare sector*

### **1. Introduction**

The healthcare sector is a critical sector that has a significant impact on individuals and communities worldwide (Burlea-Schiopoiu & Ferhati, 2020). As the demand for healthcare services continues to increase, there is a need for healthcare organizations to implement effective quality management systems (QMS) to enhance patient care outcomes, ensure patient safety, and improve operational efficiency. A robust QMS enables healthcare providers to identify and address potential risks and opportunities for improvement proactively (Rawshdeh et al., 2022). Furthermore, implementing a QMS can help healthcare organizations comply

with regulatory requirements and achieve accreditation or certification, which can enhance their reputation and attract more patients. In addition to implementing QMS, healthcare organizations can benefit from adopting business excellence models, such as the Baldrige Performance Excellence Framework (Garvin D., 1991), the Deming Model (Anderson, Rungtusanatham, & Schroeder, 1994) and the European Foundation for Quality Management (EFQM) Model (Calvo-Mora, Navarro-García, & Periañez-Cristobal, 2015). They have been utilized worldwide to improve the quality of patient care and assess the performance of healthcare organizations (Antunes, Hadi-Vencheh, Jamshidi, Tan, &

Wanke, 2023; Noronha et al., 2023).

The Baldrige Criteria for Excellence in Performance, or the American Model of Total Quality Management (TQM), was developed in response to a crisis in American competitiveness during the information age. Established by the United States Congress in 1987, the model has seven categories that provide strategic direction for the whole system. These categories include leadership, strategic planning, customer and market focus, information and analysis, focus on human resources, management of business processes, and results. Over 60 national and regional awards use the Baldrige criteria as their framework (Garvin D., 1991). Second, the Deming Model (also known as the Japanese Model of TQM), has been in place since 1951, with the Japanese Union of Scientists and Engineers establishing the Deming Award to acknowledge contributions to quality and product. Rather than providing a structured framework for organizing and ranking criteria, the award assesses 10 criteria that carry equal weight. (Anderson et al., 1994). Finally, the EFQM Excellence Model, or the European model of TQM, is utilized as a foundation for good management practices and long-term sustainability. Although each organization is unique, the model offers a generic, non-prescriptive

framework consisting of nine criteria that can be applied to any organization. While there are differences among these models of excellence, most of their objectives and criteria overlap (Heras-Saizarbitoria, Casadesús, & Marimón, 2011; Hosseini Ezzabadi, Dehghani Saryazdi, & Mostafaeipour, 2015).

Several studies have compared these models, highlighting differences in their application category, criterion, scope of assessment, value, and concept (Bohoris, 1995; Doulatabadi & Yusof, 2018; L.J. Porter & S.J. Tanner, 2004; Vaxevanidis, Krivokapic,

Stefanatos, Dasic, & Petropoulos, 2006). Overall, different countries and regions have developed their own national models of excellence or have adopted established models of Total Quality Management (TQM), including the American, Japanese, and European models. A study conducted by Mohammad (2010) provides a summary of the situation regarding the Business Excellence Award and associated models in various regions and countries worldwide. Analysis of the data reveals that European countries tend to prefer the EFQM excellence model or models developed from it, while American countries lean toward the Baldrige criteria as their primary model for excellence, with many models being based on these criteria (Mohammad, M, 2010).

The EFQM model offers a holistic approach to evaluating healthcare organizational performance and management, including assessing the QMS (Bocoya-Maline, Rey-Moreno, & Calvo-Mora, 2023). The EFQM model allows healthcare organizations to have a deeper understanding of their own progress through self-assessment (Bou-Llusar, Escrig-Tena, Roca-Puig, & Beltrán-Martín, 2009). This enables organizations to determine where they stand in their journey toward excellence and plan their next steps (Bocoya-Maline et al., 2023; Nicolaou & George Kentas, 2017; Oubrahim, Sefiani, & Happonen, 2022). EFQM has developed several tools to assist organizations in completing this process, ranging from a simple questionnaire to simulating an EFQM award evaluation. This approach prioritizes a customer-focused approach, continuous improvement, and stakeholder engagement. Selecting an appropriate model or benchmark allows healthcare organizations to improve their business excellence, enhance patient care outcomes, and ensure patient safety. By prioritizing these objectives and choosing an appropriate model or benchmark, healthcare organizations can improve their overall

performance and contribute to the advancement of the healthcare industry. This model also gives a guideline for organizations to establish an appropriate management system regardless of the sector, size, structure or maturity (Ahidar, Sarsri, & Sefiani, 2018). It is a complete model that can be used either at the private sector or the public sector (Josep Davins Miralles, 2007). Based on the reasons cited above, the EFQM model was selected as the preferred model for the healthcare sector assessment.

In light of the ongoing COVID-19 pandemic, research efforts have increasingly focused on the healthcare sector. As such, the use of an excellence model such as EFQM in the healthcare sector has been chosen to be researched. The purpose of the paper is to provide an overview of how the EFQM model is used within the healthcare sector, as well as to examine feedback from those who have implemented the model in their own practices.

The remainder of this paper is structured as follows. Section 2 goes into the methodology employed to conduct the study. Section 3 includes the literature review. The findings and discussions are presented in Section 4. Finally, the summarized conclusion is discussed in Section 5.

## 2. Research methodology

Given the critical nature of the healthcare sector, which strives to provide quality care that directly or indirectly impacts human lives, and the abundance of quality and excellence models, frameworks, and awards, the objective of this study is to investigate the utilization and advantages of the EFQM excellence model in healthcare. Specifically, the study aims to address the following research questions:

RQ1. How do decision-makers operating in the healthcare sector utilize the EFQM model?

RQ2. What are the benefits associated with the adoption of the EFQM model in the healthcare sector?

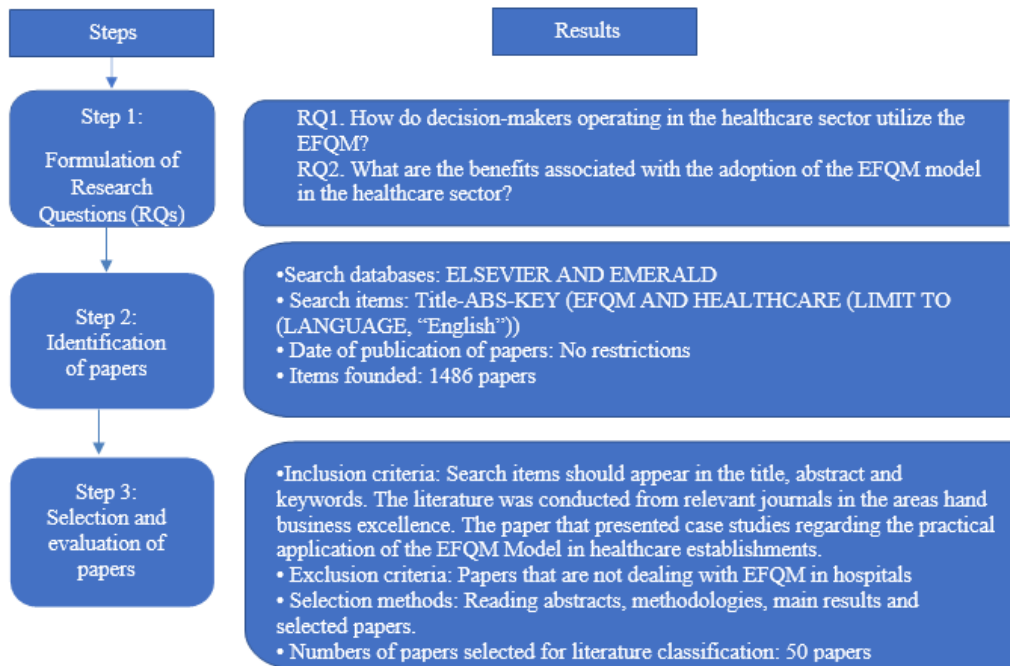
The present study focuses on articles published in the widely recognized academic databases, Elsevier and Emerald, which are widely used search tools in academia. While there are several databases available, these two were chosen due to their extensive coverage. However, it should be noted that this study is not quantitative in nature, and the objective is not to conduct an exhaustive analysis of all articles. The aim is qualitative, with the purpose of identifying key characteristics related to the application and use of the EFQM model in the healthcare sector. Only peer-reviewed journal articles were included in the study, and conference papers and unpublished works were excluded. The search terms "EFQM" and "HEALTH" were used in all texts, summaries, keywords, and titles. Review papers and case studies were considered in the study, without any specific time frame. The search ended in April 2023, resulting in 864 articles in Emerald and 622 articles in Elsevier. After initial screening, a total of 140 articles were identified, which were then rigorously analyzed for practical application and use of the EFQM model. Finally, 50 articles were selected and analyzed using Excel to group the data by job description, place of application, country, methodology, and any integrated models. The steps of the study are summarized in Figure 1.

## 3. Literature review

EFQM model and reported their strengths and weaknesses. They integrated the model with different tools and created "modules for excellences" based on the strengths and weaknesses. Others strengths and weaknesses were also identified in studies by (Naylor, 1999), (Arcelay et al., 1999) and (Nabitz & Klazinga, 1999) (Hayes, 2007) (Ferrándiz-Santos et al., 2010), and several

actions were proposed for implementation. PARETO has been used by authors such as (Martínez, 2012) for prioritizing the essential key points, and (M. P. del Ríoa, et al., 2006) use the score achieved as an internal reference to monitor changes in the quality of service. (Holland & Fennell, 2000a) have concluded that the assessment tool generated useful discussion within hospitals and provided an opportunity for the teams to explore current issues relating to their services. Factors that managers take into consideration during the implementation process to let the EFQM model be an ideal tool for supporting the delivery of clinical governance are discussed in (Jackson, 2000) (Escrig & de Menezes, 2016). The EFQM model has been used for both internal and external assessment by authors such as (Nabitz & Walburg, 2000) and (Moracho et al., 2001) (Ugalde, Sierra, & Pardo, 2001) (Rodríguez-González et al., 2019). The assessment must be aligned with continuous improvement and repeated as necessary to follow the scores of the different criteria. (Favaretti et al., 2015), applied the model over ten years and demonstrated improvement in evaluation results. Barriers and difficulties encountered in the process of EFQM implementation are discussed in (Moeller & Sonntag, 2001) and (Jackson & Bircher, 2002) (Güven-Uslu, 2005) (Ignacio et al., 2001). (Stahr, 2001), mentions improvement of performance indicators such as the reduction of average length of stay for a dedicated hernia service. (Simón, Guix, Nualart, M. Surroca, & Carbonell, 2001) suggest that the EFQM vocabulary is not suitable for healthcare and should be integrated with the Joint Commission. However, (Fernando Palacioa, Ignacio Pascualb, & Jordi Danielc, 2002), has

translated it into clinical terms to make it understandable and easy for users, and (Moreno-Rodríguez, Cabrerizo, Pérez, & Martínez, 2013), has proposed a consensus support model based on linguistic information to conduct the self-assessment. Several authors highlight the importance of not neglecting the link between strategic and operational levels in the application of the models and the implication of several levels of managers, including (Sánchez et al., 2004) and (Rodríguez-Balo & Ferrándiz-Santos, 2004) (Vakani, Fatmi, & Naqvi, 2011) (Vernero, Nabitz, Bragonzi, Rebelli, & Molinari, 2007). (Robles-García et al., 2005), used some factors of the EFQM relative to “people” to assess the satisfaction of hospital workers, and van (van Harten, Casparie, & Fisscher, 2002), underlined the positive effects both in the EFQM-score and the staff’s work satisfaction. The EFQM model has been applied, adapted and integrated by several authors in various contexts, including (Martínez-Rodríguez, Urdaneta Pignalosa, Rosales Bordes, & Villavicencio Mavrich, 2008) (Ayuso-Murillo, de Andrés-Gimeno, Noriega-Matanza, López-Suárez, & Herrera-Peco, 2017) (Ahidar, Sarsri, & Sefiani, 2019; Mishra, Samuel, & Sharma, 2018) (Palani Natha Raja, Deshmukh, & Wadhwa, 2007) (Emilio Pariente, 2003) (Oliver, 2005) (Harr, 2001). (J. Davins Miralles, 2011) has tested the model before applying it to validate it. (Manzanera et al., 2014) used the model to evaluate previous approaches in literature. (Bartolomé-Benito et al., 2016) proposed the use of the balanced scorecard as a dashboard to display all the indicators based on the EFQM. (Jackson & Morgan, 2007) used the RADAR approach for the application of the EFQM.



**Figure 1.** Research methodology

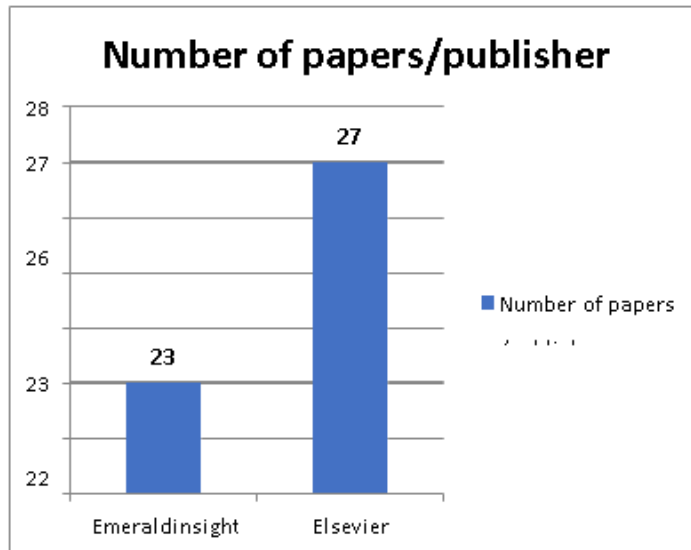
Regarding the strengths of the EFQM model, (Stewart, 2003) found that the "customers" result showed a high level of customer awareness, customer satisfaction, and generic training. (Saz Moreno et al., 2007) found strengths in processes and people. (Fariñas-Álvarez et al., 2008) used the EFQM model to benchmark different hospitals, identifying good practices in hospitals within the national health system.

Moreover, some authors have used the EFQM model for specific activities or objectives. For instance, (Mateo, de la Fuente, & Borrego, 2009) used the EFQM for the unit security plan, while (Mingo-Gómez, Navas-Cámara, Bayona-Marzo, Pérez-Gallardo, & Fernández-Pérez, 2012) and (Hashemy, Yousefi, Soodi, & Omid, 2016) used the model for measuring the satisfaction of personnel and human

empowerment. Additionally, and (de la Fuente Rodríguez et al., 2013) and (Saura et al., 2014) used the model to measure patient safety.

#### 4. Findings and discussions

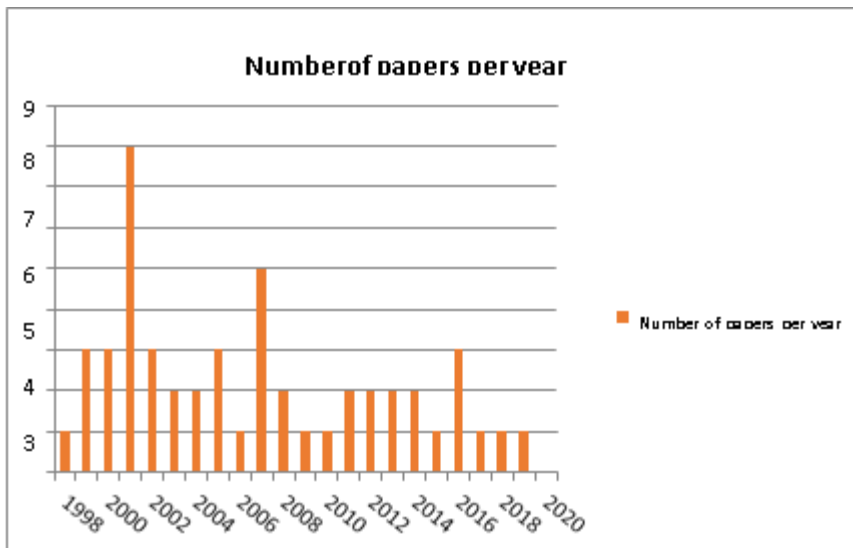
According to the analysis, the EFQM model has been employed across various sectors, particularly in healthcare. The way in which this model is utilized varies depending on the requirements of managers. On one hand, some healthcare organizations integrate the EFQM model with other standards or models, while on the other hand, some prefer to use it independently but adjusted to suit their operations. Findings revealed that there is a little difference between the numbers of papers per publisher (Fig 2).



**Figure 2.** Number of papers per publisher

Furthermore, the results showed that the first articles that deal with the application of the model appeared in 1998/ 1999, this can be explained by the fact that the EFQM model was developed in 1992 and began to be applied in the late nineties (Figure 3). Indeed, in 1999, the EFQM launched the

revision of the model and created the network of partners. The year 2001 saw a high number of publications; this is explained by the launch of the levels of excellence in 2001 by the European Foundation for Quality Management.

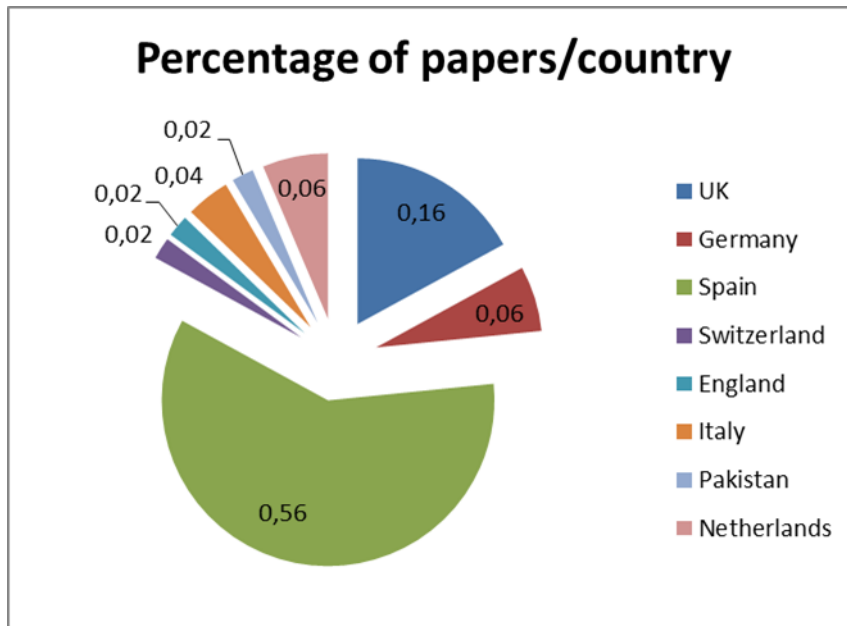


**Figure 3.** Number of papers per year



The EFQM model is more widespread in Europe. For the 50 papers filtered, the EFQM was applied in different countries (Figure 4) such as: Spain, Germany, UK,

Netherlands ...The most of the papers are located in Spain (56 %).



**Figure 4.** Percentage of papers per country

Institutions prefer to integrate the EFQM model with other models or to apply it on its own (Figure 5). 28 studies were applied without integration into other models, 22 studies were integrated into different models in particular sectoral and national models specific to the countries where the model was applied. Only 2 studies have integrated the EFQM model with ISO family, this is explained by the fact that hospitals do not have the obligation to be ISO certified unlike the automotive sector where customers require certification IATF 16949 (before ISO TS 16949).

45 studies have adapted the model to the activity before applying it because terminology is important and make the self-assessment easy to understand. The authors find that the EFQM model is not suitable for the hospital sector and must be personalized

before the use in order to be effective.

The healthcare sector has some unique characteristics that distinguish it from other industries. Healthcare organizations have to deal with complex patient needs, high levels of risk and uncertainty, and a range of stakeholders with competing interests.

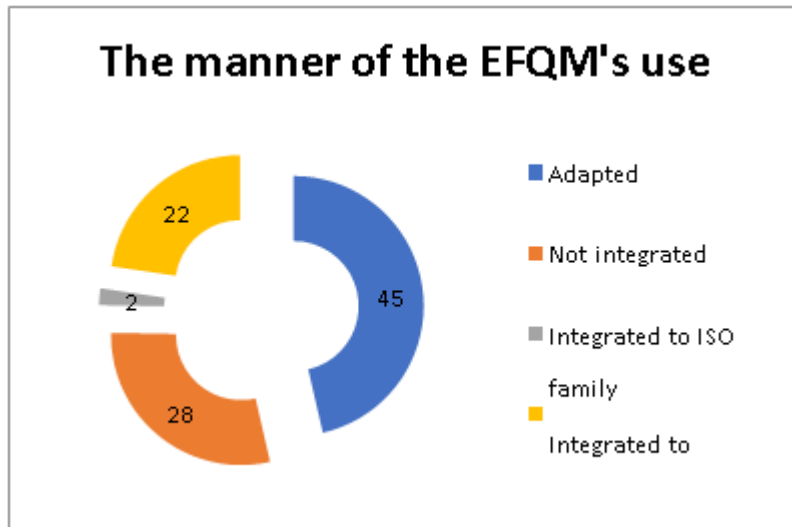
Therefore, to effectively apply the EFQM model to the healthcare sector, it needs to be adapted to address the specific challenges and requirements of healthcare organizations. For instance, the EFQM model should incorporate the values of patient-centered care and the importance of involving patients and their families in decision-making processes.

Additionally, healthcare organizations need to take into account the regulatory requirements and standards that govern the

industry, such as those related to patient safety, privacy, and confidentiality. Therefore, the EFQM model needs to be aligned with these regulations and standards to ensure compliance and enhance the overall quality of care.

In conclusion, the EFQM model can be a valuable tool for healthcare organizations to

improve their performance and enhance the quality of care they provide. However, to be effective in this sector, the model needs to be adapted to address the unique characteristics and requirements of healthcare organizations.



**Figure 5.** The manner of the EFQM's use

Regarding the sector of application of the model, the model has been applied to different specialties:

- Emergencies (Moreno-Rodríguez et al., 2013)
  - Internal medicine(Martínez, 2012)
- Primary care services(Emilio Pariente, 2003)
- Intensive care services(Saura et al., 2014)
- Dental practice (Vakani et al., 2011)
- Pharmacy (Rodríguez-González et al., 2019)
- Acute care (Möller & Sonntag, 1998)
- Service unit Rehabilitation (Möller & Sonntag, 1998)
- Mental health (Holland & Fennell, 2000b)
- Learning disability (Holland & Fennell, 2000b)
- Forensics(Holland & Fennell, 2000b)
- Anti addiction center (Nabitz & Walburg, 2000)
- Maternity (Ignacio et al., 2001)
- Oncology (M. P. del Río, et al., 2006)
- Coronary heart disease services (Jackson & Morgan, 2007)
- Hospitalization zone(Saura et al., 2014)
- Surgical area (Saura et al., 2014)
- Intensive medicine service(Saura et al., 2014)

- Diabetic service (Mishra et al., 2018) .... And others

All the experiences (100%) show positive feedback on using the EFQM model on healthcare sector, because it a suitable tool that shows the strengths and weaknesses of any organization (hospital, primary care...) and specialties.

The studies that have been adapted the model suggest that the EFQM is more effective when it is adapted and integrated with others standards.

The EFQM was integrated to different tools, models or standards. Sometimes it is integrated or combined with one other standard, two or more depending on the need

and the objective of the establishment. The different techniques, methods or tools that were used with the model EFQM can be classified in two categories: local and national or international (Table 1).

The table 1 shows that the model EFQM can be integrated with various models, techniques local, national and international.

The scorecard is the most used tool in our case (three studies), because of the common points that exist between EFQM and BSC. In fact, the axis of the BSC: financial, customer process, education and growth are included in the EFQM which will make the integration easier.

**Table 1.** The methods and techniques combined with the EFQM in literature in healthcare sector

Local and national	International
PUACS (Preparation-Undertake-Analyze-Correct-Sustain) (Mingo-Gómez et al., 2012)	SWOT (Rodríguez-González et al., 2019)
CPC (Contrato Programa de Centro) (Bartolomé-Benito et al., 2016)	BALANCED SCORE CARD (Rodríguez-González et al., 2019)
The approach of LOPEZ-FRESNO (Manzanera et al., 2014)	SURVEYS (Rodríguez-González et al., 2019)
Consensus support model based on linguistic information (Moreno-Rodríguez et al., 2013)	AHP (Mingo-Gómez et al., 2012)
JCI (Joint Commission International) (J. Davins Miralles, 2011)	FOCUS GROUP (Mingo-Gómez et al., 2012)
the Catalan Institute of Health (J. Davins Miralles, 2011)	DMAIC (Mingo-Gómez et al., 2012)
EET (los ejes transversales) (Ferrándiz-Santos et al., 2010)	6 SIGMA (Mingo-Gómez et al., 2012)
Key indicators of the Spain National health system (Martínez-rodríguez, Rosales bordes, & Villavicencio mavrigh, 2008)	BSC (Bartolomé-Benito et al., 2016)
The APEX PH (Assessment Protocol for Excellence in Public Health). (Oliver, 2005)	SCORECARD (Saura et al., 2014)
(NPHPSP) National Public Health Performance Standards Program (Oliver, 2005)	(Rodríguez-Balo & Ferrándiz-Santos, 2004)
The personal satisfaction survey (Robles-García et al., 2005)	MBNQA (Martínez-rodríguez et al., 2008; Palani Natha Raja et al., 2007)
Receptive context of change model (Guyen-	kanji Business Excellence Model (Palani Natha Raja et al., 2007)
	TQM (Saz Moreno et al., 2007)
	DELPHI (Moreno-Rodríguez et al., 2013)
	(Oliver, 2005)
	PARETO (Martínez, 2012)
	modèle Hoshin Kanri (Rodríguez-Balo & Ferrándiz-Santos, 2004)
	Matrix chart (Möller & Sonntag, 1998)

Uslu, 2005)  
 Model GIB (General, Integrativo y Básico)(Rodríguez-Balo & Ferrándiz-Santos, 2004)  
 BASAM(van Harten et al., 2002)  
 The model of Lorenzo (Fernando Palacioa et al., 2002)  
 ACE(Accountability,Culture, Effectiveness)(Holland & Fenne II, 2000)  
 INK Model(Institute of Dutch Quality model )(Nabitz & Klazinga, 1999)

### 5. Conclusion

The proposed study has demonstrated that the EFQM model is highly recommended for the hospital sector, as it provides managers with insights into the strengths and weaknesses of their organization. However, for an effective implementation, it is advisable to adapt or integrate the model with other relevant techniques, standards or methodologies that managers consider useful. Our research has reviewed various models that have been successfully integrated with the EFQM in literature, which can serve as a source of inspiration for professionals and researchers.

To ensure a successful implementation, it is important to prepare an adapted or integrated EFQM model that is well-structured and based on validated methodologies or approaches published in literature. This will enable an easy, efficient and optimal implementation process.

Nonetheless, the implementation of an integrated EFQM model must also take into account the potential obstacles and challenges that have been highlighted in the literature. For instance, there is a risk of neglecting the importance of a critical variable, as well as a lack of communication and competent resources. Therefore, these potential issues should be addressed in the

planning phase to ensure the success of the integrated system.

Furthermore, it is important to note that the implementation of an integrated EFQM model should be viewed as an ongoing process rather than a one-time event. Managers must continuously monitor and evaluate the system to identify areas that require improvement and make necessary adjustments. This ensures that the system remains relevant and effective in the constantly evolving healthcare landscape.

In addition, involving all stakeholders in the implementation process is crucial (Oubrahim & Sefiani, 2022; Oubrahim, Sefiani, & Happonen, 2023; Oubrahim, Sefiani, Happonen, & Savastano, 2022; Oubrahim, Sefiani, Quattrociocchi, & Savastano, 2022). This includes not only managers but also staff, patients, and other external stakeholders such as regulatory bodies. Their feedback and insights can provide valuable perspectives that can be incorporated into the integrated EFQM model.

Finally, it is essential to ensure that the implementation of an integrated EFQM model is aligned with the organization's overall goals and objectives. This will ensure that the system is integrated seamlessly into the existing structure and processes, and contributes towards achieving the desired outcomes.

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## IMPROVING ACTIVE DISTURBANCE REJECTION DRC CONTROL FOR ROBOTICS HOME-BASED TO LOWER EXTREMITY REHABILITATION CARE

**Abstract:** *This study is intended to be used as a fundamental guideline for developing locally established restoration frameworks for exoskeletons (Robotics), particularly in the event of the COVID-19 pandemic. This work describes a one-degree-of-freedom exoskeleton-leg dynamic demonstration and control recreation (automated knee joined with sitting level). The linear active disturbance rejection control (LADRC) and the corresponding proportional-derivative-integral (PID) controller for position and speed control are the two regulators that make up the control structure. The findings of the MATLAB reconstruction reveal that the proposed regulator (LADRC) has a respectable potential for providing scheduled recovery treatment to reduce appendages, particularly for direction following error. The results of the proposed controller (LADRC) demonstrate quicker reactions with settling time and steady-state error are very small.*

**Keywords:** *Exoskeleton system, ADRC controller, PID controller, Robustness, Tracking performance*

### 1. Introduction

In the last 20 years, an increasing number of neurological conditions such as hemorrhage, spinal cord damage, and Disease were reported for people of all ages. The World Health Organization (WHO) identified "brain hemorrhage" as the third leading cause of weakening worldwide and one of the main causes of over 5 million casualties between 2000 and 2016 (World Health Organization [WHO], 2016) due to the development of certain illnesses. The demand for recovery administrations is rising globally. Controlled lower extremity orthotic devices, often known as motorized skeletons, and frequently regarded as aids in rehabilitation and the improvement of human gait. These devices have undergone

extensive development and presentation work, and there are still numerous problems that need to be studied due to the inherent demands of flexibility and safe interaction with the user and the environment. The control of these devices is conceivably one of the major approaches for working on their exhibition (Young & Ferris, 2017).

The analysts have been addressing existing provokes and prerequisites to configuration, control and develop recovery robots appropriate for home treatment. Subsequently, many at-home recovery gadgets have been planned inside the exploration domain (Aylar et al., 2021). Additionally, the present state of the global crisis increases interest in robot-assisted restoration frameworks in order to reduce the risk of contamination for both patients and

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medical care provider organizations (Kimmig et al.,2020). Robot-helped recovery practice for useful variation of knee joint broadens an extraordinary chance for post-stroke patients. Likewise could be an extraordinary apparatus to gauge utilitarian enhancements of muscles and joint movements.

An robotic leg's instrumentation setup is capable of performing accurate location and power estimations as well as being prepared to collaborate with humans (Huang et al.,2019). More critically, electro-mechanical actuators of the framework can play out an undertaking more than once inside the ideal work area of a joint. The test in this field is to discover suitable control systems for these gadgets, which can be adjusted to the useful abilities of the clients, for a consistent intellectual and physical interaction. Hence, users and exoskeleton should cooperate during restoration, in an instinctive and synergistic way, to permit more normal developments, and work with their contribution for an improvement at their neural versatility. For this reason, diverse control approaches dependent on movement aim have been accounted for to work on the exhibition of the exoskeleton to execute activities that are both fitting for the restoration errand and compares to the client's assumptions (Tucker et al.,2015). Due to the dubious components and the inadvertent subject's reactions during walk recovery, the design of an exact control system for a low appendage skeleton framework does not present many challenges. For more than a decade, lower appendage exoskeletons and orthoses have been controlled by typical automated stages.

The purpose of the exoskeleton control is to aid the wearer in partially or completely reestablishing engine function. The majority of these recent publications emphasize the use of conventional PD or PID control techniques. It is well recognized that these regulators are weak to model errors and

disturbances (Akhtaruzzaman et al.,2020). For (Rifai et al.,2011), a bounded control force was applied gradually while employing the EICOSI orthosis to regulate a lower appendage orthosis placed to the knee joint for restorative items. Observations revealed a good match between patient joint development and the expected path in a respectable amount of time. It is suggested in (Mefoued et al.,2011) to employ a controlled knee-joint orthosis to restore human lower appendage growth, particularly the knee extension of the lower leg.

The control method relied on the Higher Ordering Sliding Mode Control (HOSMC) process. To assess the suitable control law's robustness, testing using conventional PID regulators was conducted. HOSMC's display tends to be more well-liked. To comprehend the regular gait, however, very few scientists have looked at the best control, in particular the linear quadratic controller. Additionally, by approximating the linear time-changing structure and substantially limiting the computational complexity linked to a few nonlinear regulators, LQR as a linear control plan may be utilized for nonlinear framework components (Knee joint model). However, the LQR is the best control strategy and should be used to identify ambiguous exoskeleton components (Castro & Zhong,2018). However, chattering due to erroneous exchanging is a problem for the sliding mode control (SMC) technique, which can limit against vulnerabilities and boundary vacillations [Wei & Aiguo,2020; Li et al.,2014]. Before the concept of active disturbance rejection control (ADRC) recently emerged, there was some work to be done managing the plant's uncertainties, including the affects of disturbances and its obscure components.

Numerous designing tools use it (Parvathy and Asha,2013; Huang and Xue,2014) to overcome these control issues at hand. The basic motion of the human knee, as according to biological traits, is flexion-

expansion in the frontal plane. In this approach, the plan of the device knee always has a single absolutely turning DOF (Li et al.,2019). The advantages of this approach include a reduction in weight and an increase in the complexity of the exoskeleton and control frameworks.

This work introduces the design and control reproduction of a 1-DoF automated limb for knee practice in order to reduce weight. An exceptional seat is attached to the limb so that a disabled person can be seated on it and perform treatments for their knee joints. In this work, an input regulator, which makes up for the absolute unsettling influences by simple linear active disturbance rejection control (ADRC) is intended to balance out knee movement joint controller framework. The paper's contribution of this study can be highlighted by the following points:

- An improved ADRC built by modified the ESO for traditional ADRC depending on desired trajectory response with a one design parameter related to closed-loop poles location.
- The proposed controller satisfied the stability criterion by using pole-placement technique.
- Study the validity of modified ESO for estimation and cancellation by a proper controller law

## 2. Methodology

In this section, we introduce the basic concepts behind the knee-joint mathematical model, as well as the ADRC control elements, and develop the suggested controller.

### 2.1 Knee-joint mathematical model

As shown in Figure 1, which depicts the skeleton is controlled through a controller that transmits power to the lower leg, the relatively lower extremity framework in this article consists of a person wearing an

activated orthosis chair that swings in around lower leg. Throughout this framework, the strap synchronizes movement between the two portions and links the exoskeleton to the human leg. The considered dynamic orthosis's mechanics design outline shows that is the exact position of the involved knee joint, in which  $\theta = 0$  rad refers to complete leg extension,  $\theta = \pi/2$  rad is the resting condition, and  $\theta = 3\pi/4$  rad is the maximal leg flexion.

The top and bottom halves of the motorized exoskeleton each have (1DoF). An active segment of a DC brushless motor drives the top portion. Typically, the person leg and the incorporated motorized exoskeleton constitute up the system. The exoskeleton is a piece of machinery that is fixed to the participant's knee using straps and fits properly on that leg. The corresponding models for the shank and orthosis will be derived similarly. It is based on the kinematic concept of materials in rotational:-

$$J\ddot{\theta} = \sum \tau_i \quad (1)$$

$J$  represents the overall inertia, and  $\tau$  represents the torques applied to every joint's leg orthosis. The lower leg joint orthosis model can be expressed as follows using the Lagrangian formulas (Han ,2009; Hala et al.;2012; Kashif et al.,2019):

$$J\ddot{\theta} = -\tau_g \cos\theta - A \operatorname{sgn}\dot{\theta} - B\dot{\theta} + \tau_h + \tau_e \quad (2)$$

Where  $\dot{\theta}$  and  $\ddot{\theta}$  are, respectively, the lower leg angular velocity and acceleration, and  $\theta$  is the knee joint angle between the exact place of the shank and the fully adjustable location, while  $\tau_e$  is the desired exoskeleton torque. The solid friction factor, viscosity friction coefficient, gravity torque, and person disturbance torque are denoted by the letters  $A$ ,  $B$ ,  $\tau_g$ , and  $\tau_h$ . The measurements of the adult limb are listed in Table 1 (Hala et al.,2012; Kashif et al.,2019).

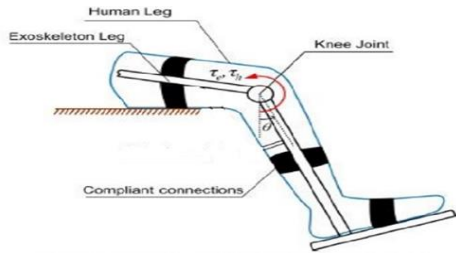


Figure 1. An exoskeleton around the knee

## 2.2 ADRC design

In the remainder of this work, an ADRC is intended to manage the following issue for the knee joint 1-DoF controller framework presented in the section 2.1. The outline of the planned control framework is displayed in Figure 2.

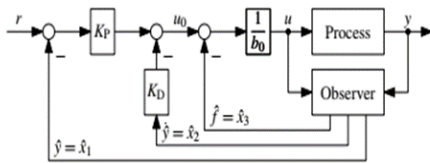


Figure 2. ADRC structure

To prevent overflow and enhance control performance, divide the reference input signal into two parts. The first portion should represent the desired trajectory, and the second should be its derivative. Consider the powerful framework in equation (2) that can be represented by the development of a second order nonlinear conceptual framework:

$$\ddot{\theta} = f(t, \theta, \dot{\theta}, w) + b\tau \quad (3)$$

$b$  is a boundary that is an established one. The abbreviation " $f$ " refers to the combined effect of internal and external influences. In actual situations, it is usually difficult to get an exact mathematical representation of  $f$ . ADRC offers a really important solution to this problem. The key idea is that, if  $f$  can be evaluated gradually in some fashion, it will typically be dropped using the control action,

turning equation (3) into a second integration process. In other words, a time - variant unidentified system of equation 2 is roughly decreased to a continuous - time basic system that may be successfully regulated using, for example, a PD regulator. This ingenious idea is what changes a control problem into an estimating problem. The following is how the suggested layout is presented:-

### A- Extended-state observer (ESO)

The structure in equation (2) can be expressed using the state space form shown as :(Han, 2009;Wammeedh et al.,2020; Amjad,2018)

$$\begin{aligned} \dot{x}_1 &= x_2 \\ \dot{x}_2 &= x_3 + b_o \tau \end{aligned} \quad (4)$$

$$\begin{aligned} \dot{x}_3 &= \hat{f} \\ y &= x_1 \end{aligned}$$

When equation (4) expressed in state-space matrix notation:-

$$\begin{aligned} \dot{x} &= Ax + B\tau + Eh \\ y &= cx \end{aligned} \quad (5)$$

Where

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix}, B = \begin{bmatrix} 0 \\ b \\ 0 \end{bmatrix}, E = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}, c = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \quad (6)$$

The observer of equation (5), in this case takes the form of the most widely used linear Luenberger-like estimator, which is:-

$$\begin{aligned} \dot{\hat{x}} &= A \hat{x} + \hat{b} \tau_c + L (y - \hat{x}_1) \\ \hat{y} &= C \hat{x} \end{aligned} \quad (7)$$

Where,  $\hat{x} = [\hat{x}_1 \ \hat{x}_2 \ \hat{x}_3]^T$  is the respective vectors representing estimates for  $y$ ,  $\dot{y}$ , and  $f$ . Since the state vector in equation 4 is expanded to include  $f$  and this observer is made to offer an estimate of that, it is known as the ESO. When properly planned and executed, the observer equation (7) will track the plant in equation (5). The pole-placement approach, for instance, can be used to

determine the variable vector  $L$  (Mefoued,2014). Let the characteristics equation for the ESO design be as follows for simplicity:-

$$Q(s) = |SI - (A - LC)| = (S + w_o)^3 \quad (8)$$

And the observer gains can be calculated as:-

$$L = [3 w_o \quad 3 w_o^2 \quad w_o^3] \quad (9)$$

There are just two borders in the ESO:  $b_o$  and  $w_o$ . Engineers are familiar with the former, and it can also be obtained by open-loop system response or ( $b \approx b_o$ ). The final stage is an adjusting parameter that increases the observer's bandwidth. Productivity and noise sensitivity can indeed be significantly compromised by tuning  $W_o$ .

The state space equation (4) can be expressed as (Wameedh et al., 2021) to modify ESO for increasing the ADRC performance.

$$\begin{aligned} \dot{x}_1 &= x_2 \\ \dot{x}_2 &= -w_c^2 x_1 - 2w_c x_2 + x_3 + b_o \tau \quad (10) \\ \dot{x}_3 &= \dot{f} \\ y &= x_1 \end{aligned}$$

Where  $w_c$  controller bandwidth. The desired closed-loop transfer function given by:-

$$\frac{Y(s)}{R(s)} = \frac{w_c^2}{s^2 + 2w_c s + w_c^2} \quad (11)$$

The modified ESO for equation (10) and related to equation (7) is:-

$$\begin{aligned} \dot{z}_1 &= z_2 + \alpha_1 (y - \hat{y}) \\ \dot{z}_2 &= -w_c^2 z_1 - 2w_c z_2 + z_3 + b_o \tau + \alpha_2 (y - \hat{y}) \\ \dot{z}_3 &= \alpha_3 (y - \hat{y}) \\ \hat{y} &= z_1 \end{aligned}$$

The modified observer gains are calculated as:-

$$\begin{aligned} \alpha_1 &= 3w_o - 2w_c \\ \alpha_2 &= 3w_o^2 - w_c^2 - 2w_c \alpha_1 \\ \alpha_3 &= w_o^3 \end{aligned} \quad (12)$$

As seen from the equation (12), the first parts of it is the same as equation (9).

### B- Controller design

Where estimate of  $x_3 \approx f$ , it can be get the control strategy :- (Han,2009; Mefoued,2014)

$$u = \tau = \frac{(w_c^2 r - f)}{b_o} \quad (13)$$

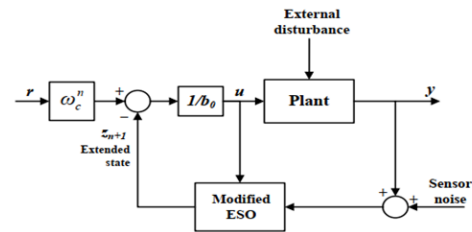
So that reduce equation (3) to simple second order:

$$\begin{aligned} \ddot{y} &= \ddot{\theta} = -2w_c \dot{y} - w_c^2 y + f + \\ b_o \left( \frac{-z_3 + w_c^2 r}{b_o} \right) &\approx -2w_c \dot{y} - w_c^2 y + w_c^2 r \end{aligned} \quad (14)$$

Equation (14) is identical to equation (11), when represent as transfer function. To calculate  $w_c$  and  $w_o$ , these related to design specifications, specially the settling time  $T_s$ , so that (Chen ,2011; Gao,2003):-

$$w_c = \frac{10}{T_s} \quad (15)$$

In this study, if select  $T_s=0.4$ sec, then  $w_c = 24.5$ rad/sec and the value of observer bandwidth  $w_o$  is calculated as  $w_o = 4w_c$  (Gao, 2003). Figure 3 show modified ADRC for any order.



**Figure 3.** ADRC with modified configuration

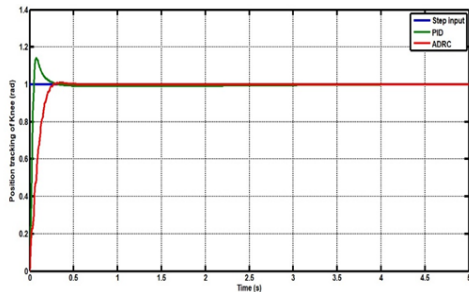
### 3. Simulation result and discussion

This part considers a numerical simulation to show the performance of the proposed control method. The following conditions are selected for equation (2):- (Hala et al.,2012; Kashif et al.,2019)

$$\begin{aligned} J &= 0.4 \text{ kg. m}^2, A = 0.6 \text{ N. m, } B = \\ &1 \text{ N. m. sec. rad}^{-1} \text{ and } \tau_g = 5 \text{ N. m.} \end{aligned}$$

**3.1 Without effect of disturbance**

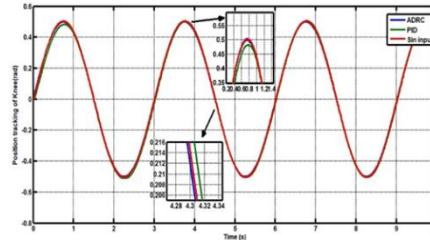
The proposed ADRC and comparing with PID controller were tested by carrying out the simulation in MATLAB(2020b) MathWorks. In this work the desired trajectory of the knee joint is taken as predefined by the doctor is (sinusoidal input) with magnitude (0.5) and frequency (2rad/s) and for general test signal(step input). In this case the performance of the proposed ADRC is compared with classical controller (PID) without external disturbance. The PID controller settings ( $K_p = 150$ ,  $K_i = 80, K_d = 15$ ) are calculated by trial and error and some tuning. The observer gains of equation 12 are ( $\alpha_1 = 239, \alpha_2 = 16501, \alpha_3 = 941192$ ). Figure 4 show the trajectory tracking performance of mentioned controllers for the knee joints for step input and Figure 5 for sin input.



**Figure 4.** Trajectory tracking comparison between ADRC and PID controller without disturbance for step input

As seen from Figure 4 the maximum overshoot  $M_p=0.005\%$  for ADRC and  $M_p=14.4\%$  for PID controller, while the transient response speed for ADRC is very high, when compared with PID to reach the steady-state. The root mean square error (R.M.S.E) for ADRC is(0.0024rad), while for PID is(0.982rad). The trajectory tracked by ADRC has best reference tracking than PID controller. For sin wave input as shown in Figure 5,

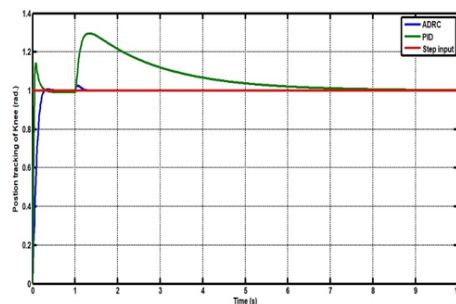
also it is clear that the differences in transient trajectory and appear the improvement of ADRC.



**Figure 5.** Trajectory tracking comparison between ADRC and PID controller without disturbance for sine input

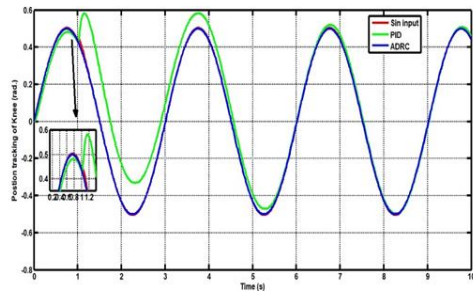
**3.2 With effect of disturbance**

We also assess the ADRC and PID control's ability to reject perturbations only with introduction of a permanent disruption. They are all set to produce the very same closed loop response. After attaining steady state, a unit step perturbation of magnitude (5N.m) is introduced to every control loop for a one-second duration. From Figure 6, it is clear that ADRC corrects the disturbance much more quickly, ensuring that its impact on the control variable stays minimal. Though PID controller could also be compensated with high overshoot and take more time to reach the steady state. This state also can be conclude for sine input signal as shown in Figure 7.



**Figure 6.** Trajectory tracking comparison between ADRC and PID controller with constant disturbance for step input

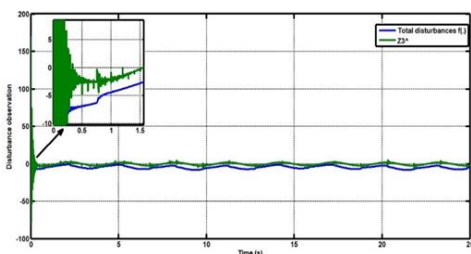




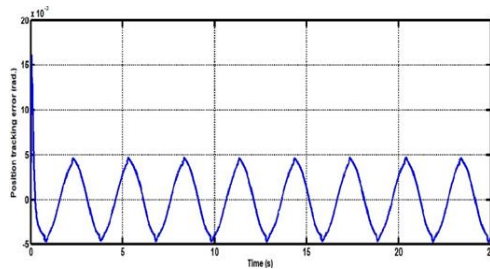
**Figure 7.** Trajectory tracking comparison between ADRC and PID controller with constant disturbance for sine input

### 3.3 Validity of ESO

The way to the success of the ADRC is the ESO, which empowers the regulator to effectively make up for the progressions in the dynamics (inertia) or the unsettling influences. To see the adequacy of the ESO, we plot the estimation state ( $Z_3$ ), against its objective (total disturbances), and complete unsettling influences, which is the subordinate of  $f(\cdot)$ . In Figure 8, it is shown that  $Z_3$  tracks, the complete aggravations  $f(\cdot)$  intently and R.M.S.E value is (0.07058rad). This permits the control law  $u(t)$  to move the plant in Equation 3 to a roughly double integrator, which can be effortlessly controlled with the PD controller. Figure 9 shows the transient trajectory error at force aggravation (sin wave) with magnitude (1) and frequency (0.5rad/s) with R.M.S.E value is (0.004262rad).



**Figure 8.** Total disturbance and its estimation



**Figure 9.** ADRC position tracking error

## 4. Conclusion

This study proposes a dynamic representation and reproduction of an exoskeleton-assisted knee joint exercise recovery system. This paper shows a control scheme for a 1-DoF exoskeleton leg's trajectory tracking. By reproducing for various input kinds, the suggested control engineering's reasonability is evaluated (step, sine). The main goal is to exercise the knee joint with the aid of an exoskeleton, ensuring a consistent and steady movement design. This type of scheduled restoration framework is desired for medical helpful practice in the COVID-19 situation to ensure the separation relationship while providing the types of support to the patients. The fundamental goal of this work is to draw out the advantage of arranging control techniques towards hearty methodology for human help and restoration cycles to make up for changes in the human-orthosis elements. Two different control laws (PID, ADRC) were tested in different operational scenarios. The results reveal that, when compared to the PID controller, the ADRC controller exhibits the least error and the smallest overshoot. When such perturbations are present, the modified ADRC controller performs as desired in respect of position error. Although the estimation error tends to reduce as observer bandwidth rises, this has the opposite effect on control action, which rises as observer bandwidth increases, particularly with step input. For showing the effectiveness of ESO, it is clear that the extra

estimated state variable ( $z_3$ ) can be cancelled the total disturbances (external torque and uncertainties) with R.M.S.E is (0.07058rad) and the error between the reference input ( $r$ ) and the position trajectory output ( $y$  or  $\theta$ ) is almost equal zero, with R.M.S.E is(0.004262rad). This research can be expanded in the future by including new observation techniques or

designing additional control systems, either to improve the ADRC or to compare performance (Humaidi et al.,2018a; Aljuboury et al.,2022; Humaidi et al.,2018b; Nasir et al.,2022; Alawad et al., 2022; Shaymaa et al., 2022). The suggested controller for 2-DOF of motion, which is used with the Knee-Hip Exoskeleton system, may be expanded in future study.

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## CARDIOVASCULAR DISEASE RISK PREDICTION USING DEEP LEARNING

**Abstract:** An unhealthy lifestyle is a direct result of today's hectic schedule, which contributes to anxiety and depression. There is a tendency to resort to excessive drug use in order to overcome these conditions. Numerous dangerous diseases, including cancer, cardiovascular disease, are brought on by all of these factors. The World Health Organization (WHO) says that Cardio Vascular Diseases (CVDs) cause the most deaths worldwide. They have become extremely common over time and are now putting much strain on nations' healthcare systems. Rapid, precise, and prompt clinical evaluation of disease severity is essential at this stage. An efficient data prediction based on deep learning was proposed in this work to assist in healthcare systems' decision-making and logistical planning. The Long Short Term Memory (LSTM) classifier's efficacy can be demonstrated by employing our method on the MIMIC-II database, which is freely accessible. Our proposed method improves prediction accuracy, as demonstrated by experiments.

**Keywords:** Long-Short Term Memory (LSTM), Artificial Neural Networks (ANN), Recurrent Neural Network (RNN)

### 1. Introduction

The healthcare industry is producing an enormous amount of data at a rapid rate. A machine learning dataset typically consist of multiple instances or examples, each of which has a set of features or attributes that describe it. The data in a data set can take many forms, including numerical values, images, text and more. The digitization of healthcare data, including biomedical images, clinical text, genomic data, Electronic Health Records (EHRs), sensing data, biomedical signals, and social media, has led to the rise of data [1,2]. The healthcare industry generates a large amount of primary and secondary data [1,2]. By 2025, the total amount of data produced around the world is expected to reach 175

zetabytes, representing an increased annual growth rate of 61 percent [3]. Only 22% of all data, according to the 2012 Digital Universe Study by International Data Corporation (IDC), could be analyzed. By 2020, the proportion of beneficial data would rise to 37% [4]. This has sparked a lot of interest in using access to healthcare data to improve patient quality and cut costs. Automated tools and novel techniques that can assist in the intelligent transformation of vast amounts of data into useful information and knowledge have become urgently required as a result of the explosive increase in stored or transient data [5]. Today, the healthcare industry generates a lot of intricate data about a patient's disease and diagnosis. Data resources from hospitals and medical devices are difficult to process

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manually, and loading them into a conventional relational database for analysis takes time and money [6].

The most prominent fields of study that aid the empowered individual in uncovering buried data for efficient decision-making are statistics and data mining. Quantification and evaluation of outcomes are facilitated by a solid foundation in statistics. However, before they can be used in data mining, statistics-based algorithms must be adjusted and scaled [7]. One of the most useful methods for obtaining useful information from large data sets is data mining [8]. Cardiovascular diseases (CVDs) are the most prevalent and widespread diseases in India and the world [11]. The World Health Organization (WHO) estimates that heart disease-related deaths account for more than 12 million deaths annually [12]. 17.9 million CVD deaths were estimated, and that number would rise to 24.2 million by 2030 [13, 15]. Heart disease and cardiovascular disease, which encompasses a wide range of conditions that affect the heart and blood vessels, are frequently used interchangeably [14]. Ischemic heart disease, rheumatoid arthritis, congenital heart disease, cardiomyopathy, valvular heart disease, aortic valve stenosis, and atherosclerosis are all examples of cardiovascular diseases [15]. Echocardiography records are the sole focus of this work's statistical and data mining tools and methods for cardiovascular disease. As a result, the significance of echocardiography data for CVD prediction will be discussed in the following section.

### **1.1 Recent literature review**

Nikam, A. et al proposed machine learning techniques to predict cardiovascular disease using features. BMI is one of the highlighting features we used for prediction. BMI is important in predicting cardiovascular disease.

The main focus of the article is the effect of BMI on the prediction of cardiovascular disease. The model has proposed with different features as well as regression and classification techniques. Conclude that BMI is a significant factor while predicting cardiovascular disease.

Mostafa, N et al analyzed some common physiological attributes to identify a pattern among the people having a cardiovascular disease which, in further, has been used to distinguish whether a person has a risk of developing cardiovascular disease or not.

Ema, R. R et al proposed a new hybrid model based on Fuzzy C-means and Artificial Neural Networks (ANNs) with Principle Component Analysis that is capable to predict heart disease. The Principal Component Analysis is used to select the important features from the dataset. Then Fuzzy C-Means Clustering is used to cluster the extracted data from PCA and finally, Artificial Neural Network is used to predict Cardiovascular Disease.

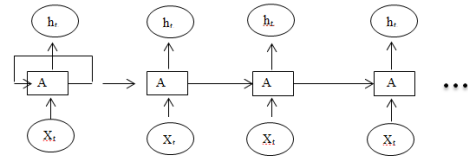
## **2. Proposed system**

Using these structured data and deep learning models to predict cardiovascular disease, which is global concern. A proposed model of the Long-Short Term Memory (LSTM) model based on the attention mechanism was presented in this chapter to address the issue of the LSTM model's low accuracy in CVD prediction. From the long sequence of CVD data at the moment, the proposed model can learn the importance of each past value to the current value, allowing for the elimination of more valuable features. Developed a dataset for experiments with the CVD data from Wuhan's core, and compared the improved model's performance to that of the original LSTM model.

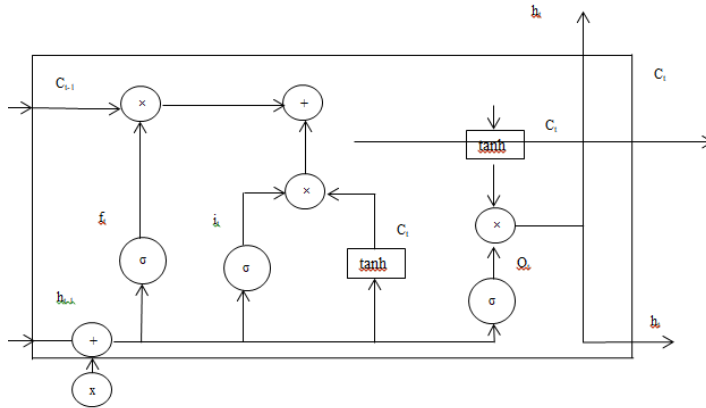
### 2.1 Construction of the attention-LSTM model

The LSTM model's fundamentals will be briefly discussed. As depicted in Figure 1., LSTM is a type of recurrent neural network.

However, compared with the conventional RNN, the structure of this repeated module A of LSTM is more complicated, as shown in Figure 2



**Figure 1.** Recurrent neural network (RNN)



**Figure 2.** The structure of LSTM cell

The forgotten gate, the input gate, and the output gate are the three components that make up this module. The Sigmoid function returns a number between 0 and 1, indicating how much of each part can pass.

$$F_t = \sigma(W_f \cdot [h_{t-1}, x_t] + b_f) \quad (1)$$

$$i_t = \sigma(W_i \cdot [h_{t-1}, x_t] + b_i) \quad (2)$$

$$\bar{C}_t = \tanh(W_c \cdot [h_{t-1}, x_t] + b_c) \quad (3)$$

$$C_t = f_t \cdot C_{t-1} + i_t \cdot \bar{C}_t \quad (4)$$

$$o_t = \sigma(W_o \cdot [h_{t-1}, x_t] + b_o) \quad (5)$$

$$h_t = o_t \cdot \tanh(C_t) \quad (6)$$

One of them is  $f_t$ , which tells us how much information we want to throw away. It decides how much additional data we should include. It decides how much data we want to send out. At time  $t$ , the input is  $x_t$ ; the previous gate's output is  $h_t$ ; the weights are  $W_f$ ,  $W_i$ ,  $W_c$ , and  $W_o$ ; the bias is  $b_f$ ; the cell state is at the previous moment  $C_{t-1}$ ; and the

cell state at the current moment is  $C_t$ .

#### Attention-LSTM Model

Because it is difficult for the model to learn information from a distant past that may be crucial to the current value. We tried to add an attention layer to the LSTM network to fix the flaw. We can apply it to the LSTM model by referring to the steps in [9] for implementing attention. As depicted in Figure 3. The LSTM model now includes an attention layer.

Among them,  $X_i$ ,  $i \in (1, n)$  is the input,  $h_i$  is the intermediate output result of each cell,  $h_i$  are input into each attention model as  $H$ , and the elements of the next layer  $h_i$  are used as  $H$  to calculate the similarity and weight coefficient, and finally get the attention coefficient. The specific attention model is shown in below figure.

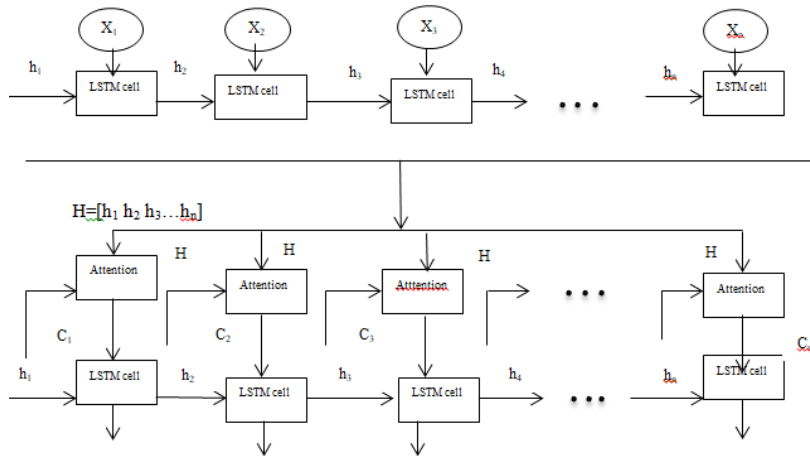


Figure 3. The process of adding an attention mechanism to the LSTM model

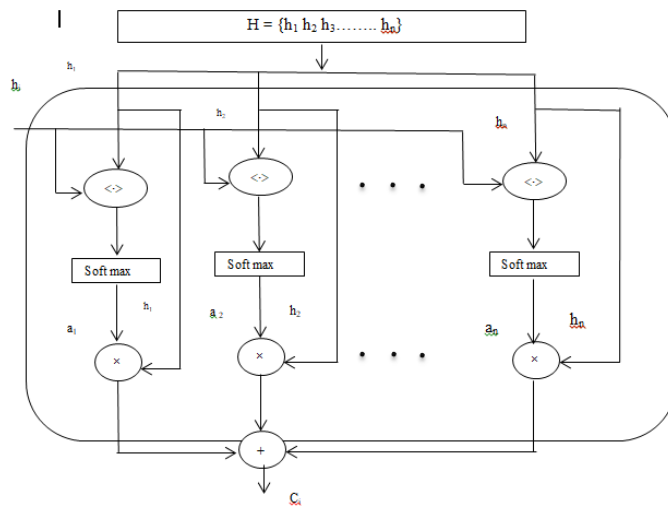


Figure 4.

Where, the similarity between the current element and the intermediate output result in the previous layer, and then normalized by the softmax function to obtain the corresponding weight coefficient  $a_i$ . Finally, a weighted summation operation is performed to obtain the Attention value  $C_i$ . The formula used in the attention layer is as follows:

$$H = [h_1 \ h_2 \ \dots \ h_n] \quad (7)$$

$$H' = [h'_1 \ h'_1 \ \dots \ h'_i] \quad (8)$$

$$\text{sim}_i = H'_i \cdot H^T \quad (9)$$

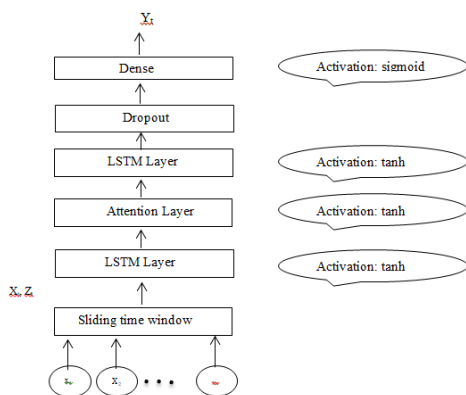
$$a_i = e^{\text{sim}_i} / \sum_{j=1}^{L_h} e^{\text{sim}_j} \quad (10)$$

$$C_i = \sum_{j=1}^{L_h} a_i \cdot h_j \quad (11)$$

In the above equations, uses vector  $H$  and  $H'$  to calculate similarity to obtain weights, uses the softmax function to normalize the weight, uses the normalized weight  $a_i$  and  $h_j$



weighted sum. The result of weighted summation is the attention weight value  $C_i$ . The implementation of the Attention layer is to retain the intermediate output results of the input sequence by the LSTM encoder, and then calculate the similarity amongst the intermediate output results of the previous layer and the current output to obtain the weight factor, and finally obtain the attention coefficient.



**Figure 5.** Attention-LSTM network architecture.

As shown in above Figure, we use the original traffic flow data to construct a feature matrix and label vector through a sliding time window method, and obtain the attention weights based on the correlation between the values in matrix  $X$  and the values in vector  $Z$  through the attention layer and generate the final prediction  $Y$ .

### Proposed algorithm 1

Input: CVD data

Output: A trained Attention-LSTM model.

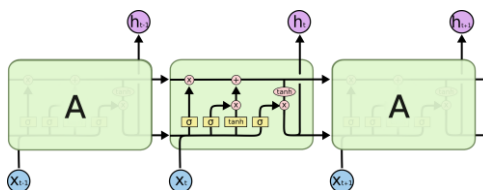
1. Construct a dataset with a sliding time window, including  $X_t$  and  $Z_t$ .
2. Normalize the values  $X_t$  and  $Z_t$ .
3. Input features matrix  $X_t$  and current disease vector  $Z_t$  are given to A-LSTM network.
4. While training epoch does not reach the set value

5. Put  $(X_t, Z_t)$  into the Attention-LSTM network for forward propagation.
6. Calculate the attention weight corresponding to each element
7. Generate  $Y_t$
8. Calculate mean square error.
9. Use RMSProp update weights for A-LSTM network.
10. End the while loop
11. Return A trained Attention-LSTM model.

The performance of the LSTM model based on the attention mechanism is verified for long time series and large prediction lag time. All prediction models use the same data set and are built in the same way. In the LSTM model, we set 2 hidden layers, the number of hidden layer neurons is 64 and 64, and the learning rate is 0.05. The network optimizer is also RMSprop. The process of Attention-LSTM model training is shown in Algorithm 1.

### 3. Conclusion

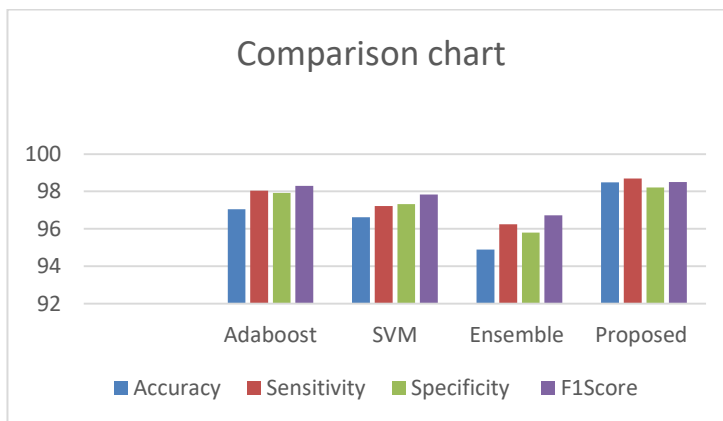
An Attention-LSTM model is made by adding an attention layer to the existing LSTM model in this project. Experiments also demonstrate that long-sequence data prediction is reliable. The Attention-LSTM model's construction process was described, and its performance was evaluated with actual CVD data sets. Prediction accuracy is improved by our proposed scheme, as demonstrated by experiments. The application of the model with the attention layer to the time series was the sole focus of this study. We can use attention mechanisms to take into account the spatial correlation of traffic flow in subsequent research.



**Figure 6.** LSTM Network Architecture

**Table 1.** Summarized Results

Method	Accuracy	Sensitivity	Specificity	F1Score
Adaboost	97.05	98.05	97.93	98.3
SVM	96.62	97.23	97.32	97.83
Ensemble	94.89	96.24	95.8	96.73
Proposed	98.49	98.7	98.21	98.5



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S. Sangavi

## CLASSIFICATION OF BRAIN TUMOR USING CONVOLUTIONAL NEURAL NETWORK

**Abstract:** *The brain is one of the vital organs of the human body and is made up of billions of cells. The abnormal, uncontrolled division of cells, also called brain tumors, puts tremendous pressure on various nerves and blood vessels and can cause irreversible damage to the body. Brain tumors can be benign (non-cancerous) and malignant(cancerous). One of the most common techniques for diagnosing brain tumors is magnetic resonance imaging (MRI), which provides detailed images of the brain. MRI images can be processed to segment brain tumors. These tumors can be segmented using various advanced machine learning algorithms and image segmentation techniques. In this paper, we propose the classification of brain tumors as glioma, meningioma, and pituitary tumor using a convolutional neural network framework. This demonstrates the efficiency of deep learning techniques to detect brain tumors using his MRI images of the brain. Performance is measured in terms of training accuracy and testing accuracy. This work was performed using an MRI image data set as input, and further preprocessing and segmentation were performed to enhance the images. The CNN ResNet50 framework ensures effective super-resolution of brain images, ensuring better tumor classification with high accuracy, especially for early cancer nodules.*

**Keywords:** *Brain Tumor; CNN Architecture; Deep Learning; Classification*

### 1. Introduction

Brain tumors are nodules that form as a result of inappropriate proliferation of brain cells and loss of brain regulatory mechanisms. There are over 130 types of brain and nervous system tumors. The World Health Organization (WHO) has classified brain tumors according to malignancy. These may be malignant (cancerous) or benign (noncancerous), and in either case brain tumors can be harmful or life threatening. Early diagnosis and treatment of brain tumors minimizes mortality. MRI is one of

the preferred scans for radiologists and doctors to diagnose brain tumors. It provides detailed 2D images of organs and tissues that can be used for both screening and staging various types of cancer. Observing the tumor growth pattern from a patient's MRI images reveals the type and grade of brain tumor. This brain tumor dataset includes 3064 T1-weighted contrast enhanced images from 233 patients with three types of brain tumors: meningioma (708 slices), glioma (1426 slices), and pituitary tumor (930 slices). Meningioma – Usually benign tumors that arise from the meninges, the membranes that

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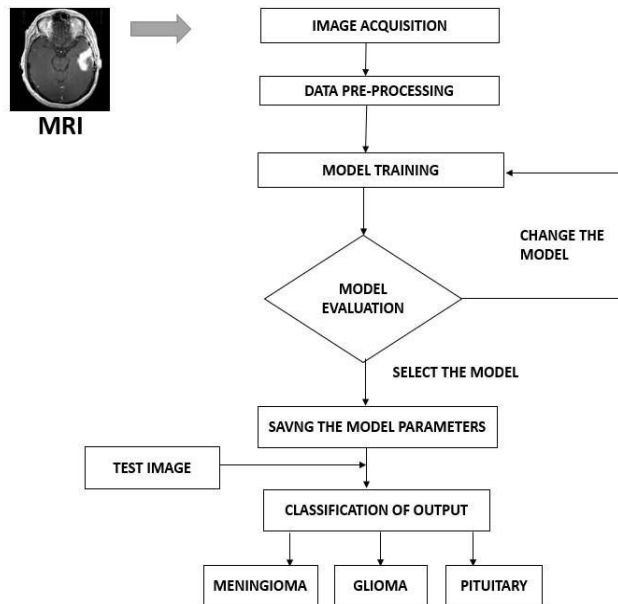
Corresponding author K. Karthik  
Email: [kk@vcet.ac.in](mailto:kk@vcet.ac.in)

line the brain and spinal cord. Glioma is a type of tumor that arises from glial cells in the brain or spine. Gliomas account for approximately 30% of all brain and central nervous system tumors and 80% of all malignant brain tumors. A pituitary tumor is an overgrowth of the pituitary gland. The pituitary gland is a small gland at the base of the brain. Regulates the balance of many hormones in the body. Most pituitary tumors are benign (benign). Various CNN-based methods have been proposed for classifying brain tumors. With such a procedure, 3 types of tumors. Meningioma, glioma, and

pituitary tumors were classified. In this article, we present a method to classify brain tumors into meningioma, glioma, and pituitary tumors using a deep neural network with Resnet 50 architecture.

## 2. Proposed methodology

Our proposed approach is based on deep learning applying convolutional neural network (CNN) algorithms. Figure 1 shows a block diagram representation of the proposed brain tumor classification system.



**Figure 1.** Block diagram representation of the proposed brain tumor classification system.

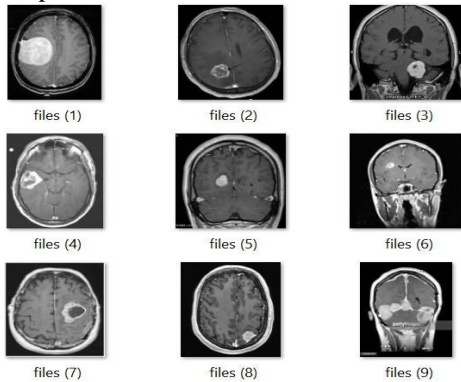
### 2.1 Image acquisition

Experiments are performed on MRI image datasets of brain tumors. This brain tumor dataset includes 3064 T1-weighted contrast enhanced images from 233 patients with three types of brain tumors: meningioma (708 slices), glioma (1426 slices), and pituitary tumor (930 slices).

**Table 1.** Type and number of Slices of Brain tumor images

TYPE OF TUMOR	NUMBER OF SLICES
Meningioma	708
Glioma	1426
Pituitary tumor	930

Split the dataset for training using a cross-validation method. There are 3064 T1-weighted contrast-enhanced images, of which 70% are for training, 15% are for validation, and 15% are for testing to assess the accuracy of the model. Out of the 3064 images available, the number of training samples is 21, the number of validation samples is 60, and the number of test samples is 60.



**Figure 2.** MRI dataset of different types of brain tumors

## 2.2 Image pre processing

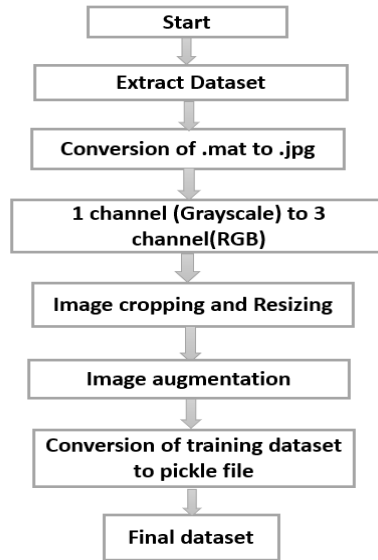
The preprocessing step improves the standard of brain tumor MR images and makes these images suitable for future processing by clinical experts or imaging modalities. It also helps in improving the parameters of MR images. Preprocessing can remove unwanted distortions and improve certain qualities that are essential for the application we are working on. These properties can be changed depending on the application. In order for the software to work properly and produce the desired results, the images must be preprocessed.

Data preprocessing consists of the following steps, which are described below.

Step 1: Convert data to image format.

Use matplotlib library to open MATLAB array file using h5py Python library and save image in his JPG format. This provides

an image dataset for training the Python library model. pydicom, which is used to read images in DICOM format. The NumPy library is used to process image arrays and the OpenCV library is used to save files in his JPEG image format. This provides an image data set for testing and validation.



**Figure 3.** Flowchart for Image Pre-processing

Step 2: Increase Image Channels

Open the image using the OpenCV library and convert the image from 1 channel (i.e. grayscale) to 3 channels (i.e. RGB channels).

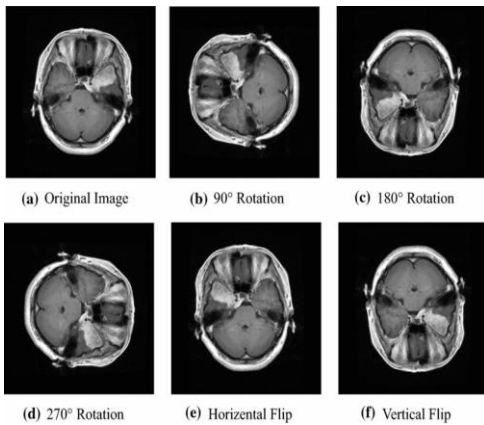
Step 3: Crop and Resize Images:

OpenCV (Open Source Computer Vision Library) is an opensource computer vision and machine learning software library. Used to reduce the size of the image to 512 x 512 to make the image a generalized resolution. This is necessary because the input images of the deep learning model must be of the same resolution.

Step 4: Augment the Image:

Augmenting the image data refers to modifying an existing image by making

changes to the existing image and including the modified version in the neural network's training data set. Modifications can be as simple as rotating, cropping, zooming, flipping, etc. Image augmentation is used to generate a custom dataset class that augments each image to different angles (0,5, 90, 120, 180, 270, 300, 330 degrees). As a result, data can be loaded, augmented, and trained in real time, rather than caching all training samples in memory for augmentation. After image augmentation, the number of augmented training samples is 17152, the number of augmented validation samples is 3680, and the number of augmented test samples is 3680.



**Figure 4.** Data augmentation applied on a given dataset

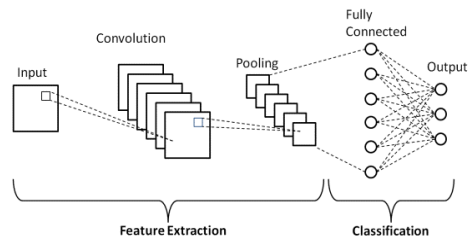
### 2.3 Dataset labeling

Data labeling is a machine learning process that identifies raw data and adds one or more descriptive and informative labels to provide context. Pickle is a handy Python tool that helps us to share, commit, and reload pretrained machine learning models. Used to serialize and deserialize Python object structures. Pickling is a technique for converting Python objects (lists, dictionaries, etc.) into character streams. This character stream is supposed to provide all the data needed to recreate the object in another

Python function. Accurate data labeling improves quality assurance within machine learning algorithms and enables model training and delivery of expected outputs.

### 3. Architecture for brain tumor classification

Convolutional Neural Networks (CNNs or Convnets) are a subset of machine learning. In deep learning, a convolutional neural network (CNN) is a type of artificial neural network commonly used for image/object detection and classification. So deep learning uses his CNN to recognize objects in images. The convnet's job is to compress the image into a manageable format while preserving the important factors for good prediction. This is important for designing architectures that are scalable to large datasets yet still capable of feature learning. CNN output layers typically use neural networks for multiclass classification. CNNs use feature extractors in the training process instead of manual implementation. A CNN's feature extractor consists of a special type of neural network that determines the weights through the training process. Pooling in convolutional neural networks is a technique for generalizing features extracted by convolutional filters, allowing the network to recognize features regardless of their location in the image. There are several approaches to pooling. The most commonly used approaches are max pooling and average pooling.



**Figure 5.** Basic Architecture of Convolutional Neural Network



ResNet-50 is a 50-layer convolutional neural network (8 convolution layers, max pool layer, average pool layer). A residual neural network is a type of artificial neural network (ANN) that stacks residual blocks to form a network. A 50-layer ResNet uses a device bottleneck design. The bottleneck remainder block uses a  $1 \times 1$  convolution known as the "bottleneck". This reduces the number of parameter and matrix multiplications. This makes training for each shift much faster. Use a 3-layer stack instead of 2. A  $7 \times 7$  kernel convolution alongside 6 other kernels with strides of size 2. Max pooling layers in increments of 2.9 layers –  $3 \times 3.6$  kernel convolutions, another layer with  $1 \times 1.6$

kernel, third layer with  $1 \times 1.256$  kernel. Repeat this 3 layers 3 times. 12 more layers with  $1 \times 1,128$  cores,  $3 \times 3,128$  cores, and  $1 \times 1,512$  cores, iterations. Over 18 layers of  $1 \times 1.256$  core and 2 cores  $3 \times 3.256$  and  $1 \times 1.102$ , 6 iterations. Repeat 9 layers of  $1 \times 1.512$  cores,  $3 \times 3.512$  cores, and  $1 \times 1.208$  cores three more times. Average pooling followed by a fully connected layer of 1000 nodes using the softmax activation feature. Skip connections were introduced to solve different problems in different architectures. ResNets solved the degradation problem by skipping connections.

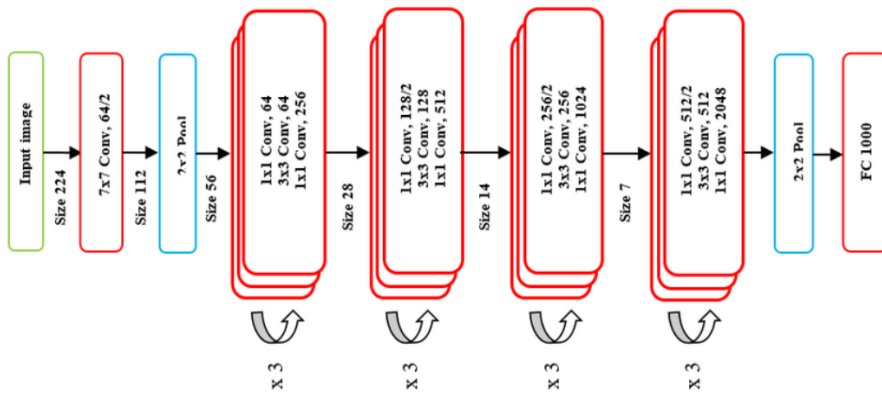


Figure 6. The proposed Resnet50 CNN architecture

## 4. Experimental setup and analysis

### 4.1 Confusion Matrix:

A machine learning confusion matrix (figure 7) is a matrix used to determine the performance of a classification model on a given test data set. It can only be determined if the true value of the test data is known. The matrix itself is easy to understand, but the associated terminology can be confusing. Also known as the error matrix because it shows the errors in the model's performance in the form of a matrix

### 4.2 Evaluation Parameters

Quantitative analysis is performed using the following metrics: Accuracy is defined as the proportion of correctly labeled subjects out of the total number of subjects. Precision is the ratio of true positive marked samples to all positive marked samples. The harmonic mean (average) of precision and recall is the F1 score.

$$\text{PRECISION} = \frac{tp}{(tp+fp)} \quad (1)$$

$$\text{RECALL} = \frac{tp}{(tp+fn)} \quad (2)$$

$$\text{ACCURACY} = \frac{(tp+tn)}{(tp+tn+fp+fn)} \quad (3)$$

where,

tp = Number of positive targeted cases which are positive,

tn = Number of negative targeted cases which are negative.

fp = Number of positive targeted cases which are negative.

fn = Number of negative targeted cases which are positive.

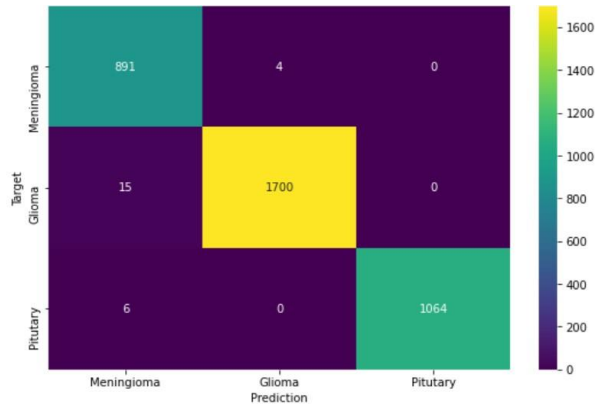


Figure 7. Confusion matrix

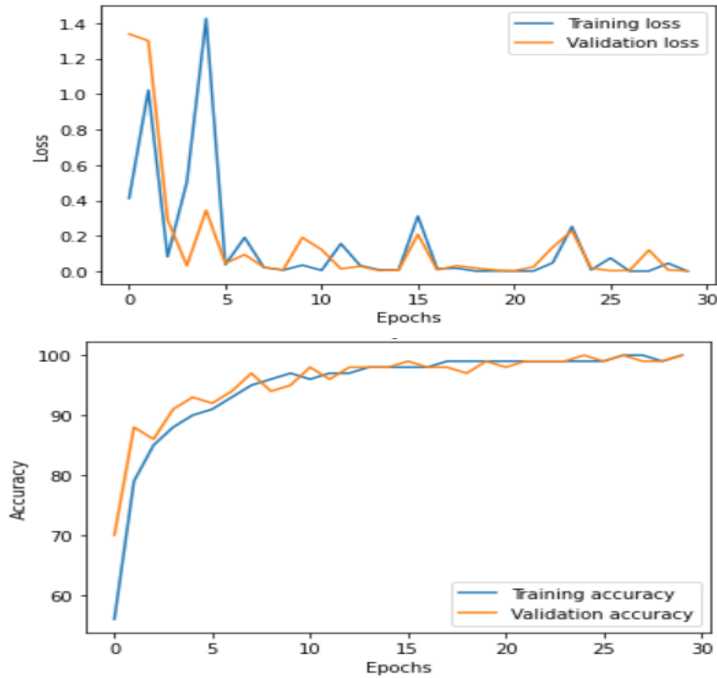


Figure 8. Training performance

**Table 2.** Performance Metrics:

Validation accuracy	98.88%
Test loss	0.0096
Test accuracy	99.32%
Recall	1.00
Precision	0.98
F1-score	0.99

From the table 2, we can see that using the ResNet-50 architecture yields the best accuracy of 99.32%, validation accuracy of 98.88%, test loss of 0.96%, and accuracy of 98%.

This skeleton is saved in .pt format using Torch Vision's built-in functionality. This file contains values for the trainable parameter. Another Python file downloads the Torch Vision framework and updates the stored weights. This framework is used for brain tumor classification of images stored in databases. To make the model available in real time, a web page is created containing pistons where MR images can be uploaded and tumors can be classified.



**Figure 9.** Screenshot of the home page

Click Upload Image and a check box will appear to select a brain MR image in JPG or

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PNG format. This web application classifies images by their tumor types.



**Figure 10.** Test image being classified correctly as Glioma

## 5. Conclusion

The main aim of this study is to classify brain tumors into three classes: meningiomas, gliomas and pituitary tumors. This paper presents an automated brain tumor classification method using DL- and ML-based techniques. MRI images are preprocessed, enhanced, and matched to a fine-tuned CNN model. B. ResNet-50, for tumor classification. After training the framework, the proposed model achieved the highest classification accuracy with minimal computational effort. Achieves a high accuracy of approximately 99.32%. Validation accuracy is excellent and loss is minimal. As a result, this study can be used in the medical field to easily identify types of brain tumors.

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**RELATIONSHIP BETWEEN UPPER ARM  
CIRCUMSTANCES AND COMPLIANCE  
WITH FE TABLET CONSUMPTION WITH  
THE INCIDENCE OF ANEMIA IN  
PREGNANT WOMEN AT EDUCATIONAL  
HEALTH CENTER IN 2022**

**Abstract:** *Anemia of pregnancy is a condition where red blood cells are reduced so they are unable to carry oxygen to all tissues. Pregnant women are anemic with hemoglobin levels <11 g%. Based on the preliminary study of interviews with 10 pregnant women, there were 5 pregnant women with anemia (50%) and 5 people without anemia (50%), pregnant women who were anemic with bad lingkarlenganatas (LILA) but adherent to taking Fe tablets 2 people ( 20%), 2 people (20%) had bad anemia but did not comply with taking Fe tablets, 1 pregnant woman had bad anemia but adhered to consuming Fe tablets (10%), pregnant women with good LILA anemia but did not adhere to consumption of Fe tablets as many as 0 people (0%), and pregnant women with no severe LILA anemia but obediently consuming Fe tablets 3 people (30%),The analytical method and cross-sectional study design used accidental sampling technique, namely mothers who came for antenatal care at the East Anvil Ulin Health Center, totaling 36 respondents. Questionnaires on compliance with the Guttman scale, LILA measurements before administering the questionnaire and anemia data were obtained from the MCH handbook. Most pregnant women with Bad LILA and experienced anemia as many as 8 respondents (33.3%) with the results of the chi square statistical test,  $p \text{ value} = 0.001 \leq \alpha (0.05)$   $H_0$  is rejected, meaning there is a relationship between LILA and Anemia in pregnant women. Most of pregnant women in the category of high compliance and anemia totaling 9 respondents (81.8%) with the results of the chi square statistical test,  $p \text{ value} = 0.036 \leq \alpha (0.05)$   $H_0$  is rejected, so there is a relationship between the level of adherence to consumption of Fe Tablets and the incidence of anemia in pregnant women.*

**Keywords:** *Upper arm circumference, compliance with Fe tablet consumption, anemia*

## 1. Introduction

Pregnancy is a very important period of life. The health of the baby being born depends on the mother who is pregnant. One of the factors that affect maternal health is the state of maternal nutrition (Ministry of Health, 2019). Physiological changes during pregnancy, namely blood volume increases blood volume during pregnancy by 50% and red blood cell mass increases by 20-30% (Watika, 2019).

Anemia in pregnancy is a condition in which red blood cells in blood circulation or hemoglobin mass are reduced so that they are unable to fulfill their function as oxygen carriers throughout the tissues. Pregnant women are said to be anemic if their hemoglobin in the blood is less than 11 gr%. The danger of anemia in pregnant women does not only affect their own safety, but also that of the fetus they contain. (Ulfa, 2020).

During pregnancy, blood volume will circulate gradually and progressively from 6 weeks of gestation, it will continue to increase at 14-14 weeks of gestation. 27 weeks. At 32-34 weeks. This increase in blood volume becomes a blood supply to the uterus, breasts, kidneys, skin and a number of other organs, as well as facilitating the exchange of gases and nutrients in the mother and fetus (Mochtar, 2019.)

Blood plasma volume increases by about 40% greater than the increase in the number of erythrocytes 20%. This causes hemodilution (blood dilution) causing anemia in pregnancy. Decreasing Hb levels in pregnant women can be overcome by fulfilling the nutritional needs of pregnant women, one of which is by giving iron supplement tablets or foods such as beans, liver and green vegetables (Denata 2020).

World Health Organization data (WHO, 2019), stated that the highest prevalence of anemia in pregnant women

was in India, China, Pakistan, Nigeria and Indonesia. Anemia of pregnant women occurs mainly in developing countries by 35-37% and in developed countries 18%. Indonesia is a developing country with a high rate of anemia in pregnant women. World Health (WHO) reports that the prevalence of anemia in pregnant women is Anemia in pregnant women who are in Banjar Regency is (23.75%), Banjarbaru is (19.62%) and Banjarmasin is (12.62%). It can be stated that the city of Banjarbaru has the second highest incidence of anemia in pregnant women and around 35-75% and increases with increasing.

Department of Health Data South Kalimantan Province (2019) (33.71%). Several factors affect anemia in pregnancy, namely age of the mother, mostly parity, distance of the gestational age (Dinkes South Kalimantan, 2019). Based on research results Basic Health (Riskesdas) year 2018, the prevalence of anemia in pregnant women in Indonesia increased to 48.9% compared to the 2013 Riskesdas which was 37.1% (Ministry of Health RI, 2019). Most of the causes of anemia in pregnant women in Indonesia are iron deficiency. Needs increase during pregnancy, low iron intake is one of the factors causing iron deficiency anemia.

Banjarbaru Health Office data found pregnant women with anemia in 2021 (January - December) of (2.29%), and in 2022 (January-June) an increase of (4.43%) with Anemia (Banjarbaru Health Office, 2021-2022). From the data from the East Ulin Foundation Health Center for 2021 (January-December) it was found that pregnant women with anemia were pregnancy, education, frequency of antenatal care, adherence of mothers to take iron tablets, infection and disease, knowledge and chronic energy deficiency (KEK). Poor nutritional status is also at risk of anemia in pregnant women 6 times higher (Mochtar, 2019).

Indicators for assessing the nutritional status of pregnant women, especially for detecting the risk of CED, use upper arm circumference (LILA) as a screening tool for CED in pregnant women and body mass index (BMI) for assessing CED status to detect good or bad nutritional status of pre-pregnancy (Susilajati, 2018). According to researchKurdanti (2020) recommends the use of LILA as a nutritional status screening in pregnant women, apart from due more practical in its use when compared with other anthropometric.

It is expected that the application of standards for antenatal care according to standards can comply with the incidence of anemia in pregnant women. The special service standards in efforts to prevent anemia in pregnant women include administering iron supplementation tablets. There are still many obstacles in the implementation of iron supplements that are often experienced, one of which is the compliance of pregnant women taking iron tablets according to recommendations is still low. Adherence to consuming blood-boosting tablets is a behavior of pregnant women that leads to a mutually agreed therapeutic goal, compliance in industry 4.0 (Fadilurrahman et al., 2021).

Hartatik(2018) explained that the characteristics of the mother (age, education and work) affect the mother's adherence to taking Fe tablets. And based on research by Nurmasari&Sumarmi (2019) it shows that pregnant women who make complete ANC visits have a lower risk of anemia. This is because pregnant women will get an early anemia examination. The preliminary study was conducted by interviewing 10 pregnant women. pregnant women with anemia (50%) and 5 people without anemia (50%), pregnant women pregnancy at the Anvil Ulin Health Center East Year 2022.2 people (20%) had anemia with bad LILA but adherent to consuming Fe tablets, 2 people (20%) had bad anemia but did not adhere to

taking Fe tablets, pregnant women with bad LILA anemia but adhered to taking Fe tablets 1 person (10%), pregnant women with good LILA anemia but 0 people (0%) did not adhere to taking fe tablets, and pregnant women with not bad LILA anemia but adhered to taking Fe tablets 3 people (30%), pregnant women with not good LILA anemia but 2 people (20%) adhere to the consumption of Fe tablets.

From these data the authors are interested in conducting research on "Relationship of Upper Arm Circumference and Fe tablet consumption compliance with the incidence of Anemia in mothers.

The purpose of this study was to analyze the relationship between upper arm circumference (LILA) in the incidence of anemia in pregnant women and maternal adherence in consuming Fe tablets at the East Ulin Foundation Health Center in 2022.

## 2. Research Methods

This type of research is an analytical survey research, with a cross-sectional research design. This research was conducted at the East LandsanUlin Health Center in the City of Banjarbaru and was carried out in the period July - August 2022. The population in this study were pregnant women visiting the East Anvil Ulin Health Center.

Banjarbaru City. The sample in this study amounted to 36 respondents. The independent variables in this study were upper arm circumference and adherence to consumption of Fe tablets. The dependent variable was Anemia. Collecting data in this study using a questionnaire. The sampling technique in this study was accidental sampling, namely pregnant women who visited the East Ulin Foundation Health Center in Banjarbaru City.

Data processing was carried out using the SPSS application version 25 and analyzed using the Chi-square test to examine the

relationship between the independent variables (upper arm circumference and adherence to consumption of Fe tablets) and the dependent variable (Anemia).

East LandsanUlin Health Center in the City of Banjarbaru and was carried out in the period July - August 2022. The population in this study were pregnant women visiting the East Anvil Ulin Health Center.

### **3. Results and Discussion**

Based on research conducted by measuring the Upper Arm Circumference (LILA) to 36 pregnant women respondents, the Upper Arm Circumference (LILA) .

Based on the research conducted by measuring using a questionnaire to 36 respondents.

Based on table 4.3 above, it can be seen that the level of adherence to consumption of Fe tablets by mothers who answered with a low level of compliance was 11 respondents (30.6%), a moderate level of knowledge was 14 respondents (38.9%), and a high level of knowledge was 11 respondents ( 30.6 %).

### **4. Discussion**

Relationship of Upper Arm Circumference with Anemia Incidence in Pregnant Women  
The statistical test results obtained the value of  $p = 0.001$ , meaning  $p \leq 0.05$  so that  $H_0$  was rejected and  $H_a$  was accepted, it can be concluded which means there is a relationship between the measurement of upper arm circumference (LILA) and the incidence of anemia in pregnant women at the East Ulin Public Health Center, Banjarbaru City.

Researchers argue that there is a relationship between LILA and the incidence of anemia in pregnant women, meaning that the higher the nutritional status which can be seen from the measurement of the LILA, the lower the

chance of anemia in pregnancy, conversely if the nutritional status is low, the incidence of anemia in pregnancy increases. This is due to poor health behavior such as eating patterns which will affect nutrition, especially pregnant women, especially the working area of the East Ulin Foundation Health Center which is a former localization place so that the majority of people are still not aware of the importance of health.

Lack of self-will to behave healthily such as not smoking, not drinking alcoholic beverages, etc. and lack of self-awareness to receive information and apply it in daily life about health and habits that cannot be eliminated.

This is in accordance with research by Mutiarasari (2019). The results of this study using the chi square test showed that there was a relationship between nutritional status and the incidence of anemia with a p value ( $0.012 \leq 0.05$ ), which means that nutritional status contributes to influencing the occurrence of anemia. This is also in line with the research by Larasajeng et al (2020) based on the Chi Square test, which obtained a p value of 0.001 ( $< 0.05$ ), so it can be concluded that there is a significant relationship between nutritional status and the incidence of anemia in pregnant women at the Kotagede II Health Center, Yogyakarta. The nutritional status of pregnant women is influenced by the substances consumed during pregnancy. Pregnant women are a group that is vulnerable to nutritional problems, especially anemia. Fetal growth and development is strongly influenced by the nutritional status of the mother.

If a pregnant woman consumes Fe tablets during pregnancy, the greater the risk of anemia in pregnancy. In the working area of the East Runway Ulin Health Center the incidence of anemia is still high because the compliance of pregnant women in consuming Fe tablets is still lacking. complaints that occur due to side effects of



Fe tablets such as nausea and dizziness, as well as the impact if you don't take Fe tablets according to the rules. Lack of motivation from husbands and families to overcome the boredom that mothers feel when taking Fe tablets.

The results of this study are in line with the research of Gilang et al (2016) for several reasons pregnant women do not finish taking Fe tablets because they forget, are bored, feel nauseous, take vitamins from a doctor, feel themselves healthy and will only take Fe tablets if they feel weak. 21 people (39.6%) took Fe tablets until they were finished and 32 people (60.4%) did not take Fe tablets, some of the reasons why pregnant women did not consume Fe tablets regularly were 37.6% felt nauseous and vomiting, 28.12% often forget, 18.75% because of bad smell, 9.3% feel themselves healthy and 6.26% are worried that their baby will grow big if they regularly take Fe tablets.

This opinion is supported by the theory of Notoadmojo (2017) which states that good knowledge of pregnant women will affect the level of adherence in taking Fe tablets. Someone has behaved in accordance with the knowledge, awareness and attitude of the stimulus, so that pregnant women who have good knowledge will also have a higher willingness to consume Fe tablets.

The results of this study are not in accordance with the research of Yeni et al (2017) that it can be seen that even though pregnant women consume Fe tablets, pregnant women still experience anemia, due to a lack of knowledge on how to consume Fe tablets correctly to speed up the absorption process. Based on the research by Kamaruddin et al. (2019) also showed that the group that was given Fe tablets alone was not enough to increase hemoglobin levels. It was also necessary to be given foods that accelerated Fe absorption and reduced consumption of foods that inhibited Fe absorption.

This is also not supported by Wasiah's theory, (2020) that knowledge of how to consume Fe tablets, among other things, is not recommended together with drinking tea because it can inhibit Fe absorption in the body but iron absorption can be increased by consuming fruits that contain vitamin C. In addition consumption of Fe tablets, for Increasing Hb levels can be done by consuming foods that contain lots of iron such as beans, red meat, green leafy vegetables.

This is not in line with the results of the Ethiopian study (2019) which was conducted in Adis, Ababa, with the results of a different proportion test, namely the results of the chi square test obtained  $p = 0.003$ , it can be concluded that there is a significant relationship between education and the incidence of anemia. The OR value is 3.95, meaning that pregnant women with low education are at risk of developing anemia by 3.95 times higher than those with higher education. The results of the Ethiopian study (2019) in a different place, namely in Denbiya, also revealed that maternal education is a factor that influences compliance with iron supplement consumption, pregnant women who have upper secondary education 3.44 times have good adherence to iron supplement consumption compared those without higher education.

This is also not supported by the theory of Nasir et al., (2020) that the educational status of high school and tertiary graduates is at least 4 times more likely to have the ability to understand and receive input from information providers. Pregnant women with higher education can increase awareness about complying with consumption with the iron supplements compared to those who cannot read and write. In addition, educated pregnant women can understand information from health workers regarding the benefits of iron supplements and the impact of iron deficiency. (Tarekegn et al., 2019).

## 5. CONCLUSIONS AND RECOMMENDATIONS

### 5.1. A. Conclusion

Based on the results of the study entitled The Relationship between Upper Arm Circumference and Fe Tablet Consumption Compliance with the Incidence of Anemia in Pregnant Women at the East Ulin Public Health Center in Banjarbaru City in 2022 from July to September from 36 research respondents it can be concluded that:

- Based on the results of the study, 19 respondents (52.8%) had anemia and 17 respondents (47.2%) did not have anemia.
- Based on the measurement of Upper Arm Circumference (LILA), the results obtained for pregnant women with Bad Upper Arm Circumference (LILA) were 24 respondents (66.7%) and pregnant women with Good Upper Arm Circumference (12 respondents (33.3%),
- Based on the level of Compliance Consumption of Fe Tablets, it was found that the category of pregnant women with Low Compliance was 11 respondents (30.6%), Moderate Compliance was 14 (38.9%), High Compliance was 11 respondents (30.6%)
- There is a relationship between the circumference of the upper arm and the incidence of anemia in pregnant women where the Chi-square test was carried out and obtained  $p$  value = 0.001
- There is a relationship between Compliance with Consumption of Fe Tablets and the incidence of anemia in pregnant women where the Chi-square test was carried out

to obtain a  $p$  value = 0.036.

### 5.2. B. Suggestion

#### 1. For Respondents

Advise pregnant women to carry out routine pregnancy checks, as well as improve their nutritional intake patterns and adherence to consuming Fe tablets regularly with the aim of improving hemoglobin levels and improving fetal development.

#### 2. For Health Centers

For health workers, especially those dealing with the problem of anemia, to provide more education on nutritional patterns and regular patterns in consuming Fe tablets as well as conducting catin (bride-to-be) classes in the form of counseling on pregnancy preparation and administration of Fe tablets.

#### 3. For Educational Institutions

For educational institutions can provide input in the development of obstetrics, especially about anemia in pregnancy.

#### 4. For Researchers

For researchers, it can be used as experience in conducting research and as a means of developing knowledge gained during education by applying it to the realities in the workplace.

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## **THE ROLE OF HUMAN RESOURCE INFORMATION SYSTEMS WHEN FACING THE COVID-19 PANDEMIC CRISIS IN YOGYAKARTA STARTUP COMPANIES**

***Abstract:** The purpose of this study was to determine the role of using human resource information systems in dealing with the Covid-19 pandemic crisis faced by startup companies in Yogyakarta. This research was conducted by taking 100 samples from various startup companies in Yogyakarta at random. The calculation technique used in this study is the Multiple Linear Regression Analysis models. Based on the results of the analysis, shows that there is a significant influence between the use of the human resource information system from the teleworking usage system, recruitment system, benefits system, support system, and performance system in its role in facing the Covid-19 pandemic crisis, where almost all startup companies in Yogyakarta implementing work from home. The results of multiple linear regression analysis show that there is a positive and significant influence on the use of the teleworking system, recruitment system, benefits system, support system, and performance system and is able to make a significant contribution in increasing the work productivity of the HR department in dealing with the Covid-19 pandemic crisis.*

***Keywords:** Human Resource Information System, Covid 19 Pandemic Crisis*

### **1. Introduction**

In recent years, the environment tends to become more complex and dynamic: new technologies and globalization increase competition forcing organizations to prove themselves to be highly productive, sustainable, and cost-effective (Dessler, 2013). Because of this, organizations need to identify and implement approaches that encourage effective management of people within the organization and bridge the gap between employees and the organization's strategic objectives. Human Resource Management (HRM) is an organic part of every organization that plays an important role in the life cycle of an organization

contributing to its success. Information Systems also significantly influence Human Resource Management because they can support many HRM functions (Papalexandri & Bourantas, 2002). But all the time, with the latest example of the Covid-19 pandemic, organizations have been called upon to operate during times of crisis, forcing Human Resource Management to adapt to new realities, ensuring that the organization's strategic goals will be achieved.

Teleworking has been used to support organizations during the rapidly changing work environment when the pandemic forced Human Resources (HR) functions and employees to face technology-based

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restructuring and work arrangements. Virtual practices are also rapidly deploying the most cost-effective solutions, while fewer employees in the future will be needed with less office space. There is no doubt that the new generation may have to work a different way from previous employers and employees have shifted to vulnerable beings who need to deal with impending layoffs; socio-psychological; economic and health costs. At the same time, individuals are and will be affected according to age; race; ethnicity; gender; personality while virtual needs that arise differ between employees who live alone and with their families. In that setting, the concept of a leader needs to be rebuilt, because the need for motivation, training, and development must be changed to the Covid-19 and post-Covid-19 era (Kniffin et al., 2020).

Human Resource Information Systems (HRIS) are likely to transform HRM functions into a more technology-based area as HR uses ever-increasing technological tools for its services. HRIS is collecting; thrifting; analyzing; using; recovering; and distributing information about HR. Through interactive techniques, HRIS can support HRM Functions, customized modules, and various IT programs that have been designed to support specific HR tasks and activities. The ethical dimension of protecting employee data is highlighted as the use of security systems, passwords, and limiting access to unauthorized persons is a necessity. Technology's contribution to transforming HR functions develops virtual workplaces; equipment; and applications; redefining the future of work and its continuity (Armstrong, 2006). Teleworking is another aspect of the new "virtual" work reality, HRIS is a new system that helps employees a lot in solving work-related problems, employees enjoy and enjoy the new system created by the company to help employees. The more a person enjoys his work, the higher the employee's performance and attachment to

the company. (Riatmaja., et al., 2021).

Specifically, the crisis is analyzed in the fourth chapter and is defined as an unwanted event that causes change with a negative effect on people. It can be classified on various levels. In particular, the Covid-19 pandemic first appeared in China and spread across the world with enormous social, economic, and political effects. During our examination, we attempted to highlight the implications of Covid-19 for the workplace as a rapidly changing environment manifesting high rates of job loss and the impending global financial crisis. Emergency changes in the workplace introduce technology and a platform-based work environment as a transition to the digital space. The role of HR must adapt to new work realities and leaders through learning and development will grow crisis leadership skills to help organizations achieve their goals (Carnevale & Hatak, 2020). Finally, recommendations for responding to this unprecedented crisis were introduced in the fifth chapter with the proposed holistic pillar-2 - a structured approach to teleworking and HRIS functions together with a new leadership model. As soil research is still precocious, future research should be focused not only on reacting to emerging challenges but also on rethinking work practices to build sustainable post-pandemic-era foundations (Dirani et al., 2020; Fernandez & Shaw, 2020).

## 2. Literature review

### 2.1 Human Resources Information System – HRIS

Management System (HRMS), e-Human Resources (e-HR) Currently, with the development of technology there is a shift to Human Resources (HRM) which tends to transform into a more technology-based field. More and more organizations are using

web-based applications and HR-related services delivered through technology as research has shown that organizations that implement advanced HR technology tools have a competitive advantage over those that do not. The modern framework requires organizations to change their HR practices and shift to the “e-HR” (electronic HR) era to simplify various processes, reduce administrative workload and other costs, increase service improvement, become more competitive, and provide valid and accurate information about employees which enable managers to make the most effective decisions that can be implemented thus forming a new, more strategic role for HR in the organization (Johnson & Gueutal, 2011). As the Society for Human Resource Management (SHRM) reports “equipped with hard data, HR can know more, do more, and be a better business advisor” (SHRM, 2002).

Like e-commerce, e-HR was first used in the 90s as a term, referring to the use of the internet in the HR field which provides information to managers and employees anytime and anywhere through internet access. “This is a shift towards automation of HR services towards information technology support in HR services” (Ruël et al., 2004). Today “a total e-HR system can include enterprise resource planning (ERP) software, HR service center, interactive voice response (IVR), web applications, voice recognition systems (VRS), and manager and employee portals” (Lengnick-Hall & Moritz, 2003). A more specialized aspect of e-HR is considered as Human Resource Information System (HRIS) or Human Resource Management System (HRM). According to Papalexandri & Bourantas, (2002), HRIS is a system that individuals can collect; store; analyze; use; recover and distribute information about human resources of an organization Thite & Kavanagh (2012) argues that HRIS includes not only computer hardware but also

software; people; forms; policies; procedures; and data (Thite & Kavanagh, 2012) “Keeping in mind the customer” is a fundamental principle of every organization and HRIS “helps by providing technology to produce accurate and timely employee information. still to fulfill this purpose” (Thite & Kavanagh, 2012, p.13). To continue, its implementation can influence and, in some cases, limit the personal relationship between HR staff and employees (Johnson & Gueutal, 2011).

There are several elements in the implementation of human resource information systems that are used by companies that implement human resource information systems as follows (Thite and Javanagh, 2011). There are 5 elements in the use of the system in HRIS, the Teleworking System, the Recruitment System, the Benefits System, the Benefits System and the Performance System.

## 2.2 Covid-19 Pandemic Crisis

A crisis in general can be defined as an unwanted event that causes a change that will have a negative effect on people (Lerbinger, 2012). In particular, crises can be classified at different levels. Vigh (2008), describes the individual crisis as something specific to a period in a person's life where the individual is negatively challenged and faced with difficulties in managing external forces and decision making while Lerbinger (2012) defines the various characteristics that make up an organizational crisis. Any event that occurs suddenly, unwanted, unpredictable, ambiguous, with a high degree of impact that breaks normality and interrupts setting goals, challenges organizational survival, causes stress, and requires quick action and decisions to be taken is considered an organizational crisis. Crisis is also defined by location such as workplace (eg industrial accident, Claus, 2011) and non-work related hazards (eg

illness, road accident, medical emergency) (Druckman, et al., 2012), regional hazard: pandemic such as SARS, MERS, (Tan & Enderwick, 2006) natural disasters (Merlot & De Cieri, 2011).

Another aspect of the crisis can be economic or health. The economic crisis is a long-term economic condition characterized by slow growth in economic activity, increased unemployment, low prices, low levels of trade and investment. The economic crisis faced in the 1930s is called the Great Depression. The global and financial crisis in 2008 has been several times more severe as manifested not only in finance but also in real economic sectors (Ngowi, 2013). A health crisis or public health crisis is a serious situation that can affect people in one or more geographic areas or even globally and can be the result of disease, industrial processes, or bad policies. The impact of a health crisis can have an impact on public health, loss of life and the economy. The Covid-19 coronavirus pandemic is a defining global health crisis for us of time and the greatest challenge we have faced since the Second World War.” However, not only is this health crisis an unprecedented socio-economic crisis and it will create social, economic and political effects that will leave deep and long-lasting scars. The virus started from Wuhan in China in December 2019 and has spread worldwide except Antarctica, reported by the World Health Organization (WHO).

### 3. Method

According to Sekaran (2003), the population is the sum of all the objects to be studied. The population in this study were all permanent employees at Yogyakarta Startup companies, totaling 88 people. During the Covid-19 pandemic, the Human Resources Department implemented the Human Resources information system. The sample

is part of the population that is expected to represent the population in the study. In preparing the sample, it is necessary to prepare a sampling frame, namely a list of all the sampling elements in the sampling population. Both from the length of work, age, and permanent employee status.

1. Independent or Independent Variable  
 Independent variables are variables that affect the existence of other variables. In this study, the independent variables are the HRIS human resource information system, which has 5 dimensions (figure 1), including:

- a) X1 : Teleworking system
- b) X2 : Recruitment system
- c) X3 : Allowance system
- d) X4 : Benefits system
- e) X5 : Performance system

2. Dependent or Dependent Variable  
 The dependent variable is a variable that is influenced by other variables. In this study, depending on the variable, Covid-19 Pandemic Crisis (Y).

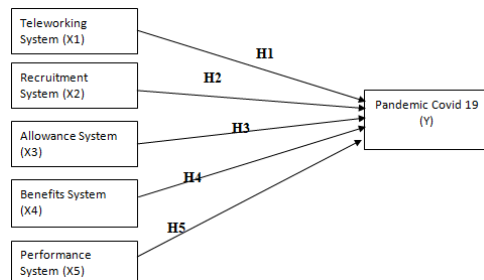


Figure 1. Variables

### 4. Results and discussion

Table 1 shows Performance Validity Test Results. Table 2 shows Interest Validity Test Results. In table 3 and 4 are Performance Reliability Test Results and Interest Reliability Test Results shown, respectively. Table 5 presents results of Multiple Linear Regression Analysis.



**Table 1.** Performance Validity Test Results

Variables	Items	$r_{count}$	$r_{table}$	Description
Teleworking system	Item1	0,734	0.3834	Valid
	Item2	0,755	0.3834	Valid
	Item3	0,878	0.3837	Valid
	Item4	0,724	0.3837	Valid
	Item5	0,875	0.3837	Valid
	Item6	0,712	0.3837	Valid
	Item7	0,899	0.3837	Valid
	Item 8	0,866	0.3837	Valid
	Item 9	0,783	0.3837	Valid
Recruitment system	Item1	0,687	0.3836	Valid
	Item2	0,775	0.3836	Valid
	Item3	0,734	0.3836	Valid
	Item4	0,688	0.3836	Valid
	Item5	0,754	0.3836	Valid
	Item6	0,722	0.3836	Valid
	Item7	0,601	0.3836	Valid
	Item8	0,752	0.3836	Valid
	Item9	0,765	0.3836	Valid
	Item10	0,633	0.3836	Valid
Allowance system	Item1	0,743	0.3838	Valid
	Item2	0,785	0.3838	Valid
	Item3	0,823	0.3838	Valid
	Item4	0,744	0.3838	Valid
	Item5	0,781	0.3838	Valid
	Item6	0,804	0.3838	Valid
	Item7	0,634	0.3838	Valid
	Item8	0,716	0.3838	Valid
	Item9	0,755	0.3838	Valid
	Item10	0,791	0.3838	Valid
Benefits system	Item1	0,384	0.3935	Valid
	Item2	0,435	0.3935	Valid
	Item3	0,621	0.3935	Valid
	Item4	0,625	0.3935	Valid
	Item5	0,543	0.3935	Valid
	Item6	0,466	0.3935	Valid
	Item7	0,587	0.3935	Valid
	Item8	0,652	0.3935	Valid
Performance system	Item1	0,566	0.3635	Valid
	Item2	0,763	0.3635	Valid
	Item3	0,562	0.3635	Valid
	Item4	0,723	0.3635	Valid
	Item5	0,476	0.3635	Valid
	Item6	0,581	0.3635	Valid
	Item7	0,748	0.3635	Valid
	Item8	0,715	0.3635	Valid
	Item9	0,624	0.3635	Valid
	Item10	0,614	0.3635	Valid
	Item11	0,628	0.3635	Valid

**Table 2.** Interest Validity Test Results

Variables	Items	$r_{count}$	$r_{table}$	Description
Teleworking system	Item1	0,777	0.3738	Valid
	Item2	0,667	0.3738	Valid
	Item3	0,623	0.3738	Valid
	Item4	0,654	0.3738	Valid
	Item5	0,677	0.3738	Valid
	Item6	0,567	0.3738	Valid
	Item7	0,656	0.3738	Valid
	Item 8	0,456	0.3738	Valid
	Item 9	0,623	0.3738	Valid
Recruitment system	Item1	0,628	0.3737	Valid
	Item2	0,532	0.3737	Valid
	Item3	0,521	0.3737	Valid
	Item4	0,632	0.3737	Valid
	Item5	0,724	0.3737	Valid
	Item6	0,567	0.3737	Valid
	Item7	0,543	0.3737	Valid
	Item8	0,721	0.3737	Valid
	Item9	0,634	0.3737	Valid
	Item10	0,501	0.3737	Valid
Allowance system	Item1	0,693	0.3737	Valid
	Item2	0,654	0.3737	Valid
	Item3	0,674	0.3737	Valid
	Item4	0,582	0.3737	Valid
	Item5	0,563	0.3737	Valid
	Item6	0,576	0.3737	Valid
	Item7	0,603	0.3737	Valid
	Item8	0,534	0.3737	Valid
	Item9	0,589	0.3737	Valid
	Item10	0,506	0.3737	Valid
Benefits system	Item1	0,741	0.3737	Valid
	Item2	0,504	0.3737	Valid
	Item3	0,676	0.3737	Valid
	Item4	0,622	0.3737	Valid
	Item5	0,672	0.3737	Valid
	Item6	0,701	0.3737	Valid
	Item7	0,602	0.3737	Valid
	Item8	0,655	0.3737	Valid
Performance system	Item1	0,703	0.3737	Valid
	Item2	0,401	0.3737	Valid
	Item3	0,555	0.3737	Valid
	Item4	0,573	0.3737	Valid
	Item5	0,521	0.3737	Valid
	Item6	0,578	0.3737	Valid
	Item7	0,616	0.3737	Valid
	Item8	0,501	0.3737	Valid
	Item9	0,517	0.3737	Valid
	Item10	0,503	0.3737	Valid
	Item11	0,708	0.3737	Valid

**Table 3.** Performance Reliability Test Results

Variable	<i>Alpha Cronbach</i>	Description
Teleworking system	0,956	Reliable
Recruitment system	0,934	Reliable
Allowance system	0,935	Reliable
Benefits system	0,789	Reliable
Performance system	0,887	Reliable

**Table 4.** Interest Reliability Test Results

Variabel	<i>Alpha Cronbach</i>	Description
Teleworking system	0,852	Reliable
Recruitment system	0,787	Reliable
Allowance system	0,734	Reliable
Benefits system	0,676	Reliable
Performance system	0,775	Reliable

**Table 5.** Multiple Linear Regression Analysis results

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-4.934	2.645		-1.876	.066
	Teleworking	.145	.033	.345	4.167	.000
	Recruitment	.087	.021	.309	3.973	.000
	Allowances	.069	.022	.277	3.912	.000
	Benefits	.221	.051	.372	4.834	.000
	performance	.102	.040	.231	2.573	.012

Based on these equations it can be described as follows:

1. Constant

A constant value of -4.934 means that the variables covering the teleworking system, recruitment system, allowance system, benefits system, and performance system do not change or are considered constant so the direction of the employee performance value at the start-up company is minus -4.934.

2. Direct evidence regression coefficient (b1)

Teleworking variable has a positive regression coefficient on employee performance, with a regression coefficient of 0.145. With this positive influence, it means that the teleworking system on employee performance at startups in Yogyakarta shows a unidirectional relationship, meaning that the higher the use of the teleworking system in the eyes of employees, the higher the performance of employees at startup

companies in Yogyakarta, assuming other variables remain the same.

3. Regression coefficient of reliability (b2)

The recruiting system variable has a positive regression coefficient on consumer satisfaction at startups in Yogyakarta, with a regression coefficient of 0.087. With this positive influence, it means that the recruitment system and employee performance results show one-way results, that any increase in employee performance can be due to a good recruitment system, assuming the lin variable remains the same.

4. Assurance regression coefficient (b3)

The benefits system variable has a positive regression coefficient on employee performance at startup companies in Yogyakarta, with a regression coefficient of 0.069. With this positive influence, it means that employee performance guarantees at startup companies in Yogyakarta show a

unidirectional relationship, meaning that a better benefits system will lead to high employee performance, assuming other variables remain constant.

5. Responsiveness regression coefficient (b4)

The benefits system variable has a positive regression coefficient on employee performance at startup companies in Yogyakarta, with a regression coefficient of 0.221. With this positive influence, it means that the benefits system for employee performance at startup companies in Yogyakarta shows a unidirectional relationship, meaning that the benefits system for startup companies in Yogyakarta will lead to higher employee performance, assuming other variables are constant.

6. Empathy regression coefficient (b5)

The performance system variable has a positive regression coefficient on employee performance at startup companies in Yogyakarta, with a regression coefficient of 0.102, this means that the implementation of the performance system on employee performance at startup companies in Yogyakarta shows a unidirectional relationship, which means the better the performance system from the company, causing better employee performance, assuming other variables are constant.

The results of multiple linear regression analysis show that there is a positive and significant influence in the simultaneous implementation of the teleworking system, recruiting system, benefits system, benefits system, and performance system for the three companies affected by the Covid-19 pandemic crisis. Research on virtual teamwork should focus on emotional expression and management in cyberspace and innovation to enable optimal system work. Also, as various forms of virtual teams have emerged (face-to-face, virtual teams, combined), further work on team classification would be useful. From a virtual

standpoint scholars of leadership and management should focus on participatory relationships in high-virtuality work settings - communication and feedback mechanisms from leaders, along with leadership approaches. Additionally, an assessment of the Covid-19 changes in the training program shifting to online status and how that will affect the efficiency, accessibility, and effectiveness of the training program should be carried out. Trust and how it is empowered through virtual systems, especially for newcomers is another important issue for future research (Kniffin et al., 2020).

Research should seek to identify ways for organizations to support social interactions while WFH employees and assess the efficiency of practices or innovations introduced (eg, virtual lunches) during the Covid-19 period to reduce loneliness and increase resilience. A new health program for employees dealing with isolation should be created. In addition, researchers should examine the effectiveness of the Covid-19 and post-Covid eras on redesign and craft work to improve working conditions compared to the pre-pandemic period. Illness in relation to WFH modalities is another issue examined further for the post-Covid era along with the contemporary preservation of employees' privacy rights concerning health checks (Kniffin et al., 2020).

During the pandemic, teleworking, and in particular, WFH has been widely implemented. In that context, an evaluation will be carried out on companies implementing teleworking needed in the post-Covid era. It is interesting to identify whether the crisis has been perceived as a driver that has paved the way for future teleworking or simply as an urgent response action with limited future applications (Belzunegui-Eraso, & Erro-Garcés, 2020). In terms of teleworking (and e-leadership which will be mentioned below), we also

recommend that research methods will shift with application to larger samples and more methods such as longitudinal or experimental (Contreras et al., 2020). Teleworking studies should also focus on how an individual's work and non-work experiences influence one another, and how an individual's work and non-work identities are expressed at home. In addition, the effects of the Covid-19 quarantine and WFH on productivity, creativity, and innovation are important for further study. Motivation and authenticity in work is another topic that will be discussed as an implication of WFH practices in the post-Covid era, especially at times when employees will enter between collocated settings (Kniffin et al., 2020).

## 5. Conclusion

This article discusses the impact of Covid-19 in the workplace with a focus on HRIS. As

the pandemic is still ongoing, researchers working around the world are still a work in progress, and access to relevant and up-to-date resources is limited. Therefore, research is still in a premature stage. In addition, this research was compiled during the lockdown, and due to limitations in granting employees access to answer questionnaires, it has been decided to approach the topic solely through a literature review based mostly on online resources due to the current state of affairs. In fact, the field is very broad, for example, the pandemic has affected various aspects of work life, which has a broad impact. Therefore, after reviewing the challenges of the pandemic, it seems that HRM needs to focus on reviewing and changing its tools and practices to suit the new workplace realities, while there are still many issues for future research that are important for further study.

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## PROCESS PRIORITIZATION OF THE UNIVERSITY OF SZEGED

**Abstract:** Operation development is time-consuming and needs a large amount of effort. Therefore, to ensure its efficiency and effectiveness, those processes should be optimized first, which can provide the most significant benefits. Our paper introduces an innovative method the University of Szeged applied for selecting these processes by their potential for optimization, involving constraint- and benefit-related attributes in the assessment. In addition, process network definition and process regulation principles are also presented. This complex method is one of the fundamental tools of the quality management activities of the University aims to help the organization meets the evolving requirements of the higher education sector.

**Keywords:** process prioritization, process assessment, university operation development

### 1. Introduction

Many organizations face the problem of how to share their limited resources among development initiatives. When there is an urgent need for improvement because of operational issues, the decision is relatively easy; focus on ‘firefighting’ and then conduct corrective and preventive actions. However, when the source of the development plan is a strategic level initiative aiming to improve the operation of more than one process, there are not enough resources – in many cases, at least – to develop everything parallelly. In this situation, decision-makers need a prioritization method.

The first and most widely applied process management-related prioritization tool might be the PEMM (Process and Enterprise Maturity Model) by Michael Hammer. It analyses the performance of processes by five “enablers”:

- design: purpose, context, documentation,

- performers: knowledge, skills, the behavior of employers,
- owner: identity, activities, authority,
- infrastructure: information systems, human resources,
- metrics: definition, uses.

In addition, at an organizational level, the method looks at four “capabilities”:

- leadership: awareness, alignment, behavior, style,
- culture: teamwork, customer focus, responsibility, attitude toward change,
- expertise: people, methodology,
- governance: process model, accountability, integration.

Hammer suggests that his framework can help the management plan process-based transformations (Hammer, 2007). However, although this method identifies obstacles to process development, it does not show which processes should be optimized first.

Many researchers apply different Multi-Criteria Decision-Making (MCDM)

frameworks to prioritize processes or other entities. Five of the most popular ones may be:

- Analytic Hierarchy Process (AHP),
- Analytic Network Process (ANP),
- Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS),
- VIKOR and
- Fuzzy Logic.

Alexander and his team comprehensively reviewed the abovementioned methods as possible ways of Lean assessment. They compared them by their popularity, simplicity of application, and superior outcomes in previous research. The researchers concluded that the fuzzy logic technique and its combinations with the others were popular in assessing Lean with greater accuracy. At the same time, the TOPSIS and the VIKOR had the more significant advantage of providing multiple and quick decisions. They highlighted that the ensemble methods provided more accuracy than standalone techniques (Alexander, 2022). We applied their results as fundamental approaches for our development.

Yildirim proposed the Digitalisation Opportunity and Priority Assessment (DOPA) based method, which combined Failure Mode and Effect Analysis (FMEA) and Voice of Customer (VoC) methods for digitalization priority setting problems. The researchers' method assessed failure and effect dimensions of processes in a product of importance, frequency, and digital control level variables (Yildirim, 2022). This approach with a redesigned set of variables could also be applied to our prioritization problems.

Researchers in Kazakhstan applied the general methods of hierarchy analysis, expert assessments, and the criteria approach to develop a decision support tool for distance learning quality assessment

(Shaporeva, 2022). However, their method was not ready to use directly in process prioritization but could be applied as a methodological basis in our project.

University professors from Russia proposed the Lean Methodology to improve service quality in higher professional education. They introduced a model for assessing the efficiency of lean mechanisms for increasing the service quality of higher professional education (Glushchenko, 2021). Unfortunately, their model did not include factors that could be used in process prioritization. Still, the suggested approach of thinking through the optimization opportunity of processes from the perspectives of Lean wastes was motivating.

In another project, researchers used fuzzy logic to create a Lean Six Sigma (LSS) readiness assessment model for enterprises in the clothing industry. They identified critical success factors (CSF) as enablers (e.g., management responsibility), criteria (e.g., organizational structure), and attributes (e.g., smooth information flow) (Abbes, 2022). Although these CSFs are not process-related, and the industry of their case study is far from higher education, the proposed assessment method has good results to be adapted in process prioritization.

Total Quality Management (TQM) is frequently implemented by universities for operation development purposes. Professors from Egypt identified some obstacles that could cause difficulties in TQM implementation in higher education. They categorized the obstacles into items such as top management, students, human resources, financial resources, educational technology, community service, scientific research, organizational culture, and educational curriculum. They found that the highest obstacles that limited TQM were financial resources obstacles, followed by organizational culture obstacles (Sabra, 2020). We used this grouping technique as a benchmark in our assessment.



Based on the approaches mentioned above and the personal experiences of the process assessment team members, a specific process prioritization and optimization method was developed to help management set goals and scope of operation development actions. The management requirements for the method were defined as follows:

- be easy to understand,
- be easy to apply,
- be easy to modify,
- reflect differences among the attitudes and circumstances of organizational units,
- contain only significant factors,
- be applicable in simulations,
- provide precise results.

To meet requirements, the proposed method was a combined and simplified version of the most widely used MCDM techniques, which

- was created, and
- the related questionnaire could be filled up in Microsoft Excel,
- the organizational unit specialties could be considered by factor weights,
- factor selection and definition were the results of consensus,

- factor weights could be modified in the assessment phase to see their effect on the outcomes,
- the list of processes was also presented by factors and priority.

This paper introduces the method in detail. Although the values of factors and weights are not actual, they can be used to demonstrate the calculation and the presentation of results.

## 2. Experiment

The assessment team defined the process matrix of the Directorate for Strategy and Development by the Operation Fields and the Operation Categories as follows:

- Operation Fields: 1. Strategy Management; 2. Partner Management; 3. Research, Development, Innovation Management; 4. Management Systems.
- Operation Categories: A. Planning; B. Organization; C. Controlling.

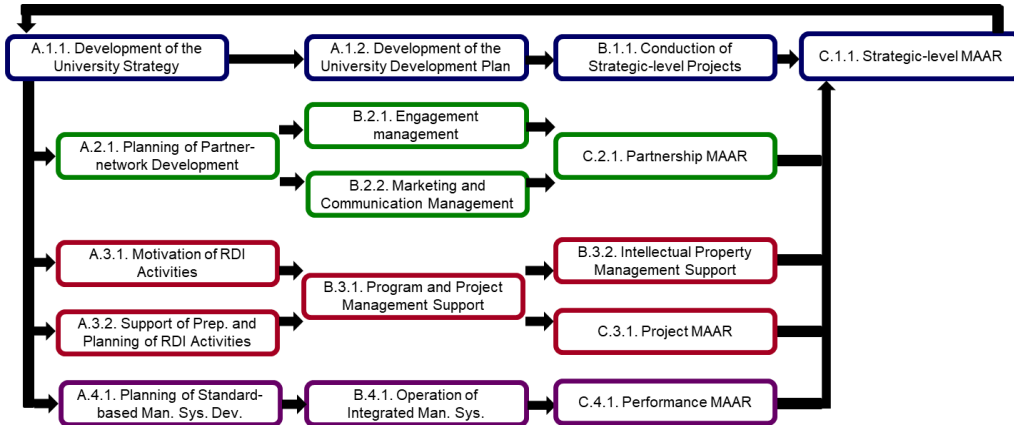
Operation Fields and Operation Categories Determined the Operation Content as a set of Main Processes (Figure 1).



**Figure 1.** Structure of the Operation Fields, the Operation Categories, and the Operation Content as a set of Main Processes.

The main processes are parts of the Process Network (Figure 2). The arrows between processes demonstrate the dominant Input-

Output connections defined in SIPOC tables (Tables 1, 2, 3, and 4).



**Figure 2.** The Process Network with the arrows between processes demonstrates the dominant Input-Output connections.

**Table 1.** Definition of Input-Output connections of Main Strategy Management Processes by SIPOC-table.

Supplier	Input	Process	Output	Customer
C.1.1.	Reports on the previous period	A.1.1. Development of the University Strategy	Strategic objectives	A.1.2.; A.2.1.; A.3.1.; A.3.2.; A.4.1
A.1.1.	Strategic objectives	A.1.2. Development of the University Development Plan	University Development Plan	B.1.1.
A.1.2.	University Development Plan	B.1.1. Conduction of Strategic-level Projects	Data, information, reports	C.1.1.
B.1.1.; C.2.1.; B.3.2.; C.3.1.; C.4.1.	Data, information, reports	C.1.1. Strategic-level Measurement, Assessment, Analysis, and Reporting	Data, information, reports	A.1.1.

**Table 2.** Definition of Input-Output connections of Main Partner Management Processes by SIPOC-table.

Supplier	Input	Process	Output	Customer
A.1.1.	Strategic objectives	A.2.1. Planning of Partner-network Development	Engagements	B.2.1.; B.2.2.
A.2.1.	Engagements	B.2.1. Engagement management	Data, information, reports	C.2.1.
A.2.1.	Strategic objectives	B.2.2. Marketing and Communication Management	Data, information, reports	C.2.1.
B.2.1.; B.2.2.	Data, information, reports	C.2.1. Partnership Measurement, Assessment, Analysis, and Reporting	Data, information, reports	C.1.1.

**Table 3.** Definition of Input-Output connections of Main Research, Development, Innovation Management Processes by SIPOC-table.

Supplier	Input	Process	Output	Customer
A.1.1.	Strategic objectives	A.3.1. Motivation of RDI Activities	Project initiatives	B.3.1.
A.1.1.	Strategic objectives, Project initiatives	A.3.2. Support of Preparation and Planning of RDI Activities	Project Plans, Tender Applications	B.3.1.
A.3.1.; A.3.2.	Project Plans, Tender Applications	B.3.1. Program and Project Management Support	Intellectual Properties, Data, information, reports	B.3.2.; C.3.1.;
B.3.1.	Intellectual Properties	B.3.2. Intellectual Property Management Support	Data, information, reports	C.1.1.
B.3.1.	Data, information, reports	C.3.1. Project Measurement, Assessment, Analysis, and Reporting	Data, information, reports	C.1.1.

**Table 4.** Definition of Input-Output connections of Main Research, Development, Innovation Management Processes by SIPOC-table.

Supplier	Input	Process	Output	Customer
A.1.1.	Strategic objectives	A.4.1. Planning of Standard-based Management Systems Development	Implemented developments	B.4.1.
A.4.1.	Implemented developments	B.4.1. Operation of Integrated Management System	Data, information, reports, development proposals	C.4.1.
B.4.1.	Data, information, reports, development proposals	C.4.1. Performance Measurement, Assessment, Analysis, and Reporting	Data, information, reports	C.1.1.

In addition, Main Processes were also defined with initiative and closing events and subprocesses.

As for prioritization, a set of factors was defined. Then, top and middle managers of organization units were asked to select the most relevant ones and give weight to them, reflecting importance. Factors were categorized into two groups as follows (see also Tables 5 and 6):

- **Process Criticality:** how critical to optimize the process to improve operation. In other words, the potential positive effect of optimization on the overall operation of the University.
- **Process Improvability:** how difficult to optimize the process to improve operation. In other words, the potential obstacles of optimization.

**Table 5.** Name, meaning, and scale of Criticality (Cr) Factors.

Factor	Meaning and scale
Transaction Number (T)	How frequently does the process run? 1 – annually; 2 – monthly; 3 – weekly; 4 – daily
Human Resource Need (H)	How many human resources are needed? 1 – one resource, small processing time; 2 – one resource, long processing time; 3 – more resources, small processing time; 4 – more resources, long processing time
Default Rate (D)	How frequently do failures occur? 1 – null or negligible; 2 – 1-10%; 3 – 10-50%; 4 – above 50%
Maintainability (M)	How difficult and time-consuming is the correction? 1 – simple, fast; 2 – simple, slow; 3 – complex, fast; 4 – complex, slow
Relevance (R)	What is the connection between strategy and the process like? 1 – weak and indirect; 2 – weak, but direct; 3 – strong, but indirect; 4 – strong and direct

**Table 6.** Name, meaning, and scale of Improvability (Im) Factors.

Factor	Meaning and scale
Control (C)	How strictly is the process controlled by laws or by university regulations? 1 – liberally or in no way, easy to modify; 2 – strictly, easy to modify; 3 – liberally, difficult to modify; 4 – strictly, difficult to modify
Level of Automatization (A)	How strictly do IT applications determine the process run? 1 – liberally or in no way, easy to modify; 2 – strictly, easy to modify; 3 – liberally, difficult to modify; 4 – strictly, difficult to modify
Flexibility (F)	How flexible and proactive is the process staff? 1 – flexible, proactive; 2 – flexible, inactive; 3 inflexible, inactive; 4 – inflexible, resistant to changes

Weights (I) were given on a Likert scale between 1 and 4, where one meant less important, and four meant highly important.

Process Priority was calculated as follows:

$$Pr = \frac{Cr}{Im} = \frac{TI_T + HI_H + DI_D + MI_M + RI_R}{CI_C + AI_A + FI_F}$$

where:

- Pr: Process Priority,
- Cr: Process Criticality,
- Im: Process Improvability,
- T: Transaction Number,
- I<sub>T</sub>: Weight of Transaction Number,
- H: Human Resource Need,
- I<sub>H</sub>: Weight of Human Resource Need,
- D: Default Rate,
- I<sub>D</sub>: Weight of Default Rate,
- M: Maintainability,
- I<sub>M</sub>: Weight of Maintainability,
- R: Relevance,
- I<sub>R</sub>: Weight of Relevance,
- C: Control,
- I<sub>C</sub>: Weight of Control,
- A: Level of Automatization,
- I<sub>A</sub>: Weight of Level of Automatization,
- F: Flexibility,
- I<sub>F</sub>: Weight of Flexibility.

Processes were assessed by individual factors and ordered by criticality, improvability, and priority. The individual factor-based assessment, together with the identification of process sensitivity, aimed to select approaches for optimization as shown by the following examples:

- time reduction approach mainly for time-sensitive processes with a high value of T and M,
- cost reduction approach mainly for cost-sensitive processes with a high value of T and H,
- failure reduction approach mainly for quality-sensitive processes with a high value of D and M,
- nonconformity reduction approach mainly for regulation-sensitive processes with a high value of D, M, and C,
- risk reduction approach mainly for risk-sensitive processes with a high value of T, D, and M,
- continuity approach mainly for availability-sensitive processes with a high value of T, D, and M,
- flexibility approach mainly for change-sensitive processes with a high value of T and F.

The order of processes by Criticality reflects the potential positive effect of optimization. Conversely, the order of processes by Improvability reflects the potential

optimization obstacles.

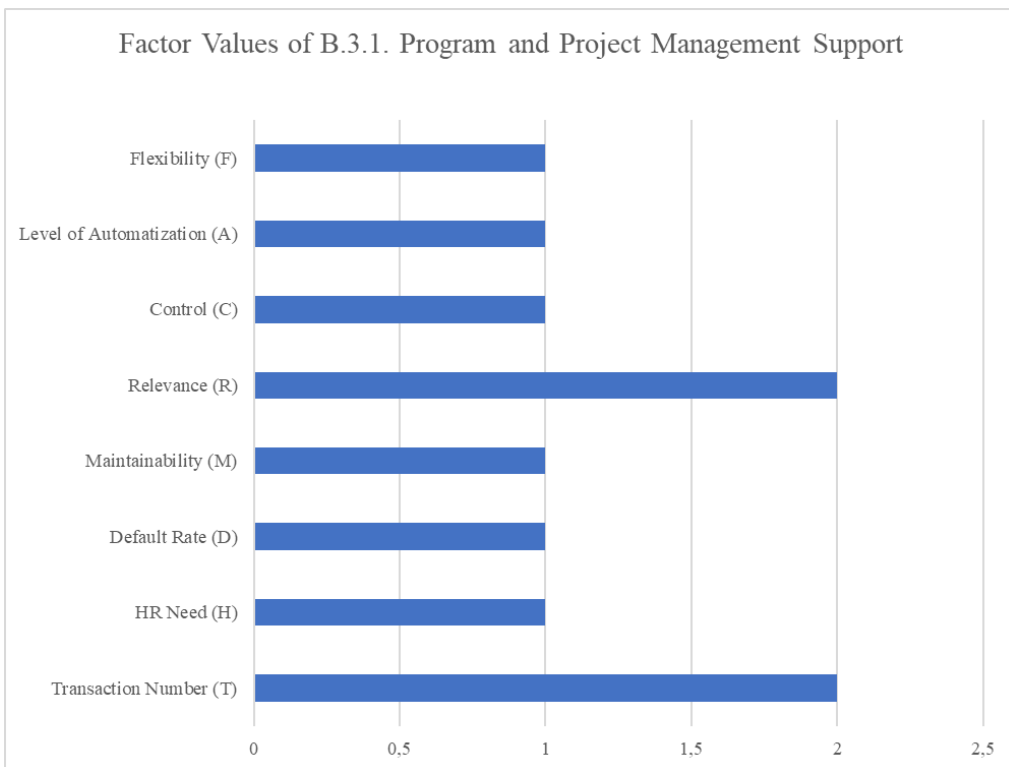
### 3. Results and Discussion

Since the assessment results contain sensitive information about the University, we modified the actual values of factors and the real order of processes.

Twenty-seven managers were involved in the survey. They were asked to rank factors

and processes. The final values were calculated as the average of their answers.

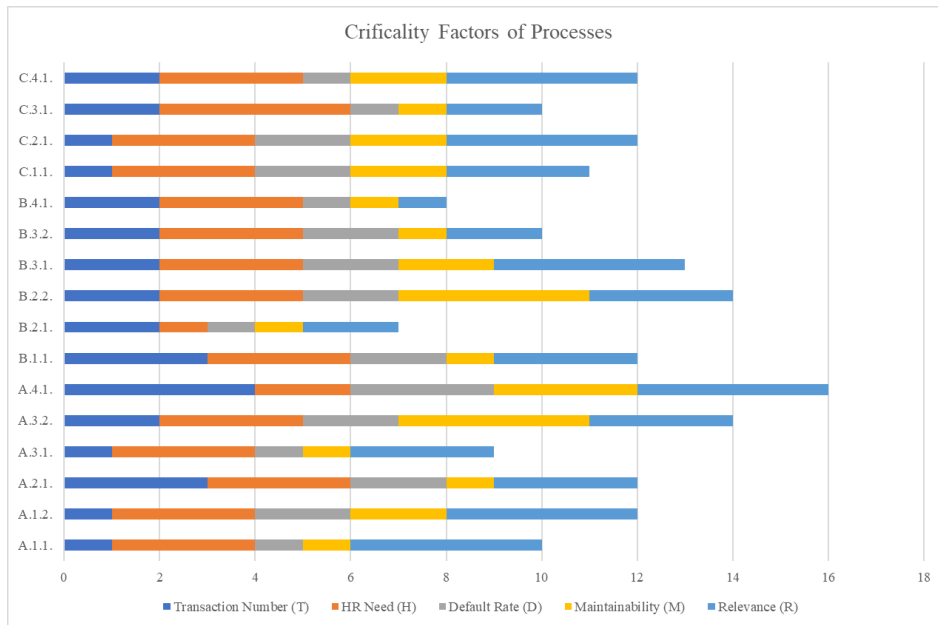
The result of the assessment by individual factors is demonstrated by the graph in Figure 3. Based on factor values and the complex time, cost, and quality sensitivity, this process should be optimized to reduce processing time and cost and achieve strategy-relevant objectives.



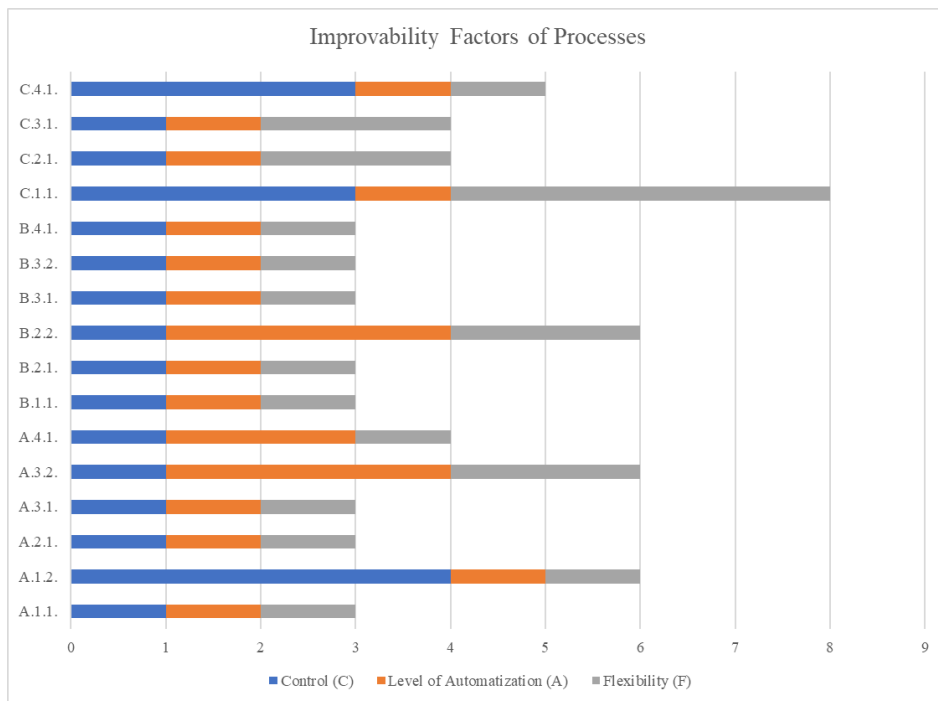
**Figure 3.** Factor Values of B.3.1. Program and Project Management Support as an example for the assessment by individual factors.

The order of processes by Criticality Factors is presented in Figure 4. According to the illustration, the A.4.1. Planning of Standard-based Management Systems Development provides the most considerable benefits.

The order of processes by Improvability Factors is presented in Figure 5. According to the illustration, the C.1.1. Strategic-level Measurement, Assessment, Analysis, and Reporting (MAAR) has the most significant obstacles from an optimization perspective.



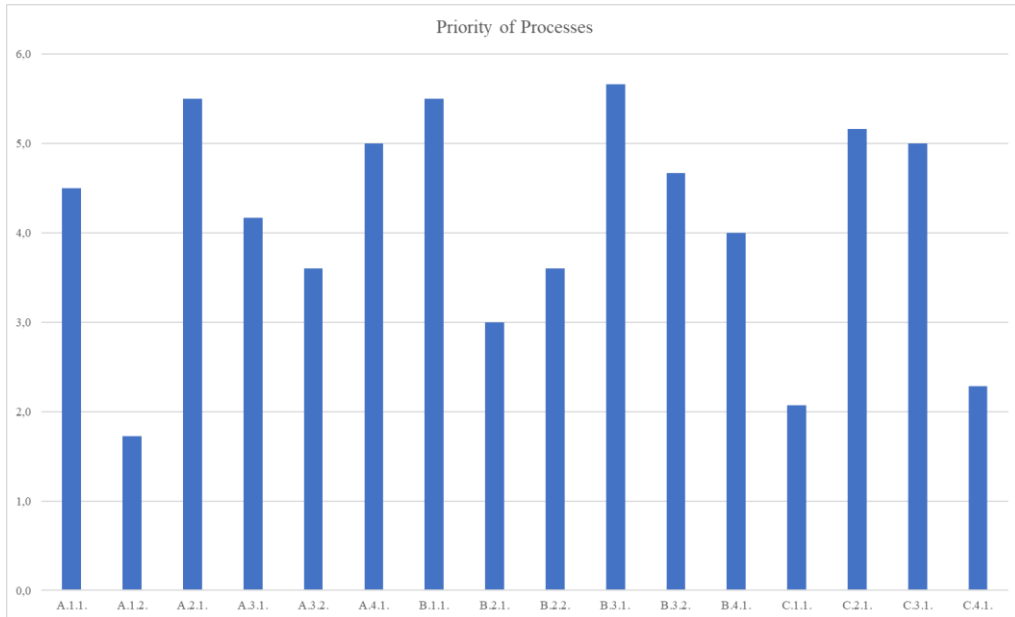
**Figure 4.** Criticality Factors of Processes in alphabetical order.



**Figure 5.** Improvability Factors of Processes in alphabetical order.

The order of processes by Priority is presented in Figure 6. According to the illustration, the A.2.1. Planning of Partner-network Development, the B.1.1.

Conduction of Strategic-level Projects, and the B.3.1. Program and Project Management Support are the essential processes from an optimization perspective.



**Figure 6.** Priority of Processes in alphabetical order.

Based on the results, the management and the professional team concluded that the new prioritization method met the previously defined requirements and served the preparation of operation development activities effectively.

After the assessment, the quality and process development team created a proposal with the assessment results and the improvement plan, including the names of the processes and the suggested optimization methods. The latter combined Lean, Six Sigma DMAIC, and BPR techniques. The main steps and tools were as follows:

1. Completing Project Charter: business background, problem statement, goal statement, in-scope, out-of-scope, risk assessment, project management processes, and project organization.

2. Process mapping (As-Is): L2 SIPOC-model, L3 cross-functional flow-chart, task attribute table, RACI-matrix.
3. Process assessment: process indicators, value-added flow analysis, waste identification.
4. Problem-solving: brainstorming, root-cause analysis, selection matrix, cost-benefit analysis.
5. Process mapping (To-Be): L2 SIPOC-model, L3 cross-functional flow-chart, task attribute table, RACI-matrix, process indicators.
6. Process automation: workflow definition, specification, and development.
7. Process documentation: Standard Operating Procedure, Workflow User Guide.



8. Process implementation: process presentation, workshops with key users, and on-the-job training.

#### 4. Conclusion

The application of process prioritization and optimization method described above succeeded. It was easy to understand and apply, it could provide realistic results reflecting the similarities and the

differences of organization units, and finally, it was helpful in operation development. Therefore, the approach and the techniques can be applied for process assessment and improvement in universities and other organizations, including service and manufacturing companies, with the same or amended set of factors and scales.

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## **INDUSTRY 4.0: SOME ASPECTS OF DEVELOPING DIDACTIC FMC**

***Abstract:** The paper discusses the modern concept of FMC management model intended for education in accordance with the Industry 4.0 strategy. The concept of managing didactic teaching aids should be based on intelligent interconnection of mechanical engineering, electronics and software, which contributes to the responding to the development of new technologies and business models. The integration of dozens of technologies is supported, some of which having been developed decades ago, but new technologies that are included in this concept are being developed almost daily. Mechanical engineers and specialized technicians trained on such or similar teaching aids are qualified to form cyber-physical systems in the fields of design, construction, and manufacturing.*

***Keywords:** Industry 4.0, CPS, Education, FMC, RFID, IoT*

### **1. Introduction**

Managing flexible manufacturing systems has been of great importance since its inception, up to the present day where automation and flexibility, among other requirements, represent key aspects of computer-integrated manufacturing and Industry 4.0. Managing can be performed at different levels, starting from computer management of individual units of the manufacturing system in real-time; management of production cells, assembly cells, measurement and control cells, and transport systems, as well as coordination and control of the entire flexible manufacturing system. The introduction of new technologies that belong to the framework of Industry 4.0 (such as modern information and communication technologies, advanced levels of automation, etc.) significantly changes the concept of manufacturing systems, both in terms of their management and the functioning. That

is why the model of managing didactic FMC (DFMC) is being viewed through the prism of Industry 4.0.

The fourth industrial revolution is characterized by the production of cyber-physical systems (CPS) based on the integration of data and knowledge. The main roles of CPS are to meet the dynamic manufacturing demands and improve efficiency, as well as to maximize the utilization of the entire industry. Industry 4.0 encompasses numerous technologies that are involved in horizontal and vertical integration, including radio frequency identification (RFID), the internet of things (IoT), cloud manufacturing, and many others.

The Industry 4.0 model promotes the connection and communication of physical components such as sensors, devices, and machines, both with each other and with the internet. According to M. Milosevic et al. (2019), the manufacturing process is divided

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into small units among which the information about successive process steps is exchanged and shared, contributing to increased flexibility and reduced coordination complexity. The goal of Industry 4.0 is to achieve higher levels of operational efficiency and productivity, as well as higher levels of automation. The main characteristics of Industry 4.0 are digitization, optimization, and adaptation to manufacturing requirements; automation and flexibility; human-machine interaction (HMI); and automated data exchange and communication. These characteristics not only correlate highly to the internet technologies and advanced intelligent algorithms but also indicate that Industry 4.0 is a process of creating new value and knowledge management.

The digitization of manufacturing allows people, products, and manufacturing facilities to be intelligently interconnected, creating the potential for increased quality, efficiency, and transparency in manufacturing. Simulation and virtual commissioning (Digital Twin) save time and money, providing a clear and efficient tool for training and research. It is possible to switch between the real system and the simulation in order to use the appropriate perspective for each purpose. In a modern, networked factory, machines and workpieces communicate with each other, as well as with ERP (Enterprise Resource Planning) systems and MES (Manufacturing Execution Systems). The increasing of computer power enables the analysis and classification of huge amounts of data that can be used to make profitable conclusions. The servicing of machines and equipment is facilitated and accelerated by digitization within the factory. Machines can independently order upcoming services, and automated downtime evaluation allows the efficient process improvement. Industrial robots become increasingly important when it comes to automated and optimal assembly of products

and their variants. For this reason, flexible cells with robotic components/systems usually constitute the core of the entire system in CP factories. With the development of the Internet of Things (IoT), and especially with the emergence and wider availability of RFID systems and their potential applications in manufacturing, a reliable method of automatic information collection and resource identification in real-time appears. Accordingly, the product and process data can be collected, exchanged, processed, and stored in the system, and as such can be applied to improve the flexibility or desired performance of manufacturing systems, or to move towards the paradigm of intelligent manufacturing. At this point, the significant issues related to the possible application of RFID technology within flexible systems can be identified, including the development of an RFID-based framework for integrating automated manufacturing systems and management information systems in factories, where RFID technology enables real-time traceability, visibility and interoperability in order to improve the overall performance of manufacturing systems.

The use of RFID devices provides new possibilities for modeling Flexible Manufacturing Cells (FMC), opening up new directions in design aimed primarily at achieving greater flexibility. Decentralized management in FMC is based on a computer intelligence system that uses the information carried by RFID tags. This RFID tag information, using adequate software solutions, provides intelligent, adaptable, and active management in obtaining the manufacturing procedures. The data for individual processing operations (e.g. specific operations, technological procedures, quality, time, priority) can be entered via RFID technology on an adequate information carrier (tag) connected to the component, decentralizing the management process and making the process more

flexible. Properly placed RFID readers in the working environment, i.e. near the manufacturing line, have the role of tracking, controlling, and detecting objects. This system based on RFID technology should potentially provide high system flexibility, which is the subject of this research.

The limited flexibility and insufficient speed response to the rapid changes in the manufacturing program in classical FMC architecture can potentially be compensated for by using RFID technology, and it is reflected in the ability increase of the subordinate computers within the system, i.e. the computers within the system gain importance in relation to the previous partial autonomous control. The flexible system gains a new role in this new situation, and the performed tasks are more complex, previously unknown to management, i.e. unpredictable, processed in real-time or, in special cases, called from the memory of the control system computer.

## 2. FMC Status (DFMC)

In the operation of classical flexible systems, in the case of didactic FMC, multiple problems arise which can be grouped into several categories. One of them relates to the weaker flexibility of the transportation system, i.e. the parts distribution, the causes of which can originate from the central control system, and it particularly shows in the case of smaller parts with more complex configurations. Another problem is related to the small number of controlled input-output functions and incomplete integration of DNC (Direct Numerical Control) into the control system. These shortcomings directly affect the modification of programs in control units, reducing the flexibility of the entire system. One possible problem within a flexible system is the temporary storage of parts in a manual warehouse.

When studying didactic flexible machining systems, the elements of the educational

process must also be taken into account (safety, clarity, dual control of the process and verification of written programs, etc.), as well as the selection of adequate components that make up the system as a whole. Since there are only a few companies in the world dealing with this issue, solutions must be sought in laboratories of higher education institutions, which, in order to ensure a proper educational process, must leave certain program codes open, taking into account the specificity of integrated equipment, educational process, maintenance, machine learning, or reengineering.

## 3. Literature Review Seen Through the Flexibility Prism of Industry 4.0 Flexibility

Companies strive for internal flexibility by adopting Industry 4.0 technologies. They perceive Industry 4.0 technologies as drivers of various internal manufacturing flexibility strategies. In this sense, findings show that cloud computing, big data, IoT, and data analytics (including AI techniques) affect all segments/dimensions/parameters of flexibility. Therefore, they can be characterized as general-purpose technologies or fundamental technologies that enable flexible manufacturing (Frank et al., 2019). These technologies do not provide flexibility on their own, but enable the identification and traceability of products, machines and materials, and provide real-time data on operations, allowing faster decision-making. The results of the analyzed study, as well as some others, show that achieving different degrees of flexibility largely depends on specific factors of the particular manufacturing, such as company manufacturing volume, process types, product diversity, life cycle, complexity, etc. Dalenogare et al. (2018) pointed out the results of research that show that companies seek flexibility mainly through investments

in equipment. One of the key questions is: Why don't industries achieve operational flexibility as one of their main benefits from Industry 4.0? The explanation is given in the answer that the factory conditions the investments in Industry 4.0, limiting what companies can implement for flexible manufacturing lines. The need for investment in upgrading the company's infrastructure is one of the biggest challenges in achieving flexibility, according to Contador et al. (2020). The analysis results showed that in companies with a large product range and short life cycles, the implementation of advanced technologies such as robots is hindered because they need to be frequently reprogrammed, thus increasing manufacturing time and costs. In such cases, technologies that increase the work productivity and flexibility are more productive because their workers are still the most flexible part of manufacturing system. On the other hand, the companies with great scope and low variations of manufacturing facilities demand highly automatised machines for special purposes in order to achieve market competitiveness. This compromise between productivity and flexibility is in accordance with areas of mass production, which is illustrated by problems with collaborative robots being very flexible, but ceasing to function all the time.

Worker adaptation to Industry 4.0 technologies has been the most frequently mentioned challenge for flexibility, as workers currently lack the necessary knowledge and training to handle the technologies (Dornelles et al., 2021). Industry 4.0 requires a different type of worker, capable of performing cognitive labor, including data processing, information interpretation, and decision-making (Ortt et al., 2020). Operators can also participate in design and decision-making, providing operational information for greater work flexibility. Although these technologies are

important, their design is still limited for wider use. More ergonomic and flexible design allows better configuration processes and helps operators in more complex tasks (Longo et al., 2017). Despite the potential of these technologies to help workers, their use is still limited, and only a few companies use them in the production applications for specific uses, such as maintenance and quality inspection (Holm, 2018).

Material (working piece) flow flexibility offers the possibility of manufacturing products by different paths, increasing the use of a larger number of machines and reducing the time flow. Traditionally, automated material handling systems are not designed to be reconfigurable, and changes in material flow arrangements often require significant halts for physical modifications and reprogramming. By applying the technologies used in Industry 4.0, new opportunities arise for creating flexible material handling systems, manufacturing management systems (ERP, MES), and material traceability systems, which are recognized as essential technologies that allow the management of many materials within factories. Moreover, autonomous robotic vehicles such as AGVs improve flexibility in terms of the ease of programming and automatic reconfiguration of transport routes. However, their use is still limited by the physical aspects of products, such as the size and cubage of transported materials.

Companies face serious challenges in achieving flexibility in their manufacturing processes (in our discussion, machining and routing). This is mainly because these two types of flexibility depend heavily on the effort required for flexible planning and design of processes and products, such as design for manufacturing techniques. In this sense, companies define their sequence operations and routes in order to optimize manufacturing time and process quality, which limits the flexibility of the line. In the

case of routing flexibility, this may happen because it requires high availability of alternative resources (Eiers et al., 2018). It has been observed that the studied companies primarily focus on increasing quality and productivity; therefore, they invest in resources for special purposes and equipment for each type of the product, limiting routing flexibility (Eiers et al., 2018). In that regard, simulation technologies can be an important tool for managers to define new route plans (Chan et al., 2006).

In flexibility operations, companies have stated that changes in the sequence of the same are still a major obstacle. Companies tend to define the manufacturing sequence in line with the technical requirements of the product or to optimize the line, making it difficult to influence changes in the sequence. Simulation tools can improve operation flexibility because they allow process modeling and analysis to find alternative sequencing of the operations. Therefore, PLM and CAD systems are useful tools for translating knowledge between fields.

The results have also shown the significance of other concepts that are factors of unforeseen circumstances for the analyzed Industry 4.0 technologies, such as modularity. These systems can be integrated with CPS for managing complex, customized manufacturing processes and rapidly adapting production capacity and functionality over time (Morgan et al., 2021). Additionally, Lean tools, ERP, and MES are expected to aid flexibility when combined with Industry 4.0 technologies (Marcon et al., 2022).

Andon systems in combination with IoT allow the equipment to respond to error warnings, stop operations, or change product routes (Rosin et al., 2020). Electronic "Kanban" (Kanban is a visual signal used to trigger action. Kanban is a Japanese word and a popular method in managing Lean

flows. Roughly translated, it means "you can see the card" (Wikipedia.) can automatically detect their inventory levels and order parts, enabling a more diverse configuration for different product designs (Marcon et al., 2022). Moreover, IoT can ensure that the right products go to the right workstations and automatically redirect products in case of errors, which is part of the "Jidoka" (By definition, Jidoka is a "Lean" method widely accepted in manufacturing and product development. Also known as autonomy, it is a simple way to protect your company from delivering low-quality products or defects to your customers while trying to maintain your time pace. Jidoka relies on four simple principles to ensure that the company delivers defect-free products: detect abnormalities, stop the process, solve the immediate problem, and investigate and solve the root of its cause.) principle. The complementarity of these concepts with unforeseen company circumstances is crucial for flexibility and productivity.

#### 4. Paper submission

One of the main characteristics of Industry 4.0 is integration. Industry 4.0 is characterized by three main types of integration: horizontal integration, vertical integration, and end-to-end integration (Kin, Liu, & Grosvenor, 2016). Liao et al. (2017) have specified these three types of integration:

- Horizontal integration is the integration of different IT systems used in various phases of manufacturing process and business planning within a company (e.g. inbound logistics, manufacturing, outbound logistics, marketing) and between several different companies (value networks) (Kusiak, 2017)
- Vertical integration is the integration of different IT systems

at different hierarchical levels (e.g. sensor and actuator level, manufacturing and execution level, manufacturing control level, and corporate planning levels) for end-to-end delivery solutions; and

- Digital end-to-end integration represents integration throughout the entire engineering process so that the digital and physical worlds are integrated throughout the product value chain, as well as in different companies, while also incorporating customer requirements.

Horizontal integration in didactic conditions can be sought in the integration of similar, independent educational technological systems at different levels. This integration simulates the integration that would occur between corporations. An example of this could be the integration between institutions that possess Industry 4.0-compliant equipment and complete the given technological process. Vertical integration plays an important role in flexibility routing and operations, as the management of a flexible string of operations and routes requires an integrated system. Vertical integration enables the information about the manufacturing complexity to be automatically sent to all subsystems (workstations) during rapid production change phases. Smart machines form a self-organized system via vertical integration that can be dynamically reconfigured to adapt to different types of products, and massive amounts of information are collected and processed to make the manufacturing process transparent.

## 5. Multi-Agent DFMC Management System Based on Macro Programming and RFID

The modified block diagram of the DFMC control model based on a multi-agent

structure, macro programming, and RFID is shown in Figure 1 (Gligorić, M. 2021). The main characteristics of the presented control model are:

- The carrier of technological and manipulation information is an RFID tag attached to the work piece (in cases of combination with pallet transport, the tag can be moved to the bottom of the pallet),
- Agents and multi-agents manage processes in approximately real-time (operation sequence, system reconfiguration, supervision, etc.) which increases DFMC flexibility,
- The transport system is based on a robot that has the property of reconfigurability (Reconfigurable robotic systems consist of at least two collaborative robots, one of which has the ability to be reconfigured. Reconfigurable robots and reconfiguration robotic systems are types of robotic systems that have the ability to restore their original function, completely or partially, after the partial damage of the system or the need for a change in certain characteristics. This is achieved by making changes to individual components.),
- DFMC modularity is achieved by using different types of flexible processing and additional machines, as well as different types of transport systems,
- Open modular structure that allows combining and mixing different intelligent transport and manipulation systems in the manufacturing process,
- Openness of software codes for research and analysis purposes,
- Partial approach to adjusting and analyzing DFMC processes (belonging to Industry 3.0), etc.



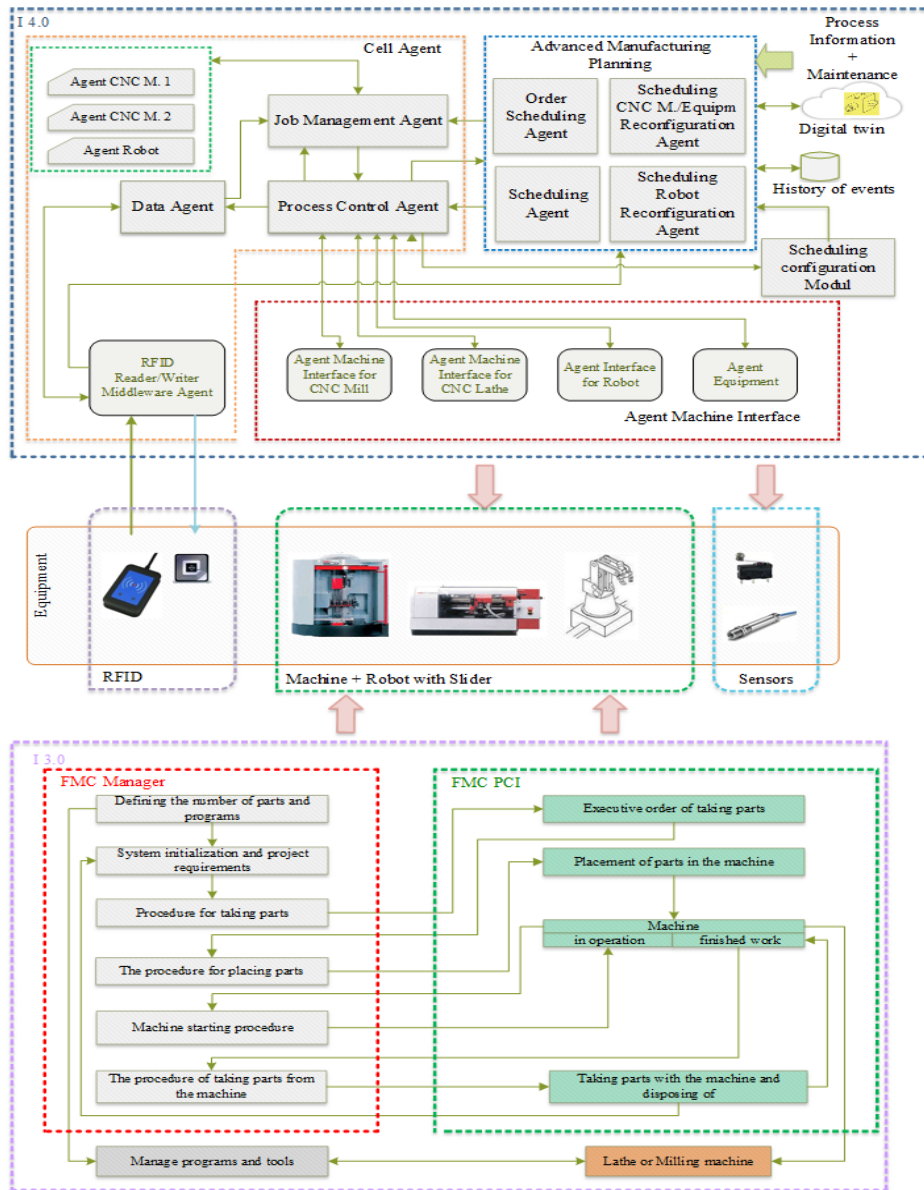


Figure 1. Block diagram of DFMC control

## 6. Conclusion

The competencies, knowledge outcomes, and skills for "smart" personnel need to be modernized and upgraded by incorporating

the knowledge necessary to implement the requirements of Industry 4.0 strategy. In order to achieve this, it is necessary to provide adequate teaching aids that offer: automatic product identification, real-time process technology planning, and

disburdenment of the control system, i.e. management localization. The multi-agent architecture of the proposed model for managing didactic flexible cells is capable of providing interoperability of RFID technology for a given constructive solution, as it enables a distributed system of management and supervision for DFMC. The management model has an advantage over smaller-sized parts that require fast program changes in processing (CNC machines) and manipulative systems (robots

with external peripheral axes) as it tends towards adaptive, "ad-hoc" management, solving unknown and unpredictable situations. This designed model introduces a flexible cell to a higher level of management. The management model combines: technology based on agents, parametric programming of CNC machines, and flexible tools and methods in the processes of generating technological procedures and transport within DFMC.

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## **PARADIGMS OF APPLICATION OF ICT IN TEACHING**

***Abstract:** The mass application of ICT and computer software in teaching, caused by the current crisis with the pandemic, found many educational institutions and teachers unprepared and insufficiently trained for their effective application in the teaching process. In order for teachers to use ICT efficiently and effectively in teaching, they need to be willing to learn new skills. Daily and functional use requires the use of more sophisticated functions of computer programs that carry out the learning and teaching process. Integrating ICT into the learning and teaching process is of crucial importance in the information society of the 21st century. The rapid development of ICT constantly affects the challenges of life and work, and therefore of pupils and students through the educational system as members of a society in which ICT is an indispensable part. It was the development of information technologies that initiated improvements in various areas such as: finance, business, health, education and others. This particularly reflected the rapid progress in the field of education and encouraged the introduction of e-learning, which is a direct result of the integration of education and technology and is considered a powerful medium for learning.*

***Keywords:** distance learning, electronic learning, neuro-fuzzy methodology*

### **1. Introduction**

New teaching methods in ICT education advocate the active role of students in their own education, and place teachers in the position of expert advisers and coordinators of the learning process.

Blended learning and a mix of content delivery tools are the right solution for capturing student attention and tracking student progress.

The subject of research in this paper is the teaching process of mathematics implemented in a traditional and modern way with the use of ICT. In this context, the experiences of many mathematics teachers have shown that students have the most problems with acquiring the content of this

school subject. Motive is a very strong factor that can influence overcoming this problem. From there came the idea to determine how the implementation of teaching can influence the level of motivation for learning mathematics.

The goal of the research of this work is to provide some kind of contribution to the establishment of a positive attitude of students towards mathematics by encouraging motivation to acquire new knowledge, as well as by contributing to the methodology of teaching mathematics.

Technology-assisted learning or standardized lessons can mitigate instructional weaknesses and significantly improve test scores.

## 2. The position of ICT in teaching

Technology-assisted learning or standardized lessons can mitigate instructional weaknesses and significantly improve test scores. Ljajić believes that ICT is defined as a combination of information technology with other technologies, especially communication technology. In practice, several types of analysis of the impact of ICT on the learning process are applied, and one of them is the SWOT analysis.

By using this analysis, we are given the opportunity to determine the strengths and weaknesses of the education system itself, as well as to improve the quality of education itself. With the help of SWOT analysis, for example, we can define each platform separately and determine which platform is the best and most represented for primary, secondary and higher education. All platforms that are used in teaching are important and therefore are proportionately represented in education. The most frequently used distance learning tools were Zoom meetings, Google meet, Email, Moodle online classroom and Cisco Webex, which students found easy to use. The Moodle online classroom, e-mail communication and online lectures were chosen as the most suitable ways of presenting the study material.

In addition to computer/digital literacy, teachers see ICT as fostering students' interest in subject matter and learning and attitudes towards information technology as

a learning tool as a key part of a lifelong interest in learning. Building on this, it becomes clear that ICT must be linked to the specific needs of individual countries while ICT is used as a student-centered tool, unlike traditional pedagogy.

### 2.1. Factors affecting the application of ICT in teaching

In the scientific literature, there is a significant number of works that highlight the strategic importance of modern ICT in educational institutions that address the issue of information and digital literacy as a function of the quality of education (Petković et al. 2018). However, despite the number of works that deal with these topics separately, no works were found that give a complete insight into the above-mentioned problem, providing an answer to the question to what extent the IT literacy of educators affects the improvement of quality in educational institutions and in what mutual relationship are these variables.

There are a number of comparative methodologies on the market so that each institution can choose an effective e-learning platform according to its needs.

In the following, we present the results of the research conducted at the Higher Education Institution in the territory of Kosovo and Metohija (KM). To the survey question about the factors that influence the degree of ICT application at the Higher Education Institution.

**Table 1.** Factors affecting the level of ICT application at the Higher Education Institution in function of the gender of the student (Milićević et al. 2021)

No.	Factors affecting the degree of application ICT in colleges/universities	Gender of students		Total
		Male	Females	
1	Activity and expertise of the teaching staff	108	63	171
2	ICT faculty/university equipment	150	125	275
3	Activities of the faculty dean/school director	37	25	62
	<i>Total</i>	295	213	508

**Table 2.** Factors affecting the level of ICT application in function of the age of the students (Milićević et al. 2021)

No.	Factors affecting the level of ICT application at colleges/universities	Age of students					Total
		19-25	26-32	33-39	40-46	54-60	
1	Activity and expertise of the teaching staff	152	13	3	2	1	171
2	ICT faculty/high school equipment	256	14	4	1	0	275
3	Activities of the Dean/Director	56	5	1	0	0	62
	<i>Total</i>	464	32	8	3	1	508

Although educational systems in Europe have been investing considerable resources in information technology since the early 1980s, when it comes to educational institutions, there are still no international standardized indicators that would show the contribution of technology and the effectiveness of its use in education (Pedro 2012). In the absence of relevant research on the application of e-teaching in the function of improving the quality of education in the Republic of Serbia, especially in the territory of Kosovo and Metohija, the purpose and justification of research in the conditions of the current pandemic is multiple.

## 2.2. Aspects of ICT application in education

When integrating technology into the pedagogical process, it is important that the teacher has the skills that allow him to use technology properly in the classroom (Denić et al. 2019). The didactic design of lessons is based on learning objectives, so it is important to adapt the use of ICT tools to the content needs of students, and not the other way around. An essential element of the success of the introduction of ICT is the choice of approach, which must be aimed at the active participation of students. Research indicates that the integrated use of ICT requires more preparation time and greater operational reliability. Research on students showed that their response to the use of e.g. mobile devices in study work is positive, although most do not believe that their

learning performance has improved (Kinash, Brand, Mathev & Kordiban 2011). Although learning outcomes are not improved, the perceived comfort and flexibility of study work can also be significantly increased. A key problem is the differences between students' opinions about their knowledge of using ICT and actual knowledge or achievements (Hatlevik, Throndsen, Loi & Gudmundsdottir 2018), as well as the duration and intensity of the use of smart devices. Felisoni and Godoi (Felisoni & Godoi 2018), for example, find that daily long-term smartphone use has a markedly negative impact on academic performance. In this context, an important role is played by teachers, who by choosing ICT and appropriate didactic use make an important contribution to the way of working within the study process, as well as to the adaptation of learning to new situations using new modern technology.

All innovations that require teachers to change many aspects of their daily routines are very demanding. Complex innovations can only be successful if a number of mutually complementary conditions are met. Therefore, the following questions should be addressed:

- What kinds of ICT skills do teachers need? What policies and programs are effective in preparing and motivating teachers for their role in education for the information society?
- What is the impact of ICT on teachers' working conditions?

Implications for changes in teacher professional development and other elements of the education system differ in how individual systems transition from traditional education to (1) technological literacy, (2) knowledge deepening, and (3) knowledge creation. Of the three approaches, the technological literacy approach involves the most fundamental policy changes. The goal of this approach is to prepare students, citizens and a workforce capable of embracing new technologies to support social development and improve economic productivity.

Application of modern ICT in teaching can take place in two directions:

- The role of modern technology is to transmit information through software

that communicates with the student and gives him instructions;

Another way is to understand learning as the ability to solve problems using one's own mind (the student comes to the solution independently, by observation, analysis, drawing a conclusion).

- For the application of ICT in teaching, the teacher is enabled to:
- Designing the classroom,
- Integrating ICT into the teaching process,
- Education of students to use computers in class,
- IT literacy of teachers,
- Ergonomics of the teaching space,
- Use of computers in teaching.

**Table 3.** Indicators of successful application of ICT in an educational institution

Indicators of successful application of ICT in an educational institution	Indicator
Technological means	optimization of equipment types and characteristics in accordance with the needs and requirements of the educational institution
Installed technologies	planning, coordination and verification of requests, communication media, furniture, lighting, security and insurance, educational institutions
Technologies available to students and teachers	providing staff who can support adequate work and learning for ICT users
Technology service	maintenance and upgrading of hardware and software
Professional development	development of human capacities of employees in an educational institution – INSET for teachers, librarians, professional associates and other employees
Planned technologies	documentation of ICT implementation plans and its placement in the educational public
Used technology	monitoring the time spent at the computer with the aim of carrying out various educational tasks of the participants in the educational process
Achieved educational outcomes	level of ICT competence of users of ICT resources
Effectiveness in mastering certain teaching subjects	achievement of educational goals, including independence in learning
Funding	total money spent on ICT implementation



### 3. Research results

Empirical data, that is, the results of research on the expectations and experiences of pupils, students and teachers in integrating distance learning into their educational activities can be an important guide for the future in terms of strategies for the development of teaching-pedagogical practice.

- SWOT analysis and discussion of student and teacher survey results

This analysis assesses internal and external factors, as well as current and future potential. SWOT analysis works best when different groups within the organization are free to provide real data rather than prescriptive messages.

- Research indicates that teachers, students and pupils must know the right way to integrate ICT into education, why and when e-learning activities are undertaken and what the expected benefits can be. In a survey of the most common distance learning problems users encountered, the majority cited the following: technical difficulties, unclear teacher instructions, and uneven workload. Teachers and students in higher education highlighted the advantages of didactic use of ICT in the learning and teaching process: active participation of students, the possibility of receiving quick feedback and the development of discussion, more transparent visualization of content and the possibility of adapting content and tasks.
- The research carried out within this paper indicates that teachers in higher education believe that the knowledge, skills and

competences of teachers represent factors that must be fulfilled, that is, satisfied, as a condition for the effective and successful use of ICT in the teaching process during the COVID-19 virus pandemic. In this sense, the importance of the technological and didactic knowledge of the teacher is emphasized, which is also connected with the ability to critically assess the appropriateness of the use of certain ICT, that is, distance learning in specific learning situations. Bullets and

### 4. Conclusion

Research indicates that teachers, students and pupils must know the right way to integrate ICT into education, why and when e-learning activities are undertaken and what the expected benefits can be. In a survey of the most common distance learning problems users encountered, the majority cited the following: technical difficulties, unclear teacher instructions, and uneven workload. Teachers and students in higher education emphasized the advantages of didactic use of ICT in the learning and teaching process: active participation of students, the possibility of receiving quick feedback and development of discussion, more transparent visualization.

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## DISTANCE LEARNING COMMUNICATION STRATEGY AT THE POLICE INSPECTORATE SCHOOL IN SOUTH KALIMANTAN

**Abstract:** *This study aims to analyze the planning, implementation and evaluation of the 49th Batch of 2020 Communication during the Covid-19 pandemic in South Kalimantan, which focused on the use of virtual learning in the distance learning process which is believed to provide easier learning, can communicate directly so that material is easy to accept. . All Education, totaling 1,550 people, implemented distance learning because it was seen as safer during the Covid pandemic, including the Police Inspector School Education. Methods This research was carried out using a qualitative approach. This type of research is descriptive qualitative. Data collection techniques are interviews, observation and documentation. the theory used is educational communication theory and interpersonal communication. Results of the study: The form of lesson planning includes the Learning Implementation Plan. Implementation of this distance learning by using the media application zoom meeting and whatsapp. Distance learning is carried out by lecturers, teaching materials will be sent and provided specifically for students who will then be given assignments to be evaluated by lecturers to evaluate the achievement of distance learning. Suggestion: communication strategies and planning, implementation and evaluation of distance learning need to be improved so that the future will be even better.*

**Keywords:** *distance learning, communication strategy, Police Inspectorate School*

### 1. Introduction

In the era of the industrial revolution 4.0, we are faced with the emergence of a new corona virus (nCov) pandemic that causes coronavirus disease 2019 (COVID-19) which has occurred in all countries, including Indonesia, which has had an impact on all life. No exception in education and lifestyle of people throughout the

country. The most striking changes can be seen in the way people live their social lives and the teaching and learning process. All learning from elementary to tertiary level (university) is controlled from home ( work from home and school from home ).

The distribution of people in the category of People Under Monitoring (ODP), People Without Symptoms (OTG) and Patients Under Monitoring (PDP) in Indonesia

showed a significant increase from 2 positive patients on 6 March 2020 to 4,839 on 14 April 2020, with an average the increase per day reached 200-300 entering April 2020, requiring the government to issue instructions regarding social restrictions. With an increase in the number of people who are positive for COVID-19, of course schools must be able to prepare a strategy for a distance learning system both in terms of educators and students and their supporting infrastructure so that learning can run smoothly.

Based on Circular Letter number 1 of 2020 concerning the prevention of corona virus disease (COVID-19) in Higher Education, the Ministry of Education and Culture states that the implementation of Distance Learning (PJJ) is adapted to the conditions of Higher Education (PT) and directs students to conduct learning from home ( school from home ). Campuses can take advantage of online learning applications such as Google Clasroo, Edmodo, Schoology, Classdojo, zoom meetings and other applications.

Education is one of the important aspects of life that has colored human life since the beginning, has become a guardian of life, and human basic needs (Yusuf, 2018: 7). Education is the learning of knowledge, skills and habits of a group of people passed down from one generation to the next through teaching, training or research. Education often takes place under the guidance of others, but is also possible on a self-taught basis. Every individual has the opportunity to learn without any obstacles. Online or distance learning makes students have to study independently, look for other learning resources that support learning on campus, sometimes the COVID-19 pandemic causes learning to be carried out face-to-face in class, so during conditions like this it must be done with the PJJ system.

In this case, of course, technology has a very important role to facilitate interaction, communication and presentation so that the

learning process goes well (Muhibbinsyah, 2004:10). Therefore, the role of learning media is needed to facilitate communication between educators and students (Borisova et al., 2016). However, if it is not used properly, of course it will only cause problems, failure occurs and learning does not go well (Blue Journal &Gurdner, nd) and will only be used as evaluation material for distance learning (Moore et al., 2010: 7).

e-Learning is an electronic-based learning process in which its use can be accessed online (Weni&Isnani, 2016: 144 – 127 ). Improving mastery of learning materials, increasing interaction between students and educators and facilitating the learning process are the objectives of e-Learning in its application (Darmayanti et al., 2007:99-133). So it is effectively used during this pandemic. However, its use is lacking because the content is only in the form of text or presentation slides , there is a need for development to increase interest in learning (Cucus&Aprilinda, 2016: 1-5). The development of e-Learning , the google classroom application as a learning medium during a pandemic is considered effective because its use is effective and efficient and can be done flexibly anytime and anywhere, is practical to use, and can improve learning outcomes (Subandi et al., 2018: 460– 463 ). However, the use of Google Classroom must be balanced and adapted to a good internet connection, this is also a problem if there is a delay in submitting assignments due to a slow connection (Fauzan&Arifin, 2019). Therefore, in its use should be adjusted to suitability of the level of learning, the quality of learning as well as the intensity and time.

The use of virtual learning in the distance learning process is believed to provide more ease of learning, being able to communicate directly so that material is easy to accept (Munawaroh, 2005). The use of virtual learning can be used one of them with the zoom application . This application is carried out as if it were happening in classroom

learning, the use of applications that are easy to use, but lately data theft has often occurred on users so that it is not safe to use and its use requires a large internet connection (Nuryana, 2020). At this time there are many applications that are used, such as being able to use webex, microsoft and other zoom meetings so that users feel safe.

Zoom Meeting itself is a learning medium using video. The founder of the Zoom Meeting application, Eric Yuan, was inaugurated in 2011 whose head office is in San Jose, California. This application is not only used for learning but can be used for office matters and other matters. This platform is free so it can be used by anyone with a time limit of forty minutes and there is no time limit if our account is paid. In this Zoom Meeting application, we can communicate directly with anyone via video. Therefore, it is suitable to be used as a learning medium.

All education implements distance learning because it is seen as safer during the Covid 19 pandemic, including the School of Police Inspector Class 49th TA. 2020. The Sumber Bachelor Police Inspector School is a Police education for graduates needed in the Police profession to be educated and formed into Police Inspectors who have the knowledge, skills, abilities and toughness. Commendable attitude and behavior in carrying out police duties in accordance with their role as a police inspector who is an expert in his field of knowledge to support his duties,

Education is the right of all nations as stated in the 1945 Constitution Article 31 paragraph (1) every citizen has the right to education. (2) every citizen is obliged to attend education and the government is obliged to finance it ( Emanuel Sujatmoko, 2010: 182). The students were also asked to return to their respective areas and return to Sukabumi at an undetermined time. this results in hampered learning. However, there is the best solution, namely the Police

Inspector School institute, which chooses to use the platform, namely WIB, to facilitate student learning and is seen as safer during the current Covid-19 pandemic. Therefore, learning for 49th batch of SIP students in 2020 is different from that of last year's SIP students.

Where all the learning and training provided must be conveyed via distance learning (PJJ) zoom meetings and whatsapp groups). However, Distance Learning (PJJ) also has advantages and disadvantages when learning takes place. The advantages of distance learning include: 1) Students can interact with lecturers, friends and learning materials without having to be limited by distance and time, students can communicate with their lecturers via e-mail, if students need additional information related to the material he learns, he can access the internet more easily. changing the role of students from those who are usually passive to be active. 2) educators can control students' learning activities through the internet, educators can use teaching materials or study instructions that are structured and scheduled via the internet, so they can discuss with students. 3) availability of e-moderating facilities where lecturers and students can communicate easily via internet facilities on a regular basis or whenever communication activities are carried out without being limited by distance, place and time; E-learning can present lessons in an interesting way. However, the use of the internet for learning or e-learning is also inseparable from various shortcomings, including: 1) For students who do not have high learning motivation, they tend to fail. 2) lack of personnel who know and have internet skills. 3) the lack of interaction between lecturers and students or even between students themselves can slow down the formation of values in the teaching and learning process; the tendency to ignore academic or social aspects and instead encourage the growth of business/commercial aspects. the learning

and teaching process tends towards training rather than education, not all places have internet facilities. 3) lack of personnel who know and have internet skills; lack of mastery of computer language. 4) Unstable signal 5) Human Error (Unfocused, Drowsiness etc). In order for distance learning to be achieved, a communication strategy is needed.

**2. Research methodology**

The type of research used is descriptive, namely analyzing and presenting facts systematically so that they can be more easily understood and concluded. This research was carried out using a qualitative approach, namely research in which the data are in the form of words (not numbers) derived from interviews, notes, document reports, etc., or research in which the emphasis is on an analytical description of an event or process as existence in a natural environment to derive a deep meaning from the process. This approach is a process.

A qualitative approach is used to reveal descriptive power and information about what they do and what they experience towards the focus of the research. Qualitative research has characteristics including: scientific, human as an instrument, using qualitative methods, inductive data analysis, descriptive, more concerned with process than results, there is focus, there are criteria for data validity, research design is provisional, research results are negotiated and agreed together.

The type of research used in this research is a case study. In this case, Nana SyaodihSukmadinata explained that a case study is a research study conducted on an integrated system. This unit can be in the form of programs, activities, events or a group of individuals related by a certain place, time or bond. In short, a case study is a research directed at collecting data, taking meaning, obtaining understanding from the

case.

Qualitative research is research based on post-positivism philosophy which is used to examine the condition of natural objects where the researcher is the key instrument and the results of his research emphasize meaning rather than generalization (Sugiyono, 2009). Descriptive research is research conducted to describe a variable, either one variable or more (independent) without making comparisons, or linking one variable to another (Sugiyono, 2009).

**Table 1.** Informant List

No.	Name	Position Status
1	YudiMartiasAnas	girl
2	Erik S onjaya	girl
3	Maya	Learners
4	fannan	Learners
5	Yudi	Learners

**3. Results and discussion**

Setukpa is an abbreviation of the School for the Formation of Officers whose task is to carry out the function of forming Polri officers from Polri members. Setukpa used to be called Secapa (Officer Candidate School). Setukpa is led by Keala, abbreviated as Kasetukpa, who is responsible to Kalemdikpol. Currently Kasukpa is led by Brigadier General Mardiaz Kusin Dwihananto.



**Figure 1.** Setukpa based on research results in 2022

Police Education & Training Institute (Lemdiklat) is a supporting element for implementing education and development under the Chief of Police with the task of planning, developing and organizing Police education in the framework of "Creating Professional, Modern and Reliable Tri Brata Personnel (Promoter)", based on the type of Polri education which includes professional, managerial education ( leadership), academic, and vocational as well as managing the education component in the ranks of the National Police Education and Training Center. The Polri Education and Training Institute is led by a Commissioner General of Police, assisted by 4 (four) Bureau Chiefs with the rank of Brigadier General of Police (Remin Bureau, Education and Training Bureau, Curriculum Bureau and Jianbang Bureau). The Polri Education and Training Institute is located on Jl. Ciputat Raya No. 40, Pondok Pinang, Kebayoran Lama, South Jakarta.

**Strategic Vision**

- VISION : To make Polri Education Institute a center of excellence in producing PRECISION POLRI members
- STRATEGY: Learning Institute for Education & Training & Position the Polri campus as a VITAL POLRI OBJECT

**KalemdiklatPolri Priority Programs:**

1. Creating a Healthy Campus
2. Creating a Safe Campus with Maximum Security
3. A Campus With a Precision Curriculum That Responds to the Challenges of Current Tasks & a Sense of Nationality
4. Making Campus a Favorite Place & Achievement Personnel
5. Building the Campus as a Center of Excellence
6. Building a Precision Campus Pilot Project

7. Creating a National Campus
8. Creating a Campus with a Strong Structure
9. Developing Sticks to Unkam
10. Increasing Lpdp Graduates
11. Equivalence of State Scholarship Masters & Doctoral Graduates with Sespimmen&Sespimti
12. Centralized Education & Training Coordination
13. Fulfillment of Sarpras Main Function of Police Practice at the Police Academy

**4. Communication Planning**

The term communication planning comes from the words planning and communication. Planning itself comes from the word plan which means everything that will or should be done. If everything that will or must be done is systematically pursued and stated in writing, it is called planning. In simple terms it can be said that planning is basically a process or effort or act of making a plan. The actions taken in making a plan are none other than the act of making decisions about what will and should be done. GR Terry (Mardikanto, 1992:281) states that planning is a process of selecting and linking facts and using them to compile assumptions that are expected to occur in the future and then formulate proposed activities to achieve the expected goals. . The important thing to note is that a plan is always oriented to the future (future oriented).

Meanwhile, communication, as you have learned in the Introduction to Communications Module, is basically the process of conveying messages from communicators to communicants, either directly or through the media with the aim of changing behavior. According to Bloom's Taxonomy (Winkel, 1990: 132), behavior change can occur in the cognitive domain, affective domain, or psychomotor domain.

Cognitive behavior is behavior related to aspects of cognition (intellectual ability or knowledge); affective behavior is behavior related to mental attitude; and psychomotor behavior is behavior related to skills. Changes in behavior in the cognitive aspect can simply be interpreted as a change from a state of not knowing to knowing; affective behavior change is a change from unwilling to willing; and changes in psychomotor behavior is a change from unable to be able.

Changes in behavior as described above that occur in the communicant or the target of communication do not automatically occur at every completion of a communication activity. Changes in the three types of behavior will only occur if the communication process carried out is truly designed and planned for the intended change objectives. In other words, changes in the communicant's behavior can occur as expected if a mature communication plan is carried out beforehand.

Then the question will arise: "What and how is the communication plan?" In simple terms it can be stated, communication planning is a written statement regarding a series of actions about how a communication activity will or must be carried out in order to achieve behavior change according to what we want. Because communication activities are basically in the form of conveying information (messages) by the communicator to the communicant, communication planning mainly concerns communicator planning, message planning, and media planning.

A written statement about everything that will or must be carried out in a communication activity is of course not just an explanation, but must be a systematic and detailed description so that it can be used as a guide in its implementation. A good plan (including a communication plan) is a plan that can actually be used as a guide that can help facilitate the implementation of an activity. Why is that, because it is possible

that in a communication project the people involved in a planning process are not necessarily involved as executors at the same time, and conversely the executors of communication activities may not be the people involved in the planning process. Therefore, between planning activities and implementation activities can be in the form of two activities (projects) each of which stands alone even though both are under the same project.

Good communication planning can determine the success of programs that will be implemented in the community. According to Middleton, good communication planning has several stages, namely, 1) collection of base line data and needs assessment; 2) formulation of communication objectives; 3) planning analysis and strategy development; 4) audience analysis and segmentation; 5) media selection; 6) message design and development; 7) management planning; 8) implementation of training; 9) implementation or execution; 10) Program evaluation. The following describes each of these stages:

#### Distance Learning (PJJ)

A Distance Study Program established with an establishment permit from the Decree of the Minister of Research, Technology and Higher Education of the Republic of Indonesia. Minister of Education and Culture (Mendikbud) Nadiem Anwar Makarim said distance learning (PJJ) could be implemented permanently after the Covid-19 pandemic. Currently, the Ministry of Education and Culture is preparing the PJJ curriculum and learning modules.

Nadiem explained, the use of technology will be fundamental in learning. The application is not only PJJ, but also the hybrid model. The use of technology provides opportunities for schools to carry out various kinds of learning activities. Nadiem said the Covid-19 pandemic had



provided an opportunity for the world of education to carry out various kinds of efficiency and technology.

Nonetheless, adapting and experimenting utilizing technology for learning activities. Currently, the Ministry of Education and Culture is conducting curriculum formulation to PJJ assessment. The curriculum is structured by considering the simplification of learning and focuses on aspects of literacy, numeracy, and character education. The team from the Ministry of Education and Culture, namely Balitbang, is preparing the curriculum.

In simple terms, the media is an intermediary in the learning process both in class and outside the classroom, which is intended to arouse attention and concentration and motivation of students to learn, but with changes in the teaching process carried out by lecturers in special situations, lecturers appear to increase their role as operators and as designers. in the delivery of learning materials. Nana Sujana (2011: 111) states that the pattern of teaching is the responsibility of the lecturer and the media, meaning that the increasing need for teaching activities, both quantitatively and qualitatively, will demand the ability of lecturers in the field of teaching technology. Hardhono (2012: 361) states that technology can be used for the development of distance education by involving a larger number of students in Indonesia.

Pannen (2012: 11) defines distance teaching as based on the separation between lecturers and students in space and time, which is designed systematically through the use of technology. Distance teaching or what is called Distance Learning initially developed in the United States, Germany, France and England, and in 1840 Sir Isac Pitman taught remotely using letters, and in 1980 the International Correspondence School (ICS) built a system of lectures home study courses as the forerunner of learning. distance learning (distance learning) which later

developed into e-learning (Ali Taufik, 2019: 1).

In a study that Web Media will be an effective and efficient means of distance learning between lecturers and students so that they can carry out the teaching-learning process without being limited by place and time (AtmokoNugroho, 2012). In a distance learning process, lecturers are expected to be able to managing online classes, designing and directing learning systems implemented by students so that there is conformity with the learning objectives to be achieved, there will be a balance and harmony between quality development and quantity development (Sardiman 2013: 170). Distance teaching is a single mode as an effort to develop distance learning using technology that can be used as an alternative to spur the development and improvement of educational functions, add new experiences and insights into teaching to be able to reach educational services to meet community needs in order to anticipate future education (Zuhairi 2012: 45).

Perry and Rumble (1987) emphasized that in the context of distance education, the meaning of the word distance is the absence of face-to-face contact between lecturers and students when the teaching and learning process occurs. Thus, distance education or PJJ is two-way communication bridged by media such as letters, telephone, radio, internet, computers, smart devices and so on.

Meanwhile, according to the Higher Education Law number 12 of 2012, article 31 concerning Distance Education (PJJ) explains that PJJ is a teaching and learning process that is carried out remotely through the use of various communication media. supported by learning facilities and services as well as an assessment system that guarantees the quality of graduates according to National Standards

Therefore, according to Perraton (1981) if we want to build a theory of distance

education, it cannot be separated from existing educational philosophy and communication theory or diffusion theory. He said that in developing distance education one should consider the aspects of expansion and dialogue.

Expansion (expansion) or equity and development of education is necessary because education is related to power. Humans who are not educated are generally in a weaker position than educated humans so that from this perspective the assumption appears that education is synonymous with the process of gaining power. Thus, how the expansion process takes place (dialogue) becomes important.

The word "dialogue" in this case, if not interpreted carefully, is like a double-edged sword; strengthening the development of the concept of conventional education and weakening the concept of distance education. By highlighting the psychological aspects of dialogue, we tend to conclude that education will be effective because students feel more comfortable and motivated to learn.

Without dialogue, education will turn into indoctrination. Distance education experts must consider this and examine all possibilities to present the concept of learning as a comfortable activity, not a burden. PJJ will not be completed without a clear theoretical basis. From a theoretical point of view, Sewart, Keagan, & Holmberg (1983) outlines three main theories regarding distance education, the theory of autonomy and independent learning, industrialization of education, and interactive communication.

The first theory is the theory of autonomy and independent learning, basically heavily influenced by social democratic views and liberal educational philosophy which states that every individual has the right to equal opportunities in education and every instructional effort should be pursued in such a way as to give freedom and independence

to participants. Learn in the learning process. Students have the freedom to consider and decide for themselves what to learn and how to learn it. That is, if in conventional education students communicate more interpersonally or consult with humans, then in distance education they do more intrapersonal communication with input in the form of information or teaching materials in printed or non-printed forms.

The second theory is the theory of educational industrialization put forward by Peters (1973). He said that the distance education system (PJJ) is a form of industrialization of teaching and learning activities which in its implementation is characterized by division of labor and mass production (teaching materials). PJJ is a method for teaching knowledge, skills, and attitudes by applying various principles of industrialization and the use of technology whose aim is to mass produce quality teaching materials so that they can be used simultaneously by a large number of students whose homes are spread all over the country.

The third theory is the theory of interaction and communication. This theory arose because many education experts agreed that the notion of independent learning does not mean self-study. Contact between students and components of institutions providing distance education is still needed, both for administrative and academic purposes; sometimes even psychological. Regarding academic matters, because it concerns the essence of education itself, distance education institutions always provide tutors. Thus, interaction between students and teachers still occurs even though the frequency and intensity of communication is limited. How to interact itself can be through face-to-face or using communication media such as letters, telephones, computers, and so on.

Holmberg (1977), including supporters of this interaction and communication theory, views distance education as a learning process in which students are not under direct supervision by the teacher as is the case in classroom teaching although they still receive assistance in the form of guidance, planning learning activities, and teaching in tutorials.

He introduced the concept of "guided didactic conversation", namely the existence of dialogue that guides and educates students so that they feel engrossed in being invited to 'talk' to discuss topics they are interested in. That is, the teaching materials studied by students must be designed in such a way that they are interesting and "self-instructed". We often hear this teaching material as a module. Both conventional modules and electronic modules are increasingly popular today. This looks more fun and encourages responsible learning.

### Learning Media Used in PJJ

In practice, the development of distance education can be seen from the development of the learning media it uses. According to Giltrow (1989) in developed countries, initially paper or printed teaching materials dominated the distance education media, then in the 1950s non-printed teaching materials such as audiovisual began to be widely used.

In the 1980s, it was difficult to know the dominant type of media. The last decade has led to the dominance of electronic learning media. Well, especially now in the era of very sophisticated information technology. Even virtual face-to-face or direct long-distance interactions have become commonplace. For newly established distance education institutions, especially in developing countries, printed teaching materials are used more because perhaps from an economic, technological and cultural point of view they are deemed more

appropriate. This is somewhat different from the situation of distance education in developed countries. In line with the development of computer technology, the development and use of non-print media in developed countries is quite intensive because the constraints for making interactive teaching materials are relatively reduced compared to the previous decade.

Currently in developing countries like Indonesia, technological problems are no longer a major problem. The current problem is the limited ability of human resources to take advantage of this technological sophistication. Moreover, the character of the Indonesian people who tend to be reluctant to cooperate and have an instant mentality of making learning media works by educators are still far from the needs of students. However, I am personally optimistic that it will gradually get better in the future. Where electronic interactive media is increasingly familiar.

### PJJ elements

From the several definitions of PJJ that have been developed by experts, if identified, distance education contains at least several elements of PJJ as follows:

1. Separation of Lecturers and students (although not completely),
2. Student independence (expected to be relatively higher than conventional education student independence/responsible learning),
3. Organizing mass production (industrial) of teaching materials, and
4. Utilization of interactive learning media, communicative media, adaptive or the like.

Planning for Distance Learning Communication (PJJ) at the 49th Batch of 2020 Student Police Inspectorate School during the Covid 19 Pandemic in South Kalimantan.

# 14<sup>th</sup> IQC International Quality Conference

QUALITY RESEARCH

In distance learning there is a form of learning planning among them that is Plan Implementation Learning. Distance learning has certain components. Every educator should prepare components learning before carrying out learning activities such as curricula and tools other. In learning distance Farthere is a number of component matter This explained by (Dr. Munir, 2008) state that component process learning distance Farthat is consists from curriculum, material learning instructional media, guidance tutorials snd strategy in learning .

Form planning which moment this used on period new normal. These educators race on semester programs and lesson plans. And this new thing is contained in the draft Minister of Education and Culture on LearningDistance learning is a guarantee of implementing distance learning more

quality, system management learning. Which fulfil standard guarantee education quality, stipulated condition main for unit education. Which will organize Learning Distance Far.

On learning distance Far Also there isparty-party which involved in learning planning. These parties include educators (Gadik) and Ban Bin Girl.

This statement is supported by the results of an interview with Mr. Yudi Martias Anas as a girl at SetukpaLemdiklatPolri: Learning Implementation Plan (RPP) used during Distance Learning (PJJ)Adjusted to the schedule that was made by Bag Bin girl . The RPP provided is 329 pages for 6 months of learning for students in the form of the National Police Education and Training Center.

LEMBAGA PENDIDIKAN DAN PELATIHAN POLRI  
SEKOLAH PEMBENTUKAN PERDIRA

KALENDER PENDIDIKAN PERUBAHAN

JENIS PENDIDIKAN : SETUJAP ANGGARAN 48  
LAMBA PENDIDIKAN : 7 BULAN (140 JP)  
TAHUN : 2020

	MARET	APRIL	MAY	JUNI	JULI	AUGUSTUS	SEPTEMBER	KETERANGAN	
MINGGU	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31							01 MAREDAKAT 210 MARI	
TANGGAL	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	02 MAREDAKAT BELAJAR 138 MARI 03 HARUKENY BELAJAR 138 MARI 04 HURUTAMA 138 MARI 05 MENCAR DATA 138 MARI 06 HAMP STUNG TAP PE POLA 138 MARI 07 HAMP TUBUH TOSKOR 138 MARI 08 HAMP PEMELATAN 138 MARI 09 LURAN BONGAL 138 MARI 10 SIK 138 MARI 11 LURAN KAPTA TULU 138 MARI 12 LATI 138 MARI 13 BUNGA DAN TAP DM 138 MARI 14 PEKAN TERBUKA 138 MARI 15 MELAHA 138 MARI 16 LURAN GLADI 138 MARI 17 LATIHAN LUPACARA TAP DM 138 MARI 18 CUTI BERGAMBA 138 MARI 19 PEKAN LILIAN 138 MARI 20 POROSING 138 MARI
MAR	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	

Sukabumi, Maret 2020  
KEPALA SEKOLAH PEMBENTUKAN PERDIRA

Drs. H. Agus Suryatno  
BRIGADIR JENDERAL POLISI

Figure 2. Setukpa Class 49 Education Calendar for 2020

Second party, the really role important in learning distance far. According to (Majid, 2005), planning can be interpreted as a drafting process, material lesson exists, use media teaching, and arranged evaluation in the allocation of time carried out at a certain time to achieve predetermined goals. So that the implementation of good learning with consider circumstances and situation.

In the distance learning strategy teaching and learning activities must be carried out. And the important role is to pay attention to the psychology of students, lest they feel uncomfortable or stressed when studying because they are burdened with piling up assignments. So you must have the right strategy to create effective distance learning, one of which is the 5M strategy. The 5M strategy itself consists of humanizing relationships, understanding concepts, building sustainability, choosing challenges, and empowering contexts. To find out the meaning of these methods, you can listen to the following explanation:

### *1. Humanizing Relationships*

Humanizing relationships has a meaning as a learning practice that is oriented towards building positive relationships with each other, starting from parents, students and lecturers. Prior to distance learning, lecturers could communicate with students and parents directly, but after PJJ, each party concerned had to access the internet and technology to communicate and build relationships.

To implement this, you can build a good relationship with parents of students, by knowing the profile, conditions of parents, and time to accompany children to study. This is done to ensure that the child's learning atmosphere is conducive.

As a lecturer, you can also discuss with students' parents about student learning methods, student habits that are carried out at home, student family backgrounds, student development and learning processes,

work and conditions of student parents. Through these discussions, you can get closer to the parents of students and get to know what students need.

### *2. Understand the Concept*

Understanding a concept is learning that goes beyond mastering content. Understanding the concept has a deep meaning and can be applied in a variety of ways. Where the tasks given in learning are related to the surrounding environment and the problems that are happening. But before that, you can communicate with parents first to help the student's learning process at home.

In implementing this strategy, you must first communicate with students about the study guide. Where students not only master the content or content, but mastery of competencies that can be applied in various contexts.

As a lecturer, you can discuss with students' parents about learning activities at home, whether there are obstacles or problems that cannot be overcome. If so, maybe you can help the student by providing additional material. Also discuss children's learning goals, where learning activities not only make children know, but understand the context of learning to be applied in life.

### *3. Building Sustainability*

Building sustainability is a learning practice to guide students in understanding directed and sustainable learning through feedback. In this case, you can give students clear and detailed assignments. After that, you can provide feedback in the form of grades, to find out students' abilities and motivate them to study to be more enthusiastic.

Then, most of the programs and needs at PJJ have met the criteria needed in the learning process. From the planning side of the input aspect, effective results are obtained. Where the infrastructure as PJJ facilities and

infrastructure is sufficient. lecturers and students also have adequate competence in the field of IT which is much needed in the PJJ process.

**4. Choose a Challenge**

Choosing a challenge means more challenging learning practices, for example by guiding students to understand their skills through a meaningful and tiered process. When teaching and learning activities take place, you don't just tell students to write, but you can combine them with more exciting discussions and activities to make students more active.

As a Lecturer, you can invite students to get involved in implementing this strategy. Where you can identify your interests, talents and skills in a variety of ways according to your profile. To support learning activities, it can also provide a choice of media and the right way to learn and do assignments and arrange good study time.

**5. Empower Context**

Empowering context has a meaning as a

learning practice that directs students to use resources and opportunities in various communities as a source of learning and a place to contribute to change. The assignments given during learning can also be adapted to the context of everyday life.

**5. Implementation of Distance Learning Communication (PJJ) at the 49th Batch of 2020 Student Police Inspectorate School during the Covid 19 Pandemic in South Kalimantan**

Implementation learning distance far this is wrong one method for overcome circumstances pandemic like this, so that participant educate still can study even at home. Matter this in accordance with the Minister Education And Culture Republic Indonesia related Letter Circular Number 4 of 2020 concerning Implementation of Education Policy in Period Emergency Spread Coronas Virus disease Covid-19.

**JADWAL PELAJARAN MINGGUAN PJJ TAHAP 2**

NAMA PENYUSUNAN : SEKOLAH INSPEKTOR POLISI TA. 2020  
 DEWASA : S. S. S. DEWASA  
 BERSAMA TANGGAL : 17 AGUSTUS 2020  
 MINGGU KE : 35 (TAHAP 2) MINGGU SISWA MINGGU

HARI	WAKTU	UNIT	MATA PELAJARAN							KETERANGAN
			A	B	C	D	E	F	G	
SENIN 17/8/2020	07.00-08.30	1	BOLA BASKET/SENI							08 - MPK 08 - 20 - 200
	07.00-08.30	1	LIBUR TAHUN 1 (MELAKUKAKAN)							
	08.30-10.00	2	LIBUR TAHUN 2 (MELAKUKAKAN)							
	10.00-11.30	3	LIBUR TAHUN 3 (MELAKUKAKAN)							
	11.30-13.00	4	LIBUR TAHUN 4 (MELAKUKAKAN)							
SELASA 18/8/2020	08.00-09.30	1	REFLEKSI TEKNIK MOTIVASI							WAKTUSOKLAT 04.00-05.00 05.00-06.00 06.00-07.00 07.00-08.00 08.00-09.00
	09.30-11.00	2	KEMERDEKAAN 1 (MELAKUKAKAN)							
	11.00-12.00	3	SUMBER 1 (MENDONGKAS PELAJARAN)							
	12.00-13.00	4	SUMBER 2 (MENDONGKAS ARTISRI)							
	13.00-14.00	5	SUMBER 3 (MENDONGKAS ARTISRI)							
RABU 19/8/2020	08.00-09.30	1	PELATIHAN							PELATIHAN 08.00-09.00 09.00-10.00 10.00-11.00 11.00-12.00 12.00-13.00
	09.30-11.00	2	PELATIHAN							
	11.00-12.00	3	PELATIHAN							
	12.00-13.00	4	PELATIHAN							
	13.00-14.00	5	PELATIHAN							
KAMIS 20/8/2020	08.00-09.30	1	PELATIHAN							PELATIHAN 08.00-09.00 09.00-10.00 10.00-11.00 11.00-12.00 12.00-13.00
	09.30-11.00	2	PELATIHAN							
	11.00-12.00	3	PELATIHAN							
	12.00-13.00	4	PELATIHAN							
	13.00-14.00	5	PELATIHAN							
JUMAT 21/8/2020	08.00-09.30	1	PELATIHAN							PELATIHAN 08.00-09.00 09.00-10.00 10.00-11.00 11.00-12.00 12.00-13.00
	09.30-11.00	2	PELATIHAN							
	11.00-12.00	3	PELATIHAN							
	12.00-13.00	4	PELATIHAN							
	13.00-14.00	5	PELATIHAN							
SABTU 22/8/2020	08.00-09.30	1	PELATIHAN							PELATIHAN 08.00-09.00 09.00-10.00 10.00-11.00 11.00-12.00 12.00-13.00
	09.30-11.00	2	PELATIHAN							
	11.00-12.00	3	PELATIHAN							
	12.00-13.00	4	PELATIHAN							
	13.00-14.00	5	PELATIHAN							

SUKABUMI, AGUSTUS 2020

KEPALA BAGIAN PENDIDIKAN DAN PELATIHAN

Drs. H. BAMBANTO, S.Pd., M.Pd.  
 "KOMBER POL. INP 202020"

**Figure 3. PJJ Stage 2 Weekly Lesson Schedule**  
 Source: documentation from the 2022 Research Results

Implementation learning distance Far this by using the media application zoom meeting and Whats App. Medialearning is Wrong Onethe most important component in learning activities. There are many learning mediathe form of which is by using electronic communication tools. According to Alaby (2020: 282) states that the implementation of distance learning (PJJ) can take advantage of WhatsApp social media in tertiary institutions, WhatsApp can be used as a media for lectures, presentations and discussions, then initially the lecturer gives material to his students in the group, then the lecturer gives instructions to work on the questions or argue about the material, when students express their ideas or opinions, it must be accompanied by their

name, absent number and the names of group members so that the lecturer can give an assessment to all students participating in the group directly.

Sahidillah and Miftahurrisqi (2019:54) state that distance learning (PJJ) can utilize WhatsApp. WhatsApp can be used as a medium for discussion, the learning created will be interesting if all children play their proper role. The position is required for Lecturers to be more creative in developing lessons or material to be taught through distance learning (PJJ) by utilizing WhatsApp . This statement is supported by the results of an interview with Mr. Erik Sonjaya as a girl at SetukpaLemdiklatPolri:



**Figure 4.** Gadik Kuswadi provides excellent service material to SIP 49 students,  
Source from 2020 documentation, 2022 research results

Submission of material in accordance with the girl in charge which is divided into several classes of distance learning students. via zoom meetings. For the determination of study time 1 day 5 units, 1 unit 90 minutes . For assignments collected 3-7 days via whatsapp group.

The mechanism for implementing distance learning via zoom meetings lasts approximately 11 hours a day. This statement is supported by the results of an interview with Mr. Fannan as a student at SetukpaLemdiklatPolri:

In my opinion, the lesson plan is good. learning is carried out from 08.00 – 12.00 then ISHOMA and continues again at 14.00-18.00. work on assignments 3-7 days via whatsapp group.

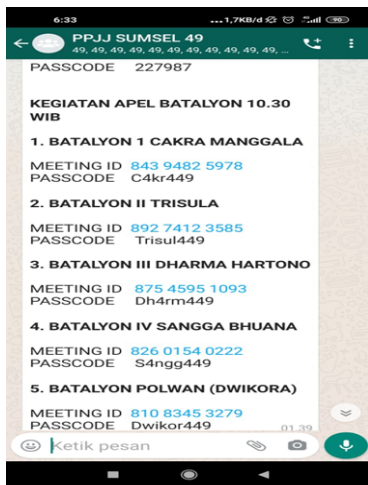


Figure 5. Student PJJ whatsapp group  
Source from 2020 documentation, 2022  
research results

## 6. Evaluation of Distance Learning Communication (PJJ) at the 49th Batch of 2020 Student Police Inspectorate School during the Covid 19 Pandemic in South Kalimantan

This statement is supported by the results of an interview with Mrs. Maya as a student at SetukpaLemdiklatPolri

In my opinion, this lesson plan is good, in accordance with the existing curriculum. The duration of time needed in learning is approximately 11 hours a day. Ishoma included. during our study we were required to pay attention to the material presented because all sessions had questions such as post tests at the end of the material. And we are also asked to review the material that has been submitted. Not forgetting the group and

individual assignments which are always our job.

This is in accordance with the opinion of Prawiyogi et. al. (2020: 95) that in distance learning or online lectures conducted by lecturers, teaching materials or materials will be delivered and provided specifically for students who will then be given assignments to be evaluated by lecturers.

Distance learning (PJJ) during the Covid-19 pandemic made students and girls have to adapt to new situations and conditions like today. Distance learning (PJJ) must still contain educational aspects and be carried out properly without reducing the quality and quality of education adopted by each educational institution.

1. Distance learning requires planning such as:
2. Formulating Learning Outcomes The formulation of learning outcomes refers to the description of the subjects that will be used in learning. The formulation of learning outcomes can be seen in the syllabus or learning implementation plan (RPP).
3. Mapping and Organizing Learning Materials Mapping and organizing learning materials is an effort to determine and classify learning materials into subject matter, sub-topics, and subject matter according to predetermined learning outcomes. Based on the predetermined learning outcomes, the tutor makes sub-topics which will then be broken down into several subject matter.
4. Choose and define learning activities

According to Wisman's theory (2017), things that need to be done to improve the quality of educational communication are: identifying communication goals, choosing the right media, studying objectives, attractiveness and credibility. The target of communication in educational communication carried out by these lecturers is students who become students. This means that the target of communication is the



millennial generation who are used to using new media so that lecturers are also required to be able to keep up with their students.

virtual face-to-face distance learning (PJJ) during the Covid-19 pandemic are Zoom , Microsoft Teams , and Google Meet. In addition, distance learning (PJJ) is also assisted by other media such as Google Form, Whatsapp, Google Drive and even social media which is usually used when the main media experiences problems, or is used to collect assignments and exams. This media can be directly accessed easily by girls and students so that they can communicate and connect with each other. In order for the message to be received and understood properly by the recipient of the message (communicant), a communication strategy is needed.

As stated by Wedananta (2016) the communication strategy has the aim of simplifying and paraphrasing explanations to avoid difficulty in understanding by the target audience. Wijaya (2015: 59) also conveys that a communication strategy can design programs in a comprehensive , logical, comprehensive, realistic and integrative manner . Gadik's communication strategy also aims to simplify learning in a comprehensive , logical, thorough, realistic and integrative direction so that students can achieve a good understanding even if they only learn from home through their respective media. The thing to do is to identify the problem that occurs. Problems that often arise in the communication process according to Marhaeni (in Syaipudin, 2020:29) are:

1. Barriers because the sender of the message is not able to convey the message to the audience
2. The message conveyed is unclear or unclear, has multiple, ambiguous or multiple interpretations and there is no similarity in the symbols (language) used between the sender and the recipient of the message.

3. Interference with signals or lines, or the flow of electricity,
4. Defocusing the recipient's attention so that the message received is not comprehensive or intact
5. Untimely, unclear feedback.

These obstacles arose in distance learning (PJJ) activities that were carried out and became a separate problem for girls. This disturbance can be in the form of signal disturbances which hinder the learning process so that the girl must also apply new strategies or methods to be able to achieve the targets she wants to achieve. Besides that, the girl also experienced obstacles in giving feedback from students.

Distance learning (PJJ) should pay attention to and adjust the tone, intonation and articulation of speech when delivering material during distance learning (PJJ). This is one of the strategies so that the delivery of material can be better. It is hoped that the material will be much more clearly conveyed.

Strategy by doing Problem Based Learning (PBL). In doing PBL, students are asked to provide answers to the questions given regarding the material discussed so that students can study well independently. Sometimes, students are also asked to present their work in distance learning sessions (PJJ). The easiest way to evaluate is to give a post-test or light questions about learning. By doing this, students' understanding of the lessons given during distance learning (PJJ) can be calculated with an average value. This is in accordance with the opinion of Prawiyogi et. al. (2020: 95) that in distance learning or online lectures conducted by lecturers, teaching materials or materials will be delivered and provided specifically for students who will then be given assignments to be evaluated by lecturers.

In addition, this can also be done by looking at the development of students while

participating in online learning. Apart from teaching in online classes, lecturers also open opportunities for students who wish to consult. Lecturers create special channels or forums through the new media used. Through these channels or forums, students can ask questions about learning and lectures. New media was chosen as one of the right alternatives to connect lecturers with students who wish to consult online because according to Ward's opinion that new media has the impression of being without mediation because it can be accessed directly without going through complicated procedures like conventional media so that it can be accessed directly by both parties (Moenawar, et. al. 2017:41).

## **7. CONCLUSION**

Learning planning starts from the stage of learning planning forms that are used in the form of learning implementation plans (RPP). In the implementation of learning there are indicators, ease of activities for students, learning media for students and assessment tools. Implementation of

Distance Learning Communication (PJJ) at the Police Inspectorate School for Students Batch 49 of 2020 during the Covid 19 pandemic in South Kalimantan.

The mechanism for implementing distance learning communication (PJJ) via the zoom meeting application and whatsapp group. The implementation of learning has been going well according to the schedule received, but the obstacles during the implementation of the interruption/blockage of signals that cannot be prevented. And sometimes the delivery of material is not clear.

Evaluation of Distance Learning Communication (PJJ) at the Police Inspectorate School for Students Batch 49 of 2020 during the Covid 19 pandemic in South Kalimantan. The achievement of distance learning is very much achieved. The evaluation used is a post test after the material ends, the task of reviewing the material by making a video presentation, daily assignments are collected with a duration of 3-7 days via the whatsapp group.

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## COLLEGIALITY IN THE ORGANIZATIONAL WORK OF STUDENTS AND THEIR EXPRESSIONS OF THE SCHOOL VALUES: AN ETHNOGRAPHIC STUDY

**Abstract:** Collegial model of leadership has become apparent as expressed by the student leaders working in the campus organizations in the university. It aims to explain how these understanding of collegial model of leadership and supportive model relates to Marist culture/education such as in articulating the values of family spirit, presence, love of work which are seemingly related to collegiality. This study aims to describe collegiality in the organization work of students and their expressions of the school core values through a realist ethnographic approach to inquiry in order to generate a holistic portrait of that shared culture from the emic experiences of the student leaders in a Marist School in the Philippines. Several themes emerged to characterize collegiality in the organization work of students: Establishing and Nurturing the ties; School Identity and Values Influencing their Relationship; Collegial-Interactions as Reflective of the School Values; and Instinctive Act of Sharing with the Work to Accomplish. The study provides a holistic portrait of the student leaders of a Marist school on how they manifest collegial-interaction in the organizational work and how school core values are expressed on their interactions. It is affirming that student leaders in this university manifest collegiality in a unique and positive way by not only manifesting it on work-level relationship but instead it develops into more personalized level of relating and connecting with each other.

**Keywords:** Collegiality, Organizational Work, School Core Values, Realist Ethnography

### 1. Introduction

Collegiality is one of the most important factors in determining the quality of a school. It is assumed that the task of developing collegiality may be integral to the task of improving schools. Collaboration appears to be the unifying theme that

characterized many of the new developments in the successful schools of the 1990s. Even the recent literature on school improvement has also shown that the most promising strategy for sustained, substantive school improvement is developing the ability among school personnel to function as professional collegial communities (Shah, 2012). But in this study, collegiality is seen

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from the lenses of students and student leaders working in the campus organizations as officers and leaders. Various studies and literatures have already defined the concept of collegial leadership as manifested by leaders in the organizations. Collegiality is commonly understood as a collaborative leadership expressed through behaviors, communication and set of beliefs of leaders that sustain collaborative processes and forces. Bush (2003) as cited by Shrifian (2011) explains in his model of collegial leadership that power and decision-making are shared with the members of the organization. The model further assumes that organizations determine policies and make decisions through a process of discussion leading to consensus. On the same article, Brundrett (1998) cited by Shrifian (2011) further explained that collegial models assume a common set of values held by members of the organization which guide the managerial activities of the organization and are thought to lead to shared educational objectives and the importance of “shared vision” as a basis for collegial decision-making.

The collegial model of organizational behavior refers to a group of people sharing a common goal and is related to teamwork. The basis of the collegial model is teamwork in which everyone works as a peer or colleague. In this model, the leader works to develop a better team and acts as a mutual contributor, a coach, a guide, who directs the team members to perform well rather than his own performance and not as a boss. The psychological result of this approach is that the members feel a sense of self-discipline as they own the responsibility of the work. This condition makes them feel that they are important and hold a place in the organization. Therefore they are inspired towards performing better in their workplace (Chauhan, 2021). Moreillon (2019) explained how collegiality and teamwork becomes essential in the context of work. To

say that there is collegiality, members of the organization see each other as companions or equals sharing and cooperating for their collective goals. In other words, there is the atmosphere of friendship, caring, and respect for one another (Mooney, et. al 2012). Teamwork implies that colleagues work collectively in an effective and efficient way to accomplish a task. The members of the organizations contributes to the achievement of the goal and everyone will share on the ‘credit’ for the outcome. Mooney (2012) further defined collegial leadership as a process involved in leaders systematically, but informally relating to persons and groups of equivalent authority in a different area for the betterment of the organization to advance a mutual mission. It involves individuals who possess the skills, abilities to effectively interact with colleagues. Similarly, Singh (2013) also emphasized that collegiality forms the backbone of a shared leadership. As a social skill, leadership makes people respect and follow others. A collegial leader shares power and authority equally among a group of colleagues which creates an atmosphere where members work together as a team to solve problems. In terms of support, a leader who uses the collegial style shows characteristics that allows to build a supportive environment where there is encouragement, listening, discerning and respect for difference and divergence of viewpoints. With the stressful nature of organizational work, it is said that social support is one of the most effective means by which people can cope with. There’s a question whether are there any cultural differences on how people utilize their social support networks. A review of studies on culture and social support presents evidence that Asians and Asian Americans are more hesitant to explicitly ask for support from others than European Americans because they are more concerned about the potentially negative relational consequences of such behaviors. Asians and Asian

Americans are more likely to use and benefit from forms of support that do not involve explicit disclosure of personal stressful events and feelings of distress (Kim, et.al, 2008).

Organizations are defined as a "process for social action" in which individuals voluntarily engaged in the work of the organization to accomplish its purpose. Being a member of a work organization fulfills basic needs met earlier in the primary family social group. Members consider the work organization a surrogate family, forming psychological attachments as well as value and ego links and they transfer needs, feelings and expectations developed in early childhood to their work. Work provides a place where individuals can belong, can express themselves openly and can receive honest feedback. Group members learn that their problems are not unique. Peers provide self-understanding and self-acceptance, a source of security which reduces tension. Psychosocial support is primarily in terms of expert cognitive advice from supervisors; emotional support from counselor; or behavioral support. Because emotional support is spontaneously developed and given, an individual is more likely to perceive it as genuine. Behavioral support is provided by helping the person do the job or by sharing responsibility with the person. Supportive work groups, where responsibilities are shared, are less personally stressful (Chapman, 1993).

In an organization, stable and durable relationships represent several resource interdependencies that lead to informal pattern of 'ties' that is called 'structure'. In the Weberian tradition, these social and informal relationships have long been considered by the bureaucratic model as particularistic obstacles to efficient collective action (Perrow 1986 as cited by Lazega 2005). In the collegial model, however, some of these durable relationships become the basis of a social discipline that

helps members cooperate and exchange, monitor, pressure, and sanction each other, and negotiate uncertain values (Lazega, 2005).

In this study, the intention is to relate how this collegial model of leadership has become apparent as expressed by the student leaders working in the campus organizations in the university. It aims to explain how these understanding of collegial model of leadership and supportive model relates to Marist culture/education such as in articulating the values of family spirit, presence, love of work which are seemingly related to collegiality. The student leaders of the university may have understood the Marist ideals or traditions because they have probably been conditioned to understand and live the values through the different orientations and formation activities given to them. However, what really is the dynamics in the student organizations when it comes to support culture and collegial interactions? How do Marist student leaders experience collegial support in the actual work in the organization? How collegial support with each other as officers been manifested and/or lived? How do they support each other? What kind of support they give and receive? How did they receive support from others? What kind of support? Martins and Terblanche (2003) explains that it is culture that is genuinely related with values and beliefs that are shared by individuals in an organization which includes the activity and behavioral set of standards. This research study intent to describe the collegial-interaction manifested and lived by the student leaders in one Marist School in the Philippines.

## **2. The Context of the Culture-Sharing Group**

Marist School is a Catholic educational community established by the Marist Brothers Inspired by the Blessed Virgin

Mary and St. Marcellin Champagnat's love for Jesus and his Gospel. The Marist Brothers of the Schools (FMS), commonly known as the Marist Brothers, is a congregation of men who devoted their lives to Christian education throughout the world, running Catholic schools or otherwise for the training and guidance of youth. It was founded in France in 1817 by Saint Marcellin Champagnat, who realized the values of Catholic Education in schools wherein God, the Blessed Virgin, Catholic Doctrine, and morality are part of the daily program. Marist is an identity of educators, students, alumni who have been part of the mission for education by the Marist Brothers- a religious congregation that is founded by Marcellin Champagnat, a priest from France. Champagnat is the Patron Saint of the university.

The Marist identity were introduced as ideals to which all Marists, students and adults alike, should commit to. The Pillars are: Presence which refers to caring for each other, seeking relationships founded on love, being attentive and welcoming with a sense of openness. Simplicity is being straightforward and genuine, humble and modest, 'doing good quietly'. Family Spirit refer to relating to each other as members of a loving family, building community, offering the warmth of welcoming, acceptance and belonging, sharing our successes and failures, setting clear standards of honesty, mutual respect, and tolerance. Love of Work... being generous of heart, constant, and persevering in our daily work, confident, visionary, decisive in meeting the needs of our community and encouraging each other to discover the dignity of our work with young people and with each other and In the Way of Mary... seeing Mary as a perfect model of being Marist, tender, strong, constant in faith, open to God's calling us to our own journey of discipleship (The International Marist Education Commission, 1998).

Notre Dame of Marbel University as the setting of this study is a Marist anchors its faith and life on the following core values as foundational qualities with which the Marist Brothers, Mission Partners, and students approach the entire educational process and academic atmosphere of the University. Family Spirit refers to the a relationship premised on love and expressed in a style which Marcellin called "family spirit." Akin to the characteristic of a good family are a warmth of welcome, acceptance, belongingness and authentic concern which should prevail where everyone has a sense of being valued and believed in, regardless of their role or their social standing. Marian is attributed to Mary as the perfect model of the Marist Educator, as she was for Marcellin. As a woman, a layperson and Jesus' first follower, she is the inspiration in living out personal faith and virtue of simplicity. Love of work implies a cheerful and careful preparation of all the things one does. It values the dignity of work as a powerful means of self-fulfillment, of giving purpose and meaning to life, and of contributing to the general economic, social and cultural well-being. Preference for the least favored is to be with those who are excluded from the mainstream of society, and those whose material poverty leads to deprivation in relation to health, family life, schooling, and educational values. Quality education is characterized as holistic where students are progressively initiated into their life-long challenge of harmonizing faith, culture and life. Integrity of Creation speaks about "Respect for the value of life" and "care for the mother earth" are two major themes in valuing the integrity of creation. It upholds life-giving values and promotes stewardship of the earth. Culture sensitivity means openness and respect to the different culture of peoples. It promotes dialogue as a way of enhancing unity in diversity. On the individual level, it is a communication between two persons with different views,



different values and traditions, to learn from each other in order for them to change and grow (ndmu.edu.ph)

### 3. Statement of the Problem

This study aims to describe collegiality in the organization work of students and their expressions of the school core values through a realist ethnographic approach to inquiry in order to generate a holistic portrait of that shared culture from the emic experiences of the student leaders in a Marist School in the Philippines.

### 4. Methods

This study utilizes a realist ethnographic approach in describing shared collegiality culture from the emic experiences of the student leaders in a Marist School in the Philippines. In this study, the researcher is interested on describing the shared patterns of actions, behaviors and some expressions of the student leaders in a Marist school on their involvement and participation in the campus organizational work and how they naturally express the core values of the institution on their interaction with each other. In this study, the Marist student leaders are the participants who belong to the culture-sharing group. These members of the group are officers of the supreme student government and collegiate student councils. They have consistently been involved in student leadership since first year in the college. All of the participants who were interviewed have served their organizations for at least 2 years. They were identified to be the active officers of the student organizations in the university. They have been visible in every organizational and institutional programs and activities. They take part in the planning, organizing, implementing, facilitating and evaluating the programs of the organizations of the university. They have been facilitators of

various formation programs for their fellow students and have also been taking part or even initiated various community extension services in the community. They all have been participated in the Marist formation leadership program of the university. This is a uniquely Marist way of forming and honing the leadership of the students in a way of a Marist.

What makes it realist ethnography? In this research, it reflects a particular stance taken by the researcher toward the group being studied. It is an objective presentation of the situation written in a third person point of view. The study narrates what has been heard and learned from sharing of the experiences and from the researcher's personal observations through his engagements and immersion with the day to day activities and interactions of the participants. The researcher ensures to be in the background as an omniscient reporter of the shared narratives and common patterns of behaviors and actions to be able to interpret how such culture of collegiality in the organizational work among students leaders in a Marist School is being lived. In the most generic sense, ethnography consists of the process of observing human behavior in a holistic cultural context. An ethnography is expected to offer a detailed and comprehensive description of culture—an account of the behaviors, beliefs, attitudes, and values of the people under study. It is 'the science of cultural description Walcott, 1975: William, 2006). In this research, the culture-sharing group are Student leaders of NDMU and the phenomenon of interest is the collegiality and their reflective expression of the school values.

### 5. Results and Discussion

Collegiality in the campus organizational work of student leaders is expressed through the themes that emerged from the experiences, reflections and narratives

shared by student leaders who have willingly participated in this study. The participants were eight (8) student leaders of the university who have been officers of the supreme student government and student council for the two consecutive school years (2020-2021 and 2021-2022). They were identified participants because of their active involvement as leaders in every activity, program and meeting being held by the student organizations. The researcher being the ethnographer in this study served as participant-observer being the in-charge of the Student Affairs and Development of the university whose role is to supervise all the undertakings of the students in the organizations. As declared in this research method, the research took one (1) school year to do observation, participate actively in the meetings and activities of the students and mingle with them before the conduct of the actual data gathering to be able to capture the spontaneity of the setting and context of the phenomenon being studied.

The study intended to describe collegiality in the organizational work as expressed by the student leaders in a Marist school in the Philippines. What makes this intention significant? Collegiality as a construct, in the case of most organizations be it for students, professional, politics, etc., has been a basic norm which is expected for every member to manifest. While it is true that collegial interaction must be a norm for every organization, the interest of this study is to look into how this concept of collegiality is being characterized as lived or expressed by the student leaders of a Marist school considering that a Marist institution is also guided with its core values where family spirit, love of work, presence among others are highly emphasized to be instilled for every student and for the student leaders in the campus organizations. The 'being Marist' of the interactions of the student leaders while they are actively engaging with student organization is the interest of this

research but with concentration on the aspect of their collegial-interactions and how they reflectively express the school core values. The following are the emerging themes that describe collegiality among student leaders in the campus organization in a Marist School and how these become reflective of the core values of the university.

## **6. Establishing and Nurturing the ties**

The students were asked to share their impressions, experiences and meaning of their interactions within the organizations while working for their specific goals or tasks. They were also asked to describe what collegiality means for them and how such becomes apparent or translated on their work relationship. Collegiality in the organizational work as shared by the students has emphasis on unfolding the kind of *relationship* they intentionally developed by exerting deliberate efforts on dealing and connecting with each other as officers of the Supreme Student Government and Collegiate Student Council of the university. *Why is it described to be intentional and/or deliberate efforts on establishing this good relationship among them?* As observed, student officers from the start are aware of the importance of rapport and good relationship in any organization to succeed in attaining the goal. In most of the organizations in the campus, initiating team building and community building activities have become part of the culture of the organizations as included in their annual and semestral plans. Aside from this, the series of meetings, constant interaction staying in their respective offices, usual conversation be it relevant to organizational work or personal matters contribute in building that rapport among them. This '*relationship*' that they intend to establish is more than just work-level or professional level of relationship as described by most of the

participants. As observed, they have profoundly developed that connections deeply like family where they care and show affective ties or connections with each other.

**Strongly personalized 'affective' ties** describe the interpersonal relationship that is experienced and shared by the student leaders from their intentional or explicit strategies on establishing this kind of relationship to nurturing phase. Affective is psychologically understood to have connections to feelings, emotions and attitudes and moods of a person. As relates to the domains of teaching, it is always referred to the emotional aspect of the learners that pedagogical process should have to enrich in order to enhance learning. The theme 'affective ties' deals with their personalized level of 'relating' and 'connecting' with each other that satisfies their emotional needs.

*Emotionally connected...like ang comfort with one another from beginning to end and also nga maka-share sa ila sang sang mga concerns mo...maka-open up... Comfortable ka with that..(P2)*

*Mafeel mo gid ang care sang bawat isa..(P5)  
Tapos everytime nga ng mag-breakdown ka or may ara ka sang problem ma-understand man sang co-organization mo biskan pirmi gin- hambal nga lain ang personal sa professional.. (P1)*

*Gina-cherish ko gid tanan nga support...Mabatyagan ko gid ang concern sang mga upod ko sa SSG. Kis-a ayawn ko ka-balance sang academics and obligations as officer, daw nabudlayan na ako mag comply, ara lang sila para mag ulikid kag magpafeel nga di kanag iisa sa amo nan ga struggle. Gina paintindi nila nga daw normal lang gid na maexperience sang mga officers. So, sa akon ang mga words nga ina very helpful gid...maka-ease gid sang balatyagon... (P5)*

*Daw malipay man ko nga ginsupportahan ko sang mga tao (referring to co-*

*officers)biskan bago pa man lang kami kilalahanay. Sa short time nga daw nag-upod kami, grabe na ang amon nga bond...close na gid,,biska outside pa sa organizational work...(P3)*

*Makita nila ko nga sa picture sa ssg very happy naku sir.. Atleast that time na notice ko nga daw na tagaan ko sang chance nga to prove myself nga tama ko. (P6)*

**'Friendship' ties:** When this group of participants asked to share their narratives on their experience of collaboration, teamwork, support and collegiality the way they have understood the concepts, essentially, they all mentioned that their treatment with each other has gradually developed into more than just being colleagues or co-officers. In their respective organizations, they said that they become are 'true-to-life-friends' and treating each other as 'family'. As observed being in the Student Affairs for quite a long time, this is something the researcher may affirm. Relationship of student leaders develop through time from being simply part of the organization to a deeper level of friendship through their constant engagement and company doing organizational work in school.

*Daw sa amo bi sir, daw wala gid namon naemphasize kung ano ang position sa council or what, we treat gid each other nga daw equal lang kami regardless of position. At the end of the day we are true friends. (P1)*

As discussed, the 'establishing' usually happens at the beginning of every school year. This is always true since every school year, transition is happening on the leadership roles of the student leaders. The set of officers changes year by year. As part of the dynamics of every student organization, be it in the Marist school or non-Marist, some officers remain as officers for the next two or three terms, some stay for only a term, and others have been officers of

the student council their whole life in the university. In other words, the composition of leaders changes every term. Thus, the kind of relationship among these officers every term may also vary depending on the compositions of the leaders with consideration to their attitudes, personalities, perspective and their intentions. Anyhow, the nature of relationship in every organization can be unpredictable considering these factors influencing their interactions. What is common among the student leaders who were interviewed was their experience being provided with emotional support and by their colleagues. The engagement usually starts with just being co-officers and colleagues in the organization. Their constant encounter working every day for organizational matters has nurtured the relationship into being not only colleagues at work but became 'friends' and that work or tasks in the organization becomes bonding time. Organizational work has become interesting and exciting every time they are with the group.

*Daw life blood...Daw life blood sa akon...Daw life blood ko gid ang maging officer. kung бага kung wala siguro yong mga support ng mga kasama ko dito, ang mental state ko siguro sir kay indi nami...Gusto ko gid ang akon experience with the group. We treat each other as more than just officers. We are friends, we are family.. (P2)*

*So for me na experience ko gid as a student leader nga may ara gid sang support when comes to preparation. Ang preparation be sir is bag-o be sa akon ang amo sini nga type sang preparation. First time ko nga maka batyag nga sa tanan mo nga hulag dapat bal-an sang tanan. Sa tanan nga hulag dapat kung anu ang ubrahon ko dapat bal-an ni kuya, bal-an ni.....Bal.an ni kuya Jay kay pati sila ma apektuhan man daw..So for me, this is connections. Not not they wanted to control me, but I feel they have concern*

*on me. They want me to learn and do things right....(P4)*

*Work becomes easy because of the trust and friendship that we have developed. Lain gid abi ang bonding sa council. After work sa council, my time gid na kami para lang magtambay- tambay kag mag sige istorya kag kinadlaw. Nadevelop gid namon sa council ang good relationship. (P5)*

*Ang support for me is give time sa mga tao. Sa mga tao around sa imo nga mag give sang initiative parehas sinang ginahambal nila sir initiative mag hatag sang full self sa pag-build sang good camaraderie..(P4)*

*May mag kamusta sa imo pirmi..maglibre sa imo kaon..Siguro ano na ang mental state ko kag ang physical state ko subong...,So, para sa akon amo gid ina gapabuhi sa akon ang support nga ma baton ko halin sa mga upod ko.. ( P2)*

*Very vocal ko nga tao. Grabe ko ka garet-garet sa tanan sir siguro ang mahatag ko lang support is the love.. Amo ina ang gusto ko nga ihatag sa ila. Emotional support sir daw amo nalang na ma-give ko sa ila sir biskan emotional support sir amo na ang ma-give ko sa ila kay more on abi sa ubra ko sir as a student leader pag tagaan ko task ubrahon ko dason so after sina ang halimbawa wala naku ubrahon mag help ko nga mag gaan ang boot nila kay kung kis.a abi sir ga-cause abi sir sang tremendous nga problem is ang emotion kung hindi mag ka-intindihanay ang isa mag-inaway amo na te daw mag-lainay buot..Di namon na gusto... Ako hindi ko na gusto sa isa ka organization kay tungod lang sina may mag lain buot may mag halin amo na bala.. (P4).*

*Amo ina una sir ang mahambal ko gid nga support nga nahatag ko gid sa SSG kag sa mga na agyan ko nga mga organization is thee emotional support kay amu man ng kaylangan ko kag bal.an ko kaylangan ko sa mga upod ko (P5)*

## 7. School Identity and Values Influencing their Relationship

The question is that, is it always natural that officers working on the same organization in school would transcend work-level relationship into deep friendship? This is where this research takes off. Can it be because from the beginning, these student officers have already been aware of the values of family spirit and presence that the institution is trying to instill among them in whatever context be it at home, in school, school organizations or non-school organization undertaking? It is quite interesting to examine how these relationship develop and how collegiality as an organizational norm is being expressed by the student officers from their day to day interaction while working in the organization.

When the participants of the study were asked to actually describe their personal experience dealing with their fellow officers in the organization, they describe their relationship to be 'connected', 'supportive', 'smooth', 'open', and 'belonginess'. These words are very much similar or related to Marist values on *Family spirit* and even *presence*. When they were asked why they actually have these kind of interactions, most of them said that it is because, '*they are in the Marist*'.

*School and these are the values that the school is trying to instill in them and that they are all aware. Being Marist student, we are expected to conform to values of the Marist. That is why we really try our best to live up the core values in everything we do in the organization. (P6)*

*Pagsiling mo nga Marist leader, magtatak gid dayun ang mga core values sang school. Example presence...so, ginatry gid ina natun i-emphasize sa atun interactions...(P5)*

*Ako sir ang interaction namon, talaga is all about building that connection with your officers. Sa umpisa medyo mahirap kay lain lain kami courses, lain-lain ginhalinan nag school sang high school, but we know nga sa Marist school, lain ang values nga ga instill. So, ginalive nuo gid ina namon nga mga values. Ang amon relationship sa organization, ginatry gi namon strengthened. (P1)*

*Sabay kami gakaon, sa apartment ururupod man kami. Nadevelop gid na namon nag relationship umpisa tong nagkasabay kami as officers. So ang amon nga interaction gaextend asta sa amon gina-istaran. Kung kaisa, myh mga issues iban sa amon. So, di na namon gina pakialaman. Pero magets naming yun. Ginahayaan lang namon asta nga mag okay na saka kausapin. So, madala namon ang relationship halin sa organizational work that we do in school. Nadevelop gid siya. (P4)*

*Halin man ko sa non-Marist school and I must say nga naappreciate ko gid ang Marist way of leading. Gina-tudlo kag gina emphasize gid ang values. That's why, kung sa organization, gina-ensure man nga gina translate ining mga values because we are aware nga amo na ang expectations from us. But, eventually, sa akon nga experience, masiling ko nga ang relationship namon, ang bonding, daw ka-natural na lang dayun. Mafeel ko nga very comfortable na kmi.. (P2)*

With these sharing of the student leaders, it can be inferred their knowledge and appreciation of the school identity that is 'Marist' considering its values may have significantly been influencing student leaders' way of directing or leading the organization and that includes the way they shape the relationship or interaction between and among them. While it is understandable that officers may have actually been influenced by the school's identity and values in shaping the way they '*relate*', '*connect*' and '*deal*', which usually is the

goal of every institution, the effort on nurturing this kind of relationship is also evident on the actions of the leaders as shared by them. After they establish at the beginning of the school year as the term of office commences, they do much effort as well on trying to strengthen and consistently maintain the family spirit and belongingness not only as influenced by the school values but it has eventually become their values learned from being part of the organization.

### 8. Collegial-Interactions as Reflective of the School Values

*'Presence'* is one of the core values of the university that is reflective of the relationship manifested by the student leaders in working for student organizations. Presence emerged as a shared expression of *common emotional* support given by each one of them. When asked what kind of emotional support do they usually receive and share with others, what's emerged is their explicit expression of giving comfort through their words, actions, and just by being there.

*Like ako ang naka assign dire pero always sila ga-inquire sa akun kung may iban kapa nga need..Basi need mo sang tao dira or just by asking question like okay ka pa ba dira nakakaon ka na or ng mga concern nila...(P1)*

*Kung mamangkot na sila if hago ba dira ako nalang mag sagot sina. Amo sina biskan sila may ara man sila sarili kag gina respect nila ang schedule ko sir subong sa SSG kag if academics, academics man. If mahambal ka nga di ka free, kay may amo ka sini nga event, sal-on sang isa so ma feel ko gid nga amu to support...(P2)*

*Kung anuman ang gina-stressan nila ara lang ko to listen, kay hindi man ko very ano gid sa mga words like indi man ko ano gid sa pag-wakal di parehas sa iban ko nga upod nga student leaders nga very ano gid*

*sila talkative or like the way nga mag-communicate ka kay daw maka-reach out gid sa other people. For me, ang way ko nalang gid is mag listen kay kis.a kailangan mo gid sang iban nga tao to listen gid sa iban man nila nga mga upod. (P3)*

*Dapat hatagan mo man sila sang for example sir kumustahon mo gid sila kung basi my hinanakit man sila sa sarili nila nga hala anu man ning akon ubra man like ng sa akon nalang... Tapos like dapat need man nila sang mga pa-comfort man sir nga dapat may chikadora time man sila habang ga-work sila. (P4)*

*For me Sir, ang sa akon, ma-define mo gid siya or ma-identify mo siya kay nga gid gina suportahan ko sang mga upod ko biskan presence lang nila ara... (P5)*

*Siguro sir as a very vocal nga tao, very vocal nga tao tapos grabe ko ka garet-garet sa tanan sir siguro ang mahatag ko lang support is the love...(P6)*

*Mag ask na sila, ga-anu na kamo da? Okay na kamo? Daw basi di kamo okay? Kung ano ang ka sadyahon ko sir as a person amuna ang gusto ko nga ihatag sa ila kung mag joke ko..Biskan emotional support sir daw amo nalang na ma-give ko sa ila. Biskan emotional support sir amo na ang ma-give ko sa ila kay more on abi sa ubra ko sir as a student leader...(P7).*

*Ang support nila is daw sila na ang naging reminder ko throughout man sato nga mga time kung mag breakdown man ko ara man sila, so emotionally, physically, kag mentally ara gid ang support nga ging pang hatag sang mga friends ko sa mga na upod ko as a student leaders sir.(P3)*

As experienced by the participants, they have shared that what they considered to be Marist in terms of their interaction with the group is *'feeling'* the atmosphere of being really part of the organization. Common example is the intentional way of *giving of comfort* when a colleague feels down because of overwhelming tasks to do in the

organizations. Comfort is felt when one opens up/shares similar experience with the other; listens to the stories of frustrations/disappointment for not feeling good about the outcome of the tasks; feels the company of a colleague and when one feels that task becomes easy and attainable because of the presence of the other. For them, this is an example of emotional support. The participants shared about their experiences being open to one another to share their concerns and listen too for the others. They also share that being open manifests being comfortable with each one. To give comfort has become part of their conscious and deliberate response to make a colleague feel better in time of so much stress. As shared by one participant, in times of stress, one initiates laughter to ease the situation. For them, presence, be it in a form of giving comfort is a concrete meaning of collegiality. Support is given through accompanying the members/colleagues and making others feel at ease by one's presence/character/personality.

*Attentiveness.* They sensitively recognize the situation when a co-officer feels down, feels bad, feels uncomfortable, and not on an active mood in the same way that their colleagues also try to be attentive to their situation when they feel the same. For them, being attentive to the condition and their co-officers and being able to find ways how to facilitate their needs is an expression of collegiality. They do not demand for an output once they know that the colleague is trying to cope with some personal issues/concerns by extending/offering help in completing the task if they feel that a colleague is having difficulty or issues. Here, it can be noted the sensitivity of the student leaders to recognize what is going on with their colleagues. Common example is that *they tend to* initiate in giving the necessary help to a colleague because they feel the need to give help for others in accomplishing the tasks. They too have experienced how

others have been attentive and sensitive to their conditions. For them, that's the Marxist way of relating each other while working for the goals. They would ask and be observant to the changes and dynamics of the mood by being sensitive on the emotions of their colleagues. They value how one feels, and how the others respond emotionally to feedback and criticism. They all agree that everyone seems to listen to each other's concerns making colleagues feel better when they feel down/ uplifting their emotions.

Support is manifested through understanding one's situation/condition too. When stressed with school works, demands, requirements, colleagues in the student council expressed their concern to the person by doing the following: assume one's tasks be it at home / student council-related tasks. Tolerance on the shown undesirable behavior (like being easily irritated). They adjust the tone of conversation from the usual/natural manner of conversation (from asserting to submitting to the person) by observing the mood of the other officers. Consoling is also evident on their interactions with the person who is experiencing problems/challenges. It is also observed how student leaders manifest being careful (tact) in giving feedback so as not to inflict hurt to the colleague. In times that a colleague missed classes or requirements, academic support is provided by giving/sharing with some notes and information for some missed classes. lectures, reviewers, etc. There are instances, that colleagues also tend to filter some disturbances that may hinder the work of a colleague being performed. They willingly to take over/ assume obligations of others when necessary in order to help lessen/improve the work. How they care for the health condition of others has also been observed and shared by the participants.

*This college sir tong diba anu tong May provincial chapter ay May to april so exam examination academic week tapos NSTP culmination tapos may Q.E sa accountancy*

so that time palang sir ga suffer naku kay daw ga duwa duwa naku sa course ko ba kay daw adlaw adlaw nalang ko depress amu sina plus ga balik-balik ko sa school kay mag process sang amuni nga papers sa culmination plus nagsali pagid ko dance interpretative kay pwerte abi ko kay feelingon ko (tawanan) amusina abi mo kaya kaya mo gid so so sa time nga to sir naga apartment pagid kame so didtu abi kada abot ko na sa apartment ara lang gid da si Ate Cas kag si Philip si Danica. My one time gid sir nga grabe gid hebe ko nag hebe ko sina tapos sila ara lang gid sila da sa gilid sir ga pamati lang sila tapos pagka aga tanan nga mga orobrahon kay naka hati man na sa amon sir, ging ubra na nila tanan wala naku nila ging tandog kung baga ginpabay-an ko nila nga matulog tapos pag abot ko naman sa school ang batasan ko be na sir nag pag mag inti ulo ko ng daw gina dali dali ko tanan nga ubra ba so sila princess hindi ko gets tong adlaw nga to wala ko nila gina baisan ga pati lang sila buas ako nalang sina bangs a ako nalang ma ubra sini kay para dira kanalang pungko kanalang amusina amu to hindi ko gets sir kay gina supladahan ko na sila pag ok lang gyapon pakikitungo nila sakun tapos, pirme pagid ko nila gina hambalan nga ayos kalang ako nalang di dri kanalang.. (P1)

Nabatyagan ko gid to sir nga may mga tao man gali nga maka intindi ba nga damu damu ka ubra tapos okay lang sa ila nga pagbigyan ka anay nila sang time nga na kay ma understand ka nila gina supportahan nila nga kag bal an nila nga passionate ka gid sa amuni nga bagay so sige lang kay gaadjust ka paman daw tanan nga bagay nga factors ma understand nila sir so amuna. (P2)

Tapos kis-a if my eh assign sa amon halimbawa si....gadali sila tapos gina in-charge nila ko so wala ko ma tap nga tao ones nga mag chat ko sa GC ara dayon sila ..Ara dayon na sila nga mag hambal nga

sige updan ka namon ako nalang dira..Bal an gid nila ang akon nga needs..(P3)

Gina-assign sa editing tapos mga upod ko (inaudible) hindi kabalo mag-edit pero ang support nga ginhatag is bisan may mga lutang gid ko nga mga moments sa pag edit ko like very patient ang mga tao sa palibot ko nga mag bulig sa akon nga i-point-out ang mga mistake ko without sang mga kalain nga remarks...

**Empowering and 'pushing'.** Support is shown by ensuring that colleagues/fellow officers are guided in accomplishing their tasks; Affirming one's potential as a leader; Affirming colleagues' potential- to gain confidence; to believe on ones' abilities/potentials; Boosting the confidence of a colleague to believe that; Gaining confidence because of the affirmation of colleagues in the group; Gained confidence on what one has been doing due to the affirmation of colleagues; Sharing knowledge gained from experiences for other to also learn.

Budlay abi siya sir nga mgstart ka nga isipon mo bal-an mo na tanan kay kung di ka mag accept sang support daw sarili mo lang gihapon gina-hambal mo nga mali. Nga-a. Di mo kailangan tanggapon ang support nila kag ang support nila didto ka naka-build sang imo nga confidence...(P3)

Kis-a sa kung mga edits nga dali lang siya himoon daw agawon pa parehas sini ni ....Agawon nya pa sa akon ang himoon basta mahimo ko lang ang mga major part nga pag-edit pero ng mga content na eh build up amo ina na makita ko gid ang support nga from her or from sa iban man nga mga ka upod ko ..(P4)

Makita nga na budlayan ang isa ginabuligan so parehas sini nga as a student leader nga mag travel sometimes gina-check nila ko kung nahimo mo na imo nga task, kag kung naka ano nako sang deadlines ko man nga naka-fill in nga and also mga small things



*gid sir ngaa mga gaps ko man kis.a nga... ginapush gid nila ko nga makaya ang mga tasks..Ginapafeel nila nga kaya ko gid himuon kaya ginaassgin nila sa akon...(P4)*

*For me sir ang support nga ma baton ko and everything else daw gina himo nya ko stable sa tanan ko nga gina himo or like as a person gid kay may mga times nga biskan sa sarili ko wala naku tiwala, tapos everytime na maka-isip ko support sa mga upod ko daw didto nga ma gain ko man ang confidence...(P1)*

*Tiwala sa sarili ko sa mga ginahimo ko nga hindi ko mag doubt sa mga actions lalo nga halin sa nga nagka covid or like daw nag separate ang everyone since sang senior high daw nadula na tong dati ko nga version nga kung diin confident ko as a person na mag take out nga iba-iba responsibilities..(P2)*

*Ti subong duu naga amat-amat palang gain naman na nga kung mas diin nag open naman ko liwat sa mga tao, nga biskan backward man ko from time to time, pero ara gid ang support or like or ang pag -anu gid daw assurance halin sa mga people around me nga ang support gid big deal gid para sakun nga gina cherish ko gid ang each nga small man na or dako man ni nga support so gina anu ko gid ma remember ko always tapos gina apply ko man sa self ko kung anu man mahambal sang tao sakun nga as support sir (P5)*

## **9. Instinctive Act to Share with the Work to Do**

They also show presence by making themselves available when their colleagues need some help from them. For instance, they ask colleagues what can be done to help on the tasks. They voluntarily offer help when felt that a colleague is having a hard time completing the assignment. They ask how colleagues feel about doing or performing a task. The second theme that

emerge on describing student leaders' experience of collegiality in the organizational work in a Marist School is their instinctive actions to willingly *share with the work or tasks*. The act of helping is a common thing among people in any context. But the word '*instinctive*' gives more meaning on the concept of 'helping' and/or sharing in the context of the Marist student leaders. What they were saying was that, helping and sharing with the work is very spontaneous, natural, automatic, and it becomes a habit. When they were asked to describe the experience of sharing with the work, they commonly said, it's just but part of the 'being' leaders more so of the 'being' Marist. When asked to elaborate a little more about that 'being' leader and Marist, they said, its unexplainable. Some said, they do not know, they just love the idea that helping and extending help with co-officers becomes so natural for them without thinking of anything as returns.

Practically, they are all conscious of the fact that extending is necessary to be able to make the work done efficiently. They are all aware how each one of them affects the others. When one member is not able to fulfill his/her tasks, it will consequently affect the entire organization. As a participant observer, this is evident on their meetings, discussions, how they make follow up with the other's work, asking each committee to report on the progress of their work and agree how they can collaborate with others. It can be noted from the interactions and sharing of experiences of the student officers that collegiality in the organization work is reflective of the kind of relationship and support that they share. Support is manifested through the initiative to help without being asked to give help or render service. For them, to give support is voluntarily given. One cannot give genuine support unless it is out of volunteerism. Support is manifested in terms of initiating

acts to guide other officers who encounter challenges to accomplish the task assigned to them. Support is also manifested by showing understanding with the situation of a colleague who is experiencing personal issues in academic, peers, family, and relationship with others. They show willingness to assume roles in order to implement the goals of the organization.

There are also other forms of acts to share in accomplishing the tasks of the organization. They shared about the support they experienced in terms of the decision making for the organization. This usually happens during ordinary meal time, organizational meal, spontaneous moment to have conversation during free time. For them, the conversation with co-officers on organizational matters help a lot on affirming their ideas and some decisions. That for them is sharing not only their physical strength for the work but ideas that are helpful for the organization.

As observed by them, the group usually is open for deliberation of issues and concerns. They like the idea that they discuss and negotiate. As experienced by the participants, they understand that discussion is always part of the process of making discussions and they're open to negotiate. When asked why they believe it that way, their common response was that because it is one thing that has also been instilled in them by the school. To have dialogue is part of being 'belong' and that everyone is given value. As mentioned by one officer, it has always been instilled in them the beauty of openness and negotiation to uphold the value of respect to differences.

*Siguro ang support for me is volunteerism na sya, may ara sang volunteerism nga word kanang nga connect sa support kay hindi ka maka give, or hindi ka maka accept sang support kung hindi mo sya volunteer gina hatag sa mga tao.. (P1)*

*Ang support for me is kung gaano ka gid ka-initiative mag-give time sa imo upod magbulig sa ila task biskan di pa na imo trabaho..(P2)*

*Ga-think initiative na daan sa self mo, or like halin sa peers mo...need na ikaw siliangan..Amo gid nakita ko dri sa amon nga interaction...Mag an gid ang work kay ang mga kaupod ko sa organization may ara gid tanan willingness to help. Makita mo gid ang pagka-Marist spirit.. (P3)*

*Pag tagaan ko task ubrahon ko dason so after sina halimbawa wala naku ubrahon mag help ko sa iban para mabulogan sila sa ila work...biskan wala nko nila ginahagad..Daw nami sa feeling nga nagahelp sa ila work nga matapos.. Sadya lang gid tana.. (P4)*

## 10. Implications

The study provides a holistic portrait of the student leaders of a Marist school on how they manifest collegial-interaction in the organizational work and how school core values are expressed on their interactions. It is affirming that student leaders in this university manifest collegiality in a unique and positive way by not only manifesting it on work-level relationship but instead it develops into more personalized level of relating and connecting with each other. This affirms the initiatives and efforts of the school on instilling the core values to the students especially to the student leaders who are considered to be models of the values. With this result, it means that the school may continue to implement its good practices that nurture the relationship of the students leaders in the organization as they also contribute to their productivity and growth. As reflected in the themes, they feel good, they are happy, they feel motivated and positive because of the comforting presence and affective connections that they have with their co-officers whom they considered friends and family in school.

Though, the school may also consider to engage more students into other dynamics that may also strengthen their expressions of other core values not only limiting to family

spirit, presence and love for work but to manifest as well other values while working in the organizations.

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**IMPLEMENTATION OF UTILIZING  
STUDENT INTERESTS AND TALENTS IN  
INCREASING STUDENT LEARNING  
OUTCOMES AT SMK NEGERI 1  
MARTAPURA AND SMK NEGERI 1 SUNGAI  
PINANG IN THE FIELD OF NATURAL  
SCIENCES**

**Abstract:** *The phenomenon of unemployment is a real picture of the condition of education in Indonesia in the aspect of developing students' interests and talents. School as a place of learning should be a place to develop students' interests and talents. An important aspect of developing students' interests and talents is having an awareness of their interests and talents. This awareness is able to lead him to a number of strategic choices in the future related to the chosen field of study, a conducive learning environment and the choice of profession according to his interests and talents. Knowledge of these interests and talents needs to be facilitated by schools, parents and the community. Regarding the empirical theory and themes discussed in this study, it is linear if the research category set is qualitative. Qualitative research must be supported by a number of data that can provide a brief description of the actual conditions that occur in the field. Qualitative research and using descriptive analysis techniques in this study aims to find out the problems and get accurate data, researchers use interviews, observation, and documentation. Research data collection was based on qualitative concepts, namely data collected based on observational activities at research locations, interviews with research subjects and research data documentation in the form of research location photo data and implementation document data. The research findings show that the implementation of the utilization of interests and talents is carried out when students register and at the same time choose the majors they are interested in. Students also choose intra and extracurricular activities to support their interests and talents. Students are also asked to fill out a student needs questionnaire as a basis for counseling services. However, at the implementation level, the use of interest has not been accompanied by a special aptitude test to support student interest.*

**Keywords:** *implementation, interest, talent, learning outcomes*

## 1. Introduction

The fundamental terminology of educational institutions is comprehensively understood in relation to the quality of formal educational institutions, namely Senior High Schools. One indicator of student acceptance and satisfaction in obtaining educational services with several supporting variables, it is explained that student satisfaction has a central place among quality indicators for higher education institutions as well as business schools (Gibson, 2010). Nevertheless, the changing environment and the differences between universities and business schools require the introduction of new measurement parameters for both student satisfaction and the new initiatives that are generated through them (Zhao and Ferran, 2016). competencies possessed, among others, explained that such approaches seek to address the tension between standards that specify the level of competence required for entry into the profession and the use of these standards as the definition of competence for serving teachers with considerable experience (Forde and McMahon, 2019). Forde et al. (2016) this is a means to maintain a developmental change orientation and relevance, without depressing or stalling practice' (Forde et al., 2016: p. 28).

School is a formal educational institution that holds and controls a vital role in improving the quality of learning output in a progressive and planned manner, so that collaborative cooperation is needed in the implemented model school. The planning function is running well and is more focused and the organizational management function is carried out in an effort to divide tasks and authority as a form of setting job descriptions for every school member. The principal, assisted by the vice principal, moves within the organizational structure and is expected to meet the organizational targets. Even though the progress is

constrained by time constraints and school activities that run concurrently and students with heterogeneous family backgrounds, overall the school program that has been set is expected to meet its target at the end of the learning year with comprehensive management.

Schools are progressively collaborating with other parties who have a linear vision and mission with school policies, including comparative studies and feasibility studies which are important indicators and variables in the International Organization for Standardization (ISO) and quality assurance in education. This series of school activities is useful in increasing the ability of human resources, so that school services in achieving educational program targets can increase progressively. In other words, it is explained that high school is a formal educational institution as a medium and location for learning and teaching. However, along with its development, Senior High School has experienced a development of meaning and usage but it is still in basic terminology that has not changed. Senior High School is a place, location or forum that is believed and recognized as a place for the process of education or learning to take place which is arranged systematically and experiences dynamic development over time (Wanidison&Shaddiq, 2021).

The process of accepting new students ideally goes through a number of stages that must be carried out. These stages include forming a committee for accepting new students which involves all elements of the teacher, administrative staff, and the school board/school committee; making and posting announcements of acceptance of new students which are carried out openly. This information must include a brief description of the institution, requirements for registration of new students regarding general and special conditions, how to register, time of registration, place of registration, registration fee, time and place

of selection, and announcement of selection results (Badrudin, 2014: 32).

Acceptance of New Students is the school's annual agenda and a number of strategies in Admission of New Students ( PPDB) are carried out directly in the form of socialization, print media publications, and online and offline publications through the media banners, banners, flyers and promotional stickers. The general target of the PPDB agenda is to find students and promote schools (Subbeh, 2018). There are four components in the implementation of educational policies, including those who implement educational policies, administrative processes, expected compliance and the impact of implementing these educational policies.

The opinion of Ripley and Franklin states that there are two aspects that are the focus of the implementation of educational policies, including compliance or compliance of implementers with agreed operational procedures and standards; phenomena that occur in the implementation process, obstacles and levels of success. The Indonesian government's policy regarding PPDB is to carry out online and offline registration and provide maximum service to the community.

Psychologically, human potential consists of the ability to think/reason and feel in the heart. Possession of potential and talent can be used to recognize and understand the progressive development of civilization and the increasing variety of challenges.

Individuals who have maximum potential must be able to determine career planning targets and must understand the global labor market and understand their desires. Careers are strongly influenced by their interests and talents, so that the individual is able to determine and plan his career appropriately. Interest arises because there is attention to an object and the attention given can lead to the desire to identify, learn, and prove further.

This condition shows that in interest, besides attention, there is also an effort to get something from the intended object of interest.

Meanwhile Buchori (2015: 135), states that interest is a person's awareness, that an object, a person, a problem or situation has something to do with him. Thus, interest must be viewed as a conscious response and if the perspective of interest is not interpreted optimally then it does not contain true intentions and goals. Meanwhile, Sadirman (2016: 76) states that a person's interest in an object will be more visible if the target object is related to the individual's wants and needs.

This opinion gives an understanding that the conditions that occur are closely related to personal needs, so that there is a tendency when seen and observed by individuals is a relationship between specific desires and needs. Foerthiono&Sadjarto's opinion (2014: 56), interest is a person's interest in an aspect, and this condition will encourage him to make a decision/action, whereas according to Shaleh, et al (2018: 263), interest can be interpreted as a tendency to pay attention and act towards people, activities or situations related to objects that are accompanied by feelings of pleasure. Zaid (2015: 47) says that interest is someone's interest that creates a desire to focus on that condition.

Interest according to Eysenck (2018: 76) is an aspect of the human mind that can encourage achieving goals. If the individual has an interest in an object, then it tends to pay attention or feel greater pleasure for that object. Interest related to one's participation contained in activities and interests is also closely related to encouragement, emotional reactions and motives. According to Sukartini (2015: 65), interest analysis can be carried out on a number of aspects, including desire For know or own object Which interested in, objectsoractivity Which respected, kind activity Forreach that

condition liked, the effort to realize the desire, a sense of pleasure towards something which interested him.

## **2. Research methods**

Research conducted at Vocational High School (SMK) Negeri 1 Martapura and SMK Negeri 1 Sungai Pinang is categorized in a qualitative scope and focuses on linear meaning with quality data implemented in qualitative analysis but consistent with quantity data as a phenomenon to support qualitative analysis of strengthening meaning as the final conclusion of the study. Data collection techniques in qualitative research can generally be categorized into two techniques, namely interactive and non-interactive data collection. The implementation of interactive techniques became the basis for conducting research at SMK Negeri 1 Martapura and SMK Negeri 1 Sungai Pinang which included semi-structured interviews. The implementation of qualitative research uses rigorous structured interviews and is carried out based on questions that lead to the depth of information and is carried out using structured informal techniques. In-depth interviews can be conducted at times and context conditions that are considered most appropriate in order to obtain complete, honest and in-depth data.

Observations at SMK Negeri 1 Martapura and SMK Negeri 1 Sungai Pinang are aimed at exploring data in the form of events, places or locations, and objects, as well as recorded images, while observation plays a role in SMK Negeri 1 Martapura and SMK Negeri 1 Sungai Pinang, the author comes directly through observation on learning activities. While direct observation at the locus is carried out by ensuring compatibility between research objectives and objects and to find out the conditions for utilizing students' interests and talents in improving student learning outcomes at research sites

and documentation in the form of writing and pictures is presented in the form of a number of quotations about documents reported in research.

The various documentation collected at SMK Negeri 1 Martapura and SMK Negeri 1 Sungai Pinang varied in nature from simple written to more complete and could even be in the form of other objects, whereas in this study, the stages of data collection in the form of research documentation were based on document data collected obtained at SMK Negeri 1 Martapura and SMK Negeri 1 Sungai Pinang. Research photo documentation in the form of photos of school buildings, facilities and infrastructure and learning facilities at SMK Negeri 1 Martapura and SMK Negeri 1 Sungai Pinang.

Data analysis according to Bogdan in Sugiyono is the process of systematically searching for and compiling data obtained from interviews, field notes, and other materials so that they can be easily understood and the findings can be informed to others. While the analysis of qualitative data is inductive, namely analysis based on the data obtained. Meanwhile, based on the opinion of Miles and Huberman (1992: 16) the analysis consists of three streams of activities that occur simultaneously, namely data reduction, data presentation, drawing conclusions/verification. It was explained that data reduction is a selection process, focusing attention on simplifying, abstracting, and transforming raw data that emerges from a number of field notes or field notes. Data reduction in this study was carried out through screening of primary and secondary data that did not support the theme, title and discussion and analysis of research data at SMK Negeri 1 Martapura and SMK Negeri 1 Sungai Pinang. Some of the data reduced in this study included documents on the status and rank of teachers as well as facilities and infrastructure at SMK Negeri 1 Martapura and SMK Negeri 1



Sungai Pinang which were not directly related to the research discussion . The next stage is the presentation of data or data display. Miles and Huberman limit the presentation of data as a set of structured information that gives the possibility of drawing conclusions and taking action. A number of student achievement matrices are presented by the author as a brief description regarding the success of the Principal's policy at SMK Negeri 1 Martapura and SMK Negeri 1 Sungai Pinang in learning activities. The organizational structure chart is also shown as the basis for the Principal's

top-down policy instruction flow. The final stage of data analysis in this study is drawing conclusions. Drawing conclusions according to Miles and Huberman is part of the activity of the complete configuration. The conclusion of this study is based on primary and secondary data collected at SMK Negeri 1 Martapura and SMK Negeri 1 Sungai Pinang and have undergone data reduction stages. A schematic description of the data analysis process using Miles and Huberman's interactive data analysis model can be seen in the following chart (Figure 1).

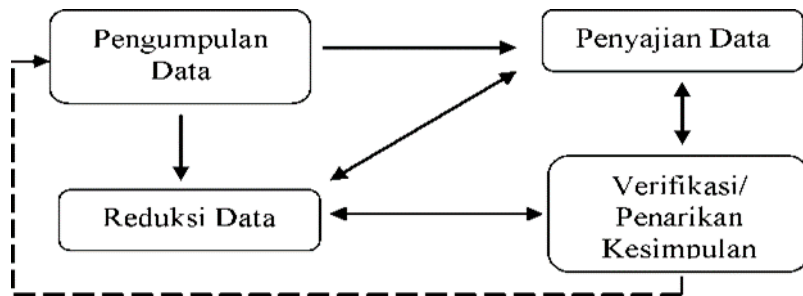


Figure 1. Interactive data analysis model

### 3. Results and Discussion

#### 3.1. Student Specialization Process at SMK Negeri 1 Martapura and SMK Negeri 1 Sungai Pinang

Acceptance of New Students or PPDB is an entry point for students to choose the major they are interested in and before making their choice, students who register have made considerations through searching for school information, majors and future professional possibilities after they graduate from Vocational High School or SMK .

The research findings show that the implementation of the use of interests and talents in improving student learning outcomes at SMK Negeri 1 Martapura and SMKN 1 Sungai Pinang shows that students who register have an incentive to choose a particular major due to an interest in a

particular field of study as an option in determining a future career.

Every time a new school year approaches, each school prepares a New Student Acceptance Program or PPBD and the mechanism that is carried out differs depending on the program and field of study that the school concentrates on. This condition is stated in the Minister of Education and Culture of the Republic of Indonesia Number 1 of 2021 concerning Acceptance of New Students in Kindergartens, Elementary Schools, Junior High Schools, High Schools, and Vocational High Schools article 32 (2) Selection of prospective new students for class ten SMK taking into account a number of aspects, including report cards attached with a certificate of rating of students from their school of origin, academic and non-academic achievements; and/or aptitude and

interest test results in accordance with the chosen field of expertise using criteria set by the school, and the business world, the industrial world, or professional associations.

These three points make it easier for schools to map students' interests and talents when prospective students register. Basically, each student has different interests and talents, so that data relating to academic and non-academic grades, student achievement and aptitude tests are taken into consideration in determining majors and student learning support activities.

The short term goal is that students are able to improve their learning outcomes while the long term goal is that students are able to play a role or work according to their interests and talents. The substance of achieving school targets effectively and efficiently really supports maximum school performance. Efficiency can be fulfilled if limited resource management achieves a margin above the target simultaneously. Meanwhile, the effectiveness of the balance of planning and achievement can only be surpassed if there is positive collaboration with the school community. Regarding school performance, which must always be consistent, cannot be separated from the discussion of an effective assessment system or measurement of school performance indicators. Thus, it is considered important to test the performance of these schools by making relevant and linear comparisons with similar schools. There are several performance indicators that are specific to their flow, among others, it is explained that a system has continuous stages to be assessed and measured both qualitatively and quantitatively. The outcomes achieved have flexibility towards developments and changes in policies and fluctuating social conditions. The flexibility of these results must be supported by data that can be processed, analyzed and collected efficiently, practically and economically.

Several determinant variables are explained in a scientific study, among others conducted by Tsinidou, Gerogiannis, and Fitsilis (2010) identified the quality determinants as academic staff, administrative services, library services, curriculum structure, location, facilities and career prospects. The authors run an analytical hierarchical process to determine the relative importance of each factor .

The debate about school performance cannot be separated from all the variables that support and influence it. The facts show that schools are institutions and organizations that are fully responsible for learning or education services that meet the quality standards set by ISO and the Education Quality Assurance Institute (LPMP). Thus, school performance will be assessed objectively based on the National Education Standards. There are parameters that are used to assess and determine school performance, at least there are several substances that must be assessed including content standards, educator and education staff standards, graduation competency standards, process standards, facilities and infrastructure standards, management standards, financing standards and educational assessment standards .

The implementation of sustainable school management has a significant effect on improving teacher performance. This condition is due to a comprehensive understanding of school management which makes educators and educational staff have sufficient understanding of the management and organization of schools as formal educational institutions. The use of learning planning methods and techniques enables teachers to improve their performance and competence.

Several categorizations of educational quality are explained in a study: a new factor was introduced by the doctoral thesis of Jewett (2012): brand and ranking. This factor has greater importance for the choice of

business school than faculty qualifications, the importance of mission, continuous quality improvement, and assessment. Focusing on the approach to surveying students, Elliot and Shin (2002) established an alternative approach to measuring overall student satisfaction using a multiple-item weighted gap score analysis and not a simple “yes” or “no” answer in surveys of students on their satisfaction with the institution. Student feedback also plays an important role in surveying. Comparison with the conditions that occurred in the research locations was at least used as a basis for measuring adjustments and improvements according to government policies which were very volatile, especially during the coronavirus disease 2019 (COVID-19) pandemic.

The reality at the research location is in stark contrast to the established concept and vision and mission. Irregular organizational management and lack of sufficient understanding of the roles, obligations, authorities and responsibilities of each school stake holder make the education system that is not run as expected. This gap is further exacerbated by the derivative problem which broadens the basic problem.

A study shows that there is a simultaneous increase in the quality of education related to the decision-making system and the accuracy of the policies taken based on the phenomena that occur in the research location, explained that Debnath et al. (2005) considered feedback from students to be important for upgrading the quality of a management education system. In this vein, the structure of the feedback form is crucial in the decision-making process, as students do not know what is important to them in terms of teaching and learning.

Meanwhile, related to the urgency of improving the quality of education, several stages of competency improvement and assessment of curriculum design and learning must be carried out immediately,

and it is explained that: in order to address this emerging need, a common framework for a quality assurance model would provide consistent assessment of learning design, content, and pedagogy (Puzziferro & Shelton, 2008).

The quality of education quality standards must be supported by several conceptual and contextual dimensions adapted to the differences in the characteristics of the research locations. It is explained that: the perception of quality assurance is very multi-dimensional and contextual and a gap exists in the view between professionals in quality assurance and academic staff and students (Smidt, 2015, p. 626). Several key dimensions of quality in higher education include excellence, value, consistency, and meeting needs and expectations; yet no one quality assurance framework can address all aspects of quality, so choices are made about what kinds of quality are assessed (Harvey, 2014; Wilger, 1997).

Based on the data found by researchers at SMKN 1 Martapura and SMKN 1 Sungai Pinang, it was stated that new student admissions were carried out online. Students who register prepare a number of files and submit them online. When asked about the origin of the information obtained related to the school, the answer emerged that the information was obtained through social media, including Instagram, WhatsApp, and also because there were relatives who had previously attended school in that place.

Students are given the convenience to access information related to PPDB through social media. If we review further, basically students who register fall into the classification of the generation born between 1995 and 2015. This classification is more familiar as Generation Z which is a generation that is familiar with the internet. As explained in Wikipedia, Generation Z is referred to as the generation, the internet generation, they have similarities with the Millennial Generation, but they are able to

apply all activities at one time, such as tweeting using a cellphone, browsing with a PC, and listening to music using a headset. Whatever is done is mostly related to cyberspace. From an early age they have been familiar with technology and are familiar with sophisticated gadgets that indirectly affect their personality. Thus, schools should take advantage of the role of social media both in order to introduce school profiles and in relation to programs for developing students' interests and talents. Furthermore, the use of technology and information has an impact on the dissemination of information both academic and non-academic. Social media is very easy to use, all accounts registered as friends on social media will be informed quickly. Utilization of social media can be used for various aspects ranging from announcements, socialization, department activities, results of extracurricular activities, student achievements and other activities. The wider use of social media has a positive impact on schools so that students are able to identify information more quickly and are able to process it into updated information that prioritizes the use of technology and information.

There is a difference between interest and aptitude. As stated by Slameto in Djaali's book, he also stated that interest is a preference for and a sense of attachment to an aspect or activity, without anyone ordering it. Interest will direct a person's activities towards goals, so that hard work, patience, and willingness to do work that can realize or achieve these life goals will appear. Thus, interest unites with a person's desire and will in living and realizing his life goals. Interest is not a genetic factor but is obtained through a process and interest in something can be learned through the learning process. Interest in something is learned and influences learning and is able to influence the acceptance of new interests. Thus it can be concluded that interest in

something is the result of learning and contributes to learning even though interest is not an essential entity.

Regarding talent which is something that appears from birth and is a gift from Allah SWT. As stated by Beni S. Ambarjaya that talent is one of the human abilities to carry out an activity and has existed since humans existed. This fact is closely related to intelligence which is a mental structure that creates skills in understanding something. Interest and talent have an interrelated relationship and talent is closely related to interest, interest is a preference for and a sense of interest in an activity, without being told. Thus gifted children are encouraged by the interests that exist within them.

### **3.2. Implementation of Utilizing Student Interests and Talents in Improving Student Learning Outcomes at SMK Negeri 1 Martapura and SMK Negeri 1 Sungai Pinang.**

The specialization of students in SMK is a process of making choices and decisions by students in the field of expertise studies, expertise study programs, and competency skills based on understanding their own potential and existing opportunities. This context is related to guidance and counseling to help students to understand themselves, accept themselves, direct themselves, make self-decisions, realize their decisions responsibly.

Guidance and counseling services are carried out with the aim that students can take advantage of their interests and talents so that learning outcomes can increase. Guidance and counseling services are still general in nature, namely informative because there is no test to determine student talent, so the services provided are general in nature, the first step given is to conduct an assessment of student needs which will then be used as a Guidance and Counseling

service program.

The services provided by Guidance and Counseling Teachers (BK) are career guidance services, study services, social and individual. In certain cases, home visits will be carried out on students. However, in certain cases, there is a student talent assessment program that is carried out for Children with Special Needs or ABK. Students with special needs will be given recommendations for majors according to the results of tests from psychologists. The basic framework for education quality must be evaluated consistently and the assessment includes curriculum design, content standards and continuous learning systems. Related to these conditions, it was explained that: A common framework for a quality assurance model would provide consistent assessment of learning design, content, and pedagogy (Puzziferro & Shelton, 2008).

Comparative research related to the similarity of the research variables explained that although Schindler et al. (2015) identified four broad conceptualizations of quality in higher education (quality as purposeful, transformative, exceptional, and accountable), there is no agreement on a definition of quality (p. 8). Probably, the main obstacle in developing a common framework is how different regions address the matter, since “accreditation and quality assurance are no longer purely national undertakings” (Green, Marmolejo, & Egron-Polak, 2012, p. 452), and different jurisdictions take different approaches to quality assurance and accreditation programs.

Meanwhile, accreditation is explained as an assessment of the quality of education: accreditation is a review of the quality of higher education institutions and programs” (CHEA, 2014, para.1). An institution or program is granted accreditation for meeting minimum standards of quality. One common accreditation theme is quality assurance assessment and continuous improvement.

Accrediting agencies have developed standards and procedures to guide institutions in the process of voluntary commitment to continuous improvement, by way of application for accreditation. These standards are used by review committees as the basis for judgment and to make recommendations and decisions.

The standardization of the competence of educators must be supported by academic abilities and educational systems and policies that experience simultaneous development within a certain period of time, especially those that occur in developing countries, it is explained that: increasingly professional standards for teaching are being adopted in education systems as a means to improve teacher quality, codify professional practice and regulate the teaching profession and education systems; particularly developing countries, look to systems where professional standards are more well established for guidance on their development and implementation (Gallie and Keevey, 2014: p. 1).

The following research as a comparative analysis was conducted by Taylor (2016): in his thesis Teachers' experience of professional standards for teachers: A case study of the enactment of teaching standards in a high performing school system makes reference to the literature review conducted as part of the Teaching Scotland's Future review which reported that “studies on the impact of [teacher] accreditation are almost non-existent” (Minister, Hulme, Elliot, & Lewin, 2010, p. 41 in Taylor, 2016: p. 1).

The variable of success and achievement of formal education institutions lies in the management of the school principal and as a leader when carrying out the educational process, the effectiveness of decision making is largely determined by competence and leadership in managing the school's resources, while the quality of education is strongly influenced by the performance of teaching and educational staff. Teacher

performance has a significant impact on the quality of education. Regarding this fact, there are research conclusions that support this statement, namely: a report commissioned to support the development of professional standards in South Africa (CDE), sought to draw lessons from the experiences of other countries; to make recommendations for the adoption of best practice in the field; and to identify the priorities for the effective development and implementation of teacher professional standards (CDE, 2017:1).

However, teachers cannot produce quality and work output according to the target if they are not supported by adequate infrastructure, appropriate methods, relevant media and a synergized curriculum. Some of these variables will be perfect in supporting teacher performance, especially in learning activities if there are competencies that support them. Performance is understood or means a positive value from the entire process of work activities and its management with the aim of achieving the expected targets. As a public education service institution, customer satisfaction is considered a priority. This fundamental reason can be understood and implemented by providing perfect service so that there is continuity and consistency within a certain period of time.

The principal as the leader of a formal educational institution has a number of substantial functions in its implementation. In order to understand this, the following describes several types of leadership characters or in the discussion of education that the principal is closely related to the performance of teaching and educational staff. There are three leadership characters that are often found in leadership systems, namely frontline leadership, executive leadership or execution, and innovator leadership in updating the organizational climate. Research that supports this explanation has found a conclusion and is

cited as follows The Center for Development and Enterprise (CDE ) study found a high degree of homogeneity with regard to the content, format, and implementation of standards in the educational systems studied which included The United States of America ( USA), England, Australia, Jamaica, Namibia and Chile (CDE, 2017).

Students who understand their talents tend to more easily develop their potential. Besides being able to choose a major that suits their abilities, students can also be more motivated to improve their learning outcomes. The process of developing students' interests and talents is carried out in schools in the form of classroom learning, practice, practice questions, and deepening of the material. Likewise, the Student Affairs division prepares other supporting activity programs in the form of extracurriculars which are also selected based on student interests. The extracurricular program is also a manifestation of developing students' interests and talents. Not a few students have made the name of the school proud with a myriad of achievements.

Even though the school has not yet held an aptitude test, there are several characteristics of gifted children in certain fields. One of the characteristics of gifted children in Paul E. Vernon's view is the drive for a high sense of intellectual curiosity . Students who choose a major on their own will have the opportunity to be gifted in their chosen field. However, there is still a probability that the field of study chosen is not in accordance with talent ownership.

Implementation of the Utilization of Students' Interests and Talents in Improving Student Learning Outcomes at SMK Negeri 1 Martapura and SMK Negeri 1 Sungai Pinang forms the basis for prospective students who have been accepted to be prepared for face-to-face learning processes. Face-to-Face Meetings or PTM are implemented after receiving an Appeal Letter from the South Kalimantan Provincial

Education Office and adjusted to the COVID-19 case in each of the regional zones. Some schools have implemented it 100% but there are areas that have only implemented it 50% according to the attached document.

There is an adaptation process if previously students carried out the learning process online, then slowly students return to face-to-face learning. There are a number of parties who say that it is more conducive if the learning process is carried out face to face. This condition has a significant effect because as a vocational school, of course, it is required to be skilled psychomotorically and not only in evaluating cognitive aspects. One's understanding of the three aspects, namely cognitive, affective and psychomotor aspects. As Rusman's opinion, a student's learning outcomes are a number of experiences gained by students covering the cognitive, affective and psychomotor domains. The learning outcomes will also be seen based on changes in student attitudes and behavior.

These conditions basically become a material consideration for schools and students in determining the majors or fields of interest. Every student who registers certainly has talents and tendencies of interest in certain fields which can be known when students register, so it is hoped that the basic nature or potential of students can develop properly. One of the school's strategies in mapping students' talents and interests is through a student needs questionnaire provided by the Counseling Guidance Teacher.

Students who have registered as students at SMKN 1 Martapura and SMKN 1 Sungai Pinang are given a student needs questionnaire. This condition also applies to students of class XI and XII as a basis for guidance and counseling services. Likewise students with special needs to get recommendations in choosing the appropriate major. One of the important

stages in the utilization of interests and talents is an instrument owned by the school to determine students' talents and interests. Every school should have an instrument as a basis for conducting career guidance services to students.

In addition to distributing student needs questionnaires by counseling teachers, the results of mapping these interests and talents will later become recommendations for conducting counseling services to students, including the tendency of students' interest in certain fields. Researchers focus on the importance of aptitude tests as stated by Dewa Ketut that aptitude tests can be divided into two broad categories, known as general aptitude tests and special aptitude tests. General aptitude tests are designed to reveal a wider range of talents, especially with regard to schoolwork. Aptitude tests in specific areas include tests for musical aptitude, artistic aptitude, mechanical aptitude, and clerical aptitude.

An understanding of a number of competencies possessed by gifted students must be distinguished between gifted children who have succeeded in realizing their potential in superior achievements, including outstanding school achievements or having won composing competitions or scientific work competitions and students who are potentially gifted, but due to certain reasons have not been successful. Realize their potential and excellence. The conditions that occurred in the class made it possible only to achieve on an average basis, but in fact it was able to be higher than the target.

When students have taken an aptitude test, it will be easier for the school to direct students' interests and talents, so that their learning outcomes are expected to be able to obtain significant improvements. Although an aptitude test has not yet been held, the school has made efforts to facilitate these students' interests and talents so that they are able to develop through classroom learning,

a number of practical activities, practice questions, and deepening the material.

The assessment and evaluation stage is an important stage because these conditions are a measure for students in mastering the majors taken. This stage will also be input for educators on strategies that should be carried out to improve, enhance and develop students' interests and talents. As stated by Susanto, learning outcomes are a number of changes that occur in students, both concerning cognitive, affective, and psychomotor aspects as a result of learning activities. Thus, student progress reports are not just reports made every semester but will be more meaningful if there is follow-up coaching and student development at school.

The basic framework for education quality must be evaluated consistently and the assessment includes curriculum design, content standards and continuous learning systems. Related to these conditions, it was explained that: A common framework for a quality assurance model would provide consistent assessment of learning design, content, and pedagogy (Puzziferro& Shelton, 2008). Comparative research related to the similarity of the research variables explained that although Schindler et al . (2015): identified four broad conceptualizations of quality in higher education (quality as purposeful, transformative, exceptional, and accountable), there is no agreement on a definition of quality (p. 8). Probably, the main obstacle in developing a common framework is how different regions address the matter, since “accreditation and quality assurance are no longer purely national undertakings” ( Green, Marmolejo, &Egron-Polak, 2012, p. 452), and different jurisdictions take different approaches to quality assurance and accreditation programs. Meanwhile, accreditation is explained as an assessment of the quality of education. Accreditation is a review of the quality of higher education institutions and programs” (CHEA, 2014, para. 1). An

institution or program is granted accreditation for meeting minimum standards of quality. One common accreditation theme is quality assurance assessment and continuous improvement. Accrediting agencies have developed standards and procedures to guide institutions in the process of voluntary commitment to continuous improvement, by way of application for accreditation. These standards are used by review committees as the basis for judgment and to make recommendations and decisions. The standardization of the competence of educators must be supported by academic abilities and educational systems and policies that experience simultaneous development within a certain period of time, especially those that occur in developing countries, it is explained that: increasingly professional standards for teaching are being adopted in education systems as a means to improve teacher quality, codify professional practice and regulate the teaching profession and education systems; particularly developing countries, look to systems where professional standards are more well established for guidance on their development and implementation (Gallie and Keevey, 2014: p. 1).

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namely frontline leadership, executive leadership or execution, and innovator leadership in updating the organizational climate. Research supporting this explanation has come to a conclusion and is cited as follows. The Center for Development and Enterprise (CDE) study found a high degree of homogeneity with regard to content, format, and application of standards in the education systems studied which included the United States, United Kingdom, Australia, Jamaica, Namibia, and Chile (CDE, 2017).

#### 4. Conclusion

Utilization of interests and talents, especially in the vocational education environment, is indeed a crucial problem because every student who has studied at school is expected to have the ability and competence to enter the world of work or profession according to his or her interests and talents. Interest is an individual's interest in carrying out an activity followed by pleasure, so that it will produce satisfaction with the results achieved. The higher the interest an individual has in carrying out a task, the higher the results he achieves. Interest in discipline and concentration in learning is the beginning of a whole series of learning processes at certain stages, including the interest of junior high school graduates in selecting senior high schools which are the next stage of education at a higher level.

Individual career planning is one of the urgent issues because careers are considered aspects that require maximum individual preparation in optimizing their potential.

1. The specialization process carried out at SMK Negeri 1 Martapura and SMK Negeri 1 Sungai Pinang is carried out when students register at school. Students search for information related to schools and majors of interest, then they prepare a number of files to be sent to the

school. In addition, students who officially become students at SMK Negeri 1 Martapura and SMK Negeri 1 Sungai Pinang will also receive a student needs questionnaire. Likewise with class XI and XII students get the same material. The student needs questionnaire is provided as a basis for creating a counseling guidance service program. In addition, the two schools have not carried out a kind of aptitude test, only that the aptitude test is intended for students with special needs with the help of psychologists with the costs being borne by the parents of the students concerned.

2. The implementation of the use of interests and talents in improving student learning outcomes at SMK Negeri 1 Martapura and SMK Negeri 1 Sungai Pinang has been running according to the circular from the South Kalimantan Provincial Education Office. Regarding the conditions of the teaching and learning process carried out online and a number of schools have begun to be tested for Face-to-Face Meetings or PTM, students can begin to study face-to-face and practice or train their mastery skills in the field of study

being studied. As one of the implementations of student talent interests, the school also facilitates students with a number of intra and extracurricular activities that students have previously chosen. A number of these activities are able to increase students' interests and talents, so that their potential is growing. Forms of developing students' talents and interests in implementing competition activities are both academic and non-academic. Assessment and evaluation of student learning outcomes are generally seen based on student development in implementing their interests and talents. Based on progress reports and student achievements, it is submitted in the form of a report from the extracurricular supervisor. Assessment and evaluation in each department related to talent is the responsibility of productive teachers. The next stage is an assessment based on student learning outcomes from both the homeroom teacher, subject teacher, productive teacher and extracurricular coaches, when evaluating learning outcomes and student achievement in class promotion meetings.

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## A TEACHER OR AN ACTOR? ON EMOTIONS AND THE EMOTIONAL LABOR AMONG TEACHERS: A LITERATURE REVIEW

**Abstract:** *The teaching profession involves demands of various kinds as recently more and more space has been given to the emotional aspect that emerges from teaching. This trend stems from the awareness that teachers need to cope not only with pedagogical tasks but also with emotional burdens since teaching does not only involve pedagogical training as it carries many emotional aspects. In recent years, more and more studies address the issue of emotions in teaching. The concept of emotional labor refers to the ability to regulate emotions in an occupational setting. Studies on emotional labor among teachers have been conducted in the United States, in Europe and Asia. The concept of emotional work was first coined in 1983 by the American sociologist Arlie Hochschild. Two main techniques (strategies) have been identified: "surface acting" - the expression of an ideal emotion that is inconsistent with the authentic emotion and "deep acting" - turning the ideal emotion into an authentic emotion in order to match the expression of the emotions demanded by the organization. Based on studies that have indicated the relevance of emotional labor to teaching, this study seeks to review the topic of emotional labor and demonstrate a link between emotional labor and emotional regulation among teachers.*

**Keywords:** *teaching profession, emotional labor, emotional regulation, surface acting, deep acting, pedagogical training, occupational setting, studies, United States, Europe, Asia, emotional work, Arlie Hochschild*

### 1. Introduction

An important theoretical contribution that emerged in the 1960s and 1970s concerned the issue of discrete emotions. Theorists assumed that there is a limited number of basic emotions - sadness, anger, fear, shame, joy, interest, contempt, disgust, and surprise - each having distinctive neurophysiological, physiognomic, motivational, and phenomenological characteristics. For

example, there are unique motivational characteristics associated with each emotion such as fear motivates escape, anger motivates aggression, shame leads to withdrawal and more. Emotions are also conceived as having dimensional properties within the framework of discrete emotions. In other words, emotions can vary in frequency, intensity, their hedonic tone and arousal level (Magai, 2001; Panksepp, 1998). The importance of these theories is

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that they undermine the view that emotions are merely disruptive and maladaptive forces in human life (Magai, 2001) and in fact, these theories place emotions at the center of many contexts in our lives. One of these contexts is the subject of emotional labor.

The concept of "emotional labor" was coined by the American sociologist Arlie Hochschild in her book *The Managed Heart* (1983). Hochschild described the work of emotions as necessary to "induce or suppress feeling in order to sustain the outward countenance that produces the proper state of mind in others" (p. 7). The concept can be interpreted in many ways, but if we simplify, we can argue that we engage in emotional labor when we feel the need to suppress our emotions. That is, keep a smile on all day, even if it is a fake smile, because if you work in a service provider industry, you cannot exhibit a sad or depressed face at work despite what you feel inside. Hochschild cited as an example, flight attendants who are expected to smile and be friendly even in stressful situations. According to Hochschild's definition, emotional labor is a combination of emotional management and life management. This is the invisible labor, for which we are not paid, that we perform to keep our environment and those surrounding us happy and comfortable. The concept includes many aspects of therapy such as, for example, emotional labor, mental load, mental burden, home management, clerical work, invisible labor (Hochschild, 1983). The expression of emotional labor stems from situations in which we actually work.

According to this theory, Hochschild (1983) argued that in a certain sense, we all engage in playacting all the time. However, our acting can be expressed in two strategies: External acting and deep acting. The external acting focuses on changing emotional expressions while deep acting concentrates on transforming internal emotions to express the desired emotion. The external acting that

is done on the surface, include forging emotions that are not really felt, and hiding real emotions. For example, the way we sometimes change our outward appearance that is expressed in body language, the posed shrug, the controlled sigh (Hochschild, 1983). Whereas deep acting changes internal emotional states to truly experience the desired emotion (Grandey, 2000). Here, what we present is the result of working on our feelings. As the Russian director Constantin Stanislavski described as physical behavior that comes from a deep place of feeling. That is, the person who is acting, does not try to look happy or sad, but conveys what he supposedly feels and others may not know that the person they're facing is not feeling what outwardly, they seem to be feeling (Hochschild, 1983).

It is evident that these acting strategies are significant since a study by Hülshager and Schewe (2011) found that in organizations, external acting was positively associated with emotional exhaustion, depersonalization, and psychological health, which are causes of burnout. In contrast, deep acting was positively associated with emotional performance, customer satisfaction, and a sense of personal achievement (Brotheridge & Lee, 2003; Grandey, 2003; Hülshager & Schewe, 2011; Johnson & Spector, 2007).

In the broader sense of emotional management to meet Hochschild's organizational norms, Grandey (2000) argued that emotional labor is a process of transforming internal emotions and external expressions, in order to reach organizational goals. Since Hochschild's pioneering research on stewardship (Hochschild, 1983), several other professions related to emotion management at work have been explored. For example, emotional labor has been shown to be performed on a daily basis by nurses, police officers, salespeople, bank employees and hotel workers (Chou et al., 2012; Gray, 2010; Lv et al., 2012; Moon &

Hur, 2011; Schaible & Gecas, 2010). The present study discusses the field of emotional labor in the context of the teaching profession.

## 2. Literature Review

It has become increasingly clear that the teaching profession places many emotional demands on those who practice it, along with the pedagogical-educational requirements of the profession (Schutz et al., 2006; Zembylas & Schutz, 2009). The literature suggests that teaching is an emotionally demanding profession because the work and the environment are vague and conflictual in nature and involve many stressors (Conley & You, 2014; Schutz & Lanehart, 2002; Somech, 2016). Studies have shown that teachers' emotions are crucial in a variety of aspects related to their work at school: in teaching practices, the relationship between them and their students, issues related to reform and change processes, and understanding the power relations and social structures within the school and the wider social circles around it (Zembylas & Schutz, 2009).

Teachers face a plethora of emotions in the classroom. Among the different emotions of teachers, positive emotions such as pleasure and pride were examined (Frenzel et al., 2009b; Sutton, 2007). Winograd (2003) lists five positive emotions that are included in the emotional demands of the teaching profession. First, students' love and enthusiasm, showing passion and enthusiasm for the current subject, avoiding both extreme and negative emotions, love their work and show a sense of humor and laughter in the face of their own mistakes as teachers. However, teachers also have to cope with negative emotions such as anxiety, anger, and frustration. Teachers experience negative emotions and strong pressure in dealing with the demands placed on them by different stakeholders, with aggressive

behaviors on the part of students and parents, with intense ongoing activities and with pressures to meet external standards (Day, 2013; James, 2011; Sutton & Wheatley, 2003). Because teachers often experience such feelings, they can affect classroom teaching and student learning (Frenzel et al., 2009b; Sutton, 2007) as well as negatively affect the conduct of the school organization (Ashforth & Kreiner; Frenzel et al., 2009a).

In order to conceptualize teachers' emotions, one can use the control-value theory of achievement emotions that Pekrun (2006) developed. According to this theory, subjective control and value appraisals precede students' emotional experiences in the learning and achievement context. Building on Pekrun's theory of student emotions, Frenzel et al., (2009b) applied the theory principles to teachers. According to these principles, teachers' emotions are created as a result of their assessments or judgments which are related to specific situations in the classroom, with teachers' goals playing a central role in the assessment process. Thus, the teachers' assessments of the classroom situation precede the teachers' feelings. That is, the teachers may experience positive emotions such as pleasure or pride if the classroom situation is appraised by them as being consistent with their goals. Conversely, they may experience negative emotions such as anxiety, anger, or frustration if the classroom situation is inconsistent with their goals. In other words, teachers will experience pleasure when they see their students display an understanding of the material being taught, and will also feel pride when students successfully complete important tasks. On the other hand, teachers may feel anxious when they are unsure if students are constantly following the classroom assignments, and anger when the path to their goals is blocked due to students' negative behavior, and frustration when students do not understand the material, despite the teacher's effort (Frenzel

et al., 2009b ).

Various studies have found that teaching requires high levels of emotional investment from its practitioners, no less and perhaps even more, than service providers in the business sector, as this occupation requires daily, prolonged and intensive face-to-face interaction between the teacher and their students and many other factors. This profession has definite rules associated with demonstrating positive and negative emotions. Presumably, the fact that teachers are required to make an emotional investment in the face of a long list of objects when a different type of emotional investment is required for each of them, also adds to the emotional burden placed on the teacher (Ginat, 2011).

The reality in Israel, as in other countries, positions teachers as service providers, students and their parents as customers and the school administration, the supervisor and the office as principals and employers. This is all the more noticeable following the policy of opening school registration areas and creating competition between schools in some cities, which has created new rules of emotions. These rules are aimed primarily at keeping students in school where the teacher is expected to avoid expressing too negative feelings towards students for the fear that they would leave the school. There is an ethical critique of the concept of the teacher as a "service provider", since the requirement towards service providers to manage their emotions in accordance with the school's marketing interests, is in stark contrast to the rules related to demonstrating feelings as part of the internal goals of education and teaching - their educational perception and the declared school's perception. As a result, in extreme situations, a teacher will smile at their students because it benefits the school image and not necessarily because a smile and emotional support are essential to the student's development (Opletka, 2011).

Today it seems clear that emotions play an important role in the workplace. This can be particularly true in the case of teachers whose job is not only to teach, but also to create and preserve a learning-friendly environment. This means showing enthusiasm during lessons, empathic response to students' needs and concerns, hiding fatigue and anger or presenting positive emotions even when the students are stacking difficulties and behaving rudely. Teachers must teach them and simultaneously, manage their own feelings in order to meet expectations related to their profession (Cheung et al., 2011; Philipp & Schüpbach, 2010). Actions that define the concept of emotional labor. However, compared to other professions, especially commercial ones, it turned out that teachers' emotional labor has unique characteristics since interactions with students, as opposed to interactions with commercial service customers, are often long-term and repetitive. A study conducted in Poland, showed that teachers' work with students was particularly demanding, as teachers were repeatedly exposed to the negative behavior of their students (Pyzalski, 2008).

Not only do emotions interfere with the teaching process, but they also seem to be the leading contributors to emotional exhaustion. For example, it can be exceedingly difficult to control anger or irritation, when communicating with students who ignore requests or harass other students. In addition, in the education system, some students may have special educational needs, which not only affect their ability to study, but also require more attention from their teachers. Teachers are supposed to help these children overcome obstacles by providing adequate support, reorganize lessons or provide extra time. Thus, working with children with learning disabilities, emotional and behavioral difficulties, health problems or other needs, can be particularly stressful and emotional



(Antoniou et al., 2000; Male & May, 1997; Mackenzie, 2012).

### 3. Emotional Labor Among Teachers

Studies have shown that teachers believe they should act according to display rules that include expressing positive emotions and suppressing negative emotions (Schutz et al., 2007; Sutton, 2004; Zembylas, 2003). Levine-Brown (2011) found that the rules associated with demonstrating emotions in the teaching profession are in fact the product of teachers' own inference as a derivative of the image of the "ideal teacher." The teachers who participated in the study admitted that they found themselves "playing the role" through pretending to express warmth and caring (Levine-Brown, 2011). Wróbel (2013), who researched the rules associated with demonstrating emotions in the Polish education system, also noted that these rules are not as clear and explicit as in other service professions, although in practice, teachers are required to face high expectations of being nice and patient all the time, and never tired or angry (Wróbel, 2013). Studies that focused on teachers as emotional laborers, found that emotional involvement is an integral part of the teaching profession (Näring et al., 2006; Philipp & Schüpbach, 2010; Sutton & Wheatley, 2003; Zapf & Holz, 2006). These rules of playacting stem from teachers' perceptions of appropriate behavior toward their students (Keller et al., 2014). The efforts that teachers make to follow these rules are actually related to the concept of emotional labor (Lee et al., 2018). Similar findings to studies that have examined emotional labor in organizations (Brotheridge & Lee, 2003; Grandey, 2003; Hülshager & Schewe, 2011; Johnson & Spector, 2007) were found in research about the acting strategies, both surface and deep

acting, among teachers. The study by Näring et al. (2006) explored how the acting strategies discussed by Hochschild (1983) associated with emotional exhaustion, depersonalization, and personal achievement of teachers. The study found that surface acting was found to be positively associated with teachers' emotional exhaustion and depersonalization, and was negatively related to their personal achievements, whereas the opposite was found for deep acting (Näring et al., 2006). Furthermore, in their longitudinal study, Philipp & Schüpbach (2010) found that teachers who tended to external acting, exhibited more emotional exhaustion, whereas teachers who employed a deep acting strategy, exhibited less significant emotional exhaustion after one year (Philipp & Schüpbach, 2010) and enhanced their job performance over time (Hülshager et al., 2010). These findings suggest that a deep acting strategy may be a more beneficial emotional labor strategy for teachers.

Keller et al. (2014) who examined the correlations between teachers' emotional labor strategies and their discrete emotions, found that negative enjoyment, anxiety, and anger, positively predicted the adoption of on the surface acting strategies. In addition, Lee et al. (2014) found that acting on the surface was in a positive correlation with anxiety, anger and frustration, and in a negative correlation with pleasure. In contrast, deep acting was found in a positive correlation with pleasure, and in a negative correlation with anxiety, anger, and frustration. These findings suggest the beneficial effects of deep acting on teachers' emotional experiences. Given that teachers' emotional labor and discrete emotions have been found to be factors in explaining emotional exhaustion (Keller et al., 2014), it can be argued that there is relevance to the question of what discrete emotions teachers actually express, fake and hide, while they are teaching (Lee & Van Vlack, 2018; Taxer

& Frenzel, 2015). A study conducted in the United States on emotional investment among teachers, focused mainly on the expression of positive emotions and the suppression of negative emotions, based on the assumption that good teaching is charged with positive emotions. In order for teachers to meet their job requirements, they are required to fake positive emotion, or reinforce such emotions, even when they do not actually experience these feelings (Pfister, 2015). Thus, there is great importance to research examining how teachers' emotions are correlated with their emotional labor strategies and their emotional regulation.

#### **4. Emotional Labor and Emotional Regulation Among Teachers**

There are three aspects to emotional regulation. First, although most of the time, humans try to reduce the negative emotion, emotional regulation is not just about that. People amplify, maintain, and lower both negative and positive emotions (Parrott, 1993). Second, many situations in which emotional regulation is activated are conscious, such as a decision to make a dramatic change or to restrain oneself when being angry. However, emotional regulation can also occur subconsciously, when for instance, a person exaggerates in their enthusiastic response to a gift they have received, that is not particularly attractive (Cole, 1986), or when a person quickly diverts attention from something annoying (Boden & Baunieisier, 1997). Third, emotional regulation cannot be viewed as a positive or negative phenomenon since the same emotion regulation strategies that allow physicians, for example, to perform their work successfully (Smith & Kleinman, 1989) can also neutralize empathy among people engaged in interrogation and torture (Bandura, 1977).

Emotions and emotional reactions can serve people well, however, there are events where the emotional reactions do more harm than good. According to Gross (2002) such situations support the idea that emotions need to be regulated, which is particularly relevant in a school setting where there are rules for social conduct. Gross' definition of emotional regulation is the ability to control the experience and the expression of emotions. That is, emotions do not force us to react as we react but only increase the chance that we will react in this way. This flexibility allows us to regulate our emotions. For example, when we are afraid, we can flee, but do not always do so. When we are angry, we can hit, but not always do it and when we are very amused, we can laugh out loud, but not always do so. The way we regulate our emotions is important, since our well-being is inextricably linked to our emotions (Gross, 2002).

Emotional regulation is considered to be one of the three general aspects required for emotional skill. The other two are: (a) understanding or appreciating emotion - the ability to correctly identify, evaluate and understand a person's emotional expressions and internal emotional states; (b) expression of emotion - a person's ability to transmit his emotions by verbal (language) and non-verbal means (facial and voice expressions, gestures, posture) (Weare, 2004). Although understanding emotions, emotional expression and emotional regulation are often referred to as separate concepts, understanding and expressing emotion are in fact important stages of emotional regulation (Gross & Thompson, 2006), which is actually corresponds with emotional labor.

Theoretically, although the body of research discusses the similarities between emotion regulation (Gross, 1998) and emotional labor (Hochschild, 1983), empirical studies on the relationship between them is lacking. Such research was conducted by Lee et al. (2016). The authors examined the relationship

between the two structures, emotional labor and emotional regulation, as well as their relationships with discreet emotions of high school teachers (Lee et al., 2016). The study found positive correlation between reappraisal and deep acting, and between suppressive strategies and surface acting. However, a weak correlation was found between emotional labor and emotional regulation, suggesting that cognitive reappraisal and deep acting, as well as oppression and surface acting, are not entirely geared to the same emotional management strategies, despite their similar ideas in the two research approaches. The authors explained this by implying that sometimes emotional labor strategies are related to specific motives while emotional regulation strategies are unrelated. For example, when people fake or hide their emotions, they act cynically, however, when they strive to change their emotions, they are honest. In contrast, people can also use emotional regulation strategies for various reasons. They can reappraise or suppress emotions for honest or cynical reasons. However, the study findings showed strong correlation to emotional labor when deep acting was positively related to teachers' positive emotions and suppression and surface strategies were positively related to negative emotions (i.e., suppression with anxiety; surface acting with anxiety, anger, and frustration) (Lee et al., 2016). In general, emotional labor strategies seem to be more related to teachers' emotions than emotional regulation strategies. In particular it seems that as in other studies cited in this paper, surface acting is the strategy with the biggest drawbacks for use by teachers.

## 5. Summary

Teachers adapt themselves to their job definitions and take on the image involved in the job and the meanings stem from it. Therefore, they adopt an expression of

emotion adjusted to the "role code". For example, they show enthusiasm or stay calm, even when their students are interfering in class. In fact, it is a suppression of emotions (e.g. anger) or faking a positive emotion to maintain the image that the role requires. Although the study by Lee et al. (2016) did not find significant positive relations between emotional labor and emotional regulation, the present paper shows that there must be a strong link between the two. Hochschild (1983) coined the term "emotional labor" to describe how employees express feelings that suit the rules of the organization or the job and they actually lose an authentic sense of identity and inner coherence to their true values and feelings. The term "deep acting" by which Hochschild described a situation in which individuals adapt their feelings to society's expectations of them, versus "surface acting" which is a representation of external behavior without matching the internal emotions of the person that acts. Thus, in order to be successful in the labor of displaying emotions, one must control the type of emotions experienced or those expressed, and this requires a skill of emotional regulation, response-focused, in which true emotions are hidden, or falsified.

According to Hochschild (1983) any form of acting, based on levels of self-deception, can affect an individual's authentic sense of identity. It can be concluded that emotional labor, in both its strategies, surface and deep, requires emotional regulation. When one fakes his or her negative emotions, in order to conform to the role code and the rules of the place, not only does one feel these negative emotions within him, it can also provoke anger within and be upsetting. That is, the very fact that a person has to pretend and falsify positive emotions when they feel negative emotions, and in that process, they do not react in anger, requires from such a person emotional regulation. It apply to the second strategy of emotional labor as well,

the deep acting, where a person needs to actually "convince" oneself to enter into a "mode" of positive emotions when they do not feel such emotions, requires emotional regulation since in this process, a person needs to restrain, actually transcend above his or her, true feelings, and adopt not only a positive response in situations where their emotions are negative, but to work on their negative emotions and actually change them, to feel and communicate positive feelings. In other words, suppress their true emotions.

Thus, this study, which indeed discusses mainly teachers, can be applied to any other profession. The researcher's recommendation is to conduct further studies that will examine in depth, the relations between emotional labor and emotional regulation among teachers since teachers are in different situations from commercial organizations. As mentioned earlier, teachers

do not "sell" goods and do not receive a monetary benefit, the more they sell. The role of the teacher is more often than not, being performed out of a sense of a mission and their "customers", i.e., the students, cannot, as in the commercial world, switch to another supplier if they are not satisfied with the service. Thus, it is in fact a unique system of interactions that must be examined in a unique and specific way to the world of teaching and be cautious in applying the principles that are in the commercial world.

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## ASSESSING THE CONSTRUCTION SUPERVISORS' COMPETENCY TRAITS AND WORK QUALITIES ASSOCIATED WITH ENGLISH PROFICIENCY FOR EFFECTIVE COMMUNICATION IN THE INDUSTRIAL FLOWS: SRI LANKAN PERSPECTIVE

**Abstract:** *With a focus on addressing the industry's knowledge gap on the use of methodical approaches to improve communication flows and productivity-related benefits/outcomes sustainably, this study intends to evaluate the competency traits and work qualities associated with construction site supervisors' proficiency in English for efficient communication in a developing country's perspective. Totally, sixty-two Sri Lankan construction supervisors were subjected to well-designed modern apprenticeship elements, and their pertinent competency traits and work qualities were evaluated using a well-designed grading mechanism associated with functional apprenticeship frameworks/manuals/tools. At various stages of the research plan, academic reviews, expert consultations, statistical tests and other blended methodologies were used. The results demonstrate the quantitative performance ratings of relevant supervisory work qualities, ensuring adaptability, reliability and generalisability. The study resulted in a conceptualised pump that allows new values of highly practicable supervision qualities to pour in towards flowing considerable impacts on current practices of many rising industries/nations.*

**Keywords:** *Construction Supervision, Job Qualities, English Proficiency, Communication, Performance Evaluation, Work-based Training*

### 1. Introduction

The competency approach can be effectively applied to produce an effective human resource management function that is in line with the organisation's strategy (Serpell & Ferrada, 2006). Nonetheless, some have noted that there is always a chance that human resource systems will undermine an organisation's competitive advantages by

impeding the mobilisation of modern competence or the proper exploitation of ones that already exist (Lindgren, Henfridsson, & Schultze, 2004). Taking on construction organisations, the construction site supervisors are the key human resources who are in charge of executing a wide range of construction site activities connected with the organisational goals by communicating with various work categories (Manoharan,

Dissanayake, Pathirana, Deegahawature, & Silva, 2022). The site supervisors, who act as a link between the project/site manager and the employees, must implement general planning rules at the level of the construction process (Manoharan et al., 2022). This necessitates that site supervisors create work schedules and share them with the staff members responsible for carrying them out (Serpell & Ferrada, 2006). Importantly, effective communication is essential to assure that projects are successful in terms of schedule and cost management (Gamil & Rahman, 2017). It is particularly crucial on construction sites, where the bulk of activities depend on the effectiveness of communication (Renault & Agumba, 2016). Similarly, effective communication is moreover significant for influencing project outcomes on construction sites (Olanrewaju, Tan, & Kwan, 2017).

The need to connect and gather information from all disciplines is extremely important as the world moves toward industrialisation and technological innovation (Pek & Mee, 2015). Communication skills are seen as an acquired competence that is necessary for social interaction, information transmission and knowledge sharing (Markovic & Salamzadeh, 2018). The ability to effectively deliver/share ideas, thoughts and opinions is the key benefit of effective communication (Serpell & Ferrada, 2006). The effectiveness of the information to be exchanged or delivered may be hampered if the communication process fails (Markovic & Salamzadeh, 2018).

Taking on the Sri Lankan construction context, the rapid increase in foreign labourers in the Sri Lankan construction sector needs to be a concern in the recent scenario since it may cause a number of issues associated with economical, cultural and environmental aspects (Manoharan, Dissanayake, Pathirana, Deegahawature, & Silva, 2021b). In order to address a scarcity of skilled/semi-skilled construction workers in

the country, Sri Lanka has considered importing a large number of workers from regional nations (Weerakkody, 2019). Compared to other industrial sectors, the construction industry largely absorbs foreign employees in Sri Lanka. The construction sector leads in the list of sectors that intake foreign workers in Sri Lanka, whereas the tourism and plantation sectors followed up second and third in the list, respectively (Weerakkody, 2019). Noticeably, the intake of foreigners to the tourism sector is three times higher than the plantation sector in size, whereas the influx of foreign workers into the construction sector is two times larger than the tourism sector in Sri Lanka, as per the statistical data provided by Weerakkody (2019). Since the majority of the foreign workers employed in Sri Lanka originated from countries with lower exchange rates, such as Bangladesh, Indonesia, India, Myanmar, Nepal and Vietnam, they are unable to interact with their supervisory staff in the local language, which could cause their job to be delayed and put at risk (Valitherm, 2014; Manoharan et al., 2021b). Due to the wide range of nationalities present in most of the high-scale infrastructure development projects in Sri Lanka, such projects are diverse in terms of both culture and language with communication during work (Manoharan et al., 2021b). TVEC (2018) highlights that a substantial language barrier is one of such major issues that prevent workers from being able to communicate adequately.

According to Wei and Yaznifard (2015), the language barrier is a key challenge in the construction business in many Asian countries as well, particularly for the communication flows around the tasks performed by supervisory staff dealing with foreign workers and project management staff. Salleh, Nordin, and Rashid (2012) also concur that the language barrier becomes more challenging when foreign workers are unable to understand the instructions. They

are unable to reach the degree of effective communication required to complete the project tasks, which makes it more troublesome as the project becomes more complicated (Salleh et al., 2012). Poor communication skills may make it impossible to complete project duties, but they may also have a number of other consequences that significantly impact construction projects (Wei & Yaznifard, 2015). Emuze and James (2013) contend that poor communication may hamper the pace of construction projects, which can also affect the projects' success in terms of schedule and money, as well as resulting in conflicts between shareholders. Inadequate communication may also result in project reworks, which add time and expense and may have unfavourable effects (Emuze & James, 2013). Similar views have been expressed by Marhani, Adnan, Baharuddin, Esa, and Hassan (2012), who claimed that poor communication could result in decreased productivity and work quality, leading to the failure of the projects.

Concerns about the usage of the English language have grown significantly in recent years, not just in Sri Lanka but in a great number of industrialised and emerging nations (Silva, Warnakulasuriya, & Arachchige, 2018; Mee et al., 2020). It is important to highlight the Malaysian construction sector, where English is given equal weight to Malay, even though Malay has long been the official national language of Malaysia (Mee et al., 2020). But, Pek et al. (2019) state that the supervisory/technical workers who come from non-English-speaking nations encounter language barriers in the Malaysian construction sector. Being able to at least speak in English, whether in an official or informal situation, is essential given that it is an international language (Mee et al., 2020). According to Ahmed (2015), an individual who can speak English well will have access to the entire world, as English is a language that is used on a global scale.

It has been difficult to effectively

communicate with people from diverse cultures (Jenifer & Raman, 2015). Relatively little use or practice of the English language in work activities can be the major fact that results in one of the most important issues in supervisory/technical workers' incapacity to speak English well (Ne'matullah, 2017). On the other hand, it needs to consider the increasing popularity of mobile applications and computerised tools, which has changed how working staff need to be familiar with the use of the English language for communicating with job tasks (Poh, Ung, & Tan, 2011; Ne'matullah, 2017). Learning the language in a variety of settings will aid speakers in developing their proficiency (Ne'matullah, 2017). Juhana (2012) highlights that several causes may be to blame for the hesitation to use English among industrial workers. The psychological issues that prevent such workers from being able to communicate include fear of making mistakes, anxiety, shyness, lack of drive and lack of confidence (Juhana, 2012).

### 1.1. Problem statement

Relating to the aspects discussed above, recent studies and the discussions with the skill sector council of Sri Lanka and construction industry experts have revealed that the above-stated language barriers need to be primarily solved among the communication channels centred on the site supervisory workers in construction projects since they are the key resources to directly connect organisational policies with the quality and productivity of work operations. Sources highlight that lack of proficiency in the English language among site supervisors has been the leading factor that results in ineffective communication outcomes and workflows in the construction industry of many numerous emerging nations, namely South Africa (Windapo, 2016), Nigeria (Nwosu, 2018), India (Anil, Chitranjan, & Jayeshkumar, 2019), etc., similar to the Sri

Lankan context (Silva et al., 2018). Such sources further reveal that this has led to making a large number of construction firms experiencing productivity loss and quality-related issues in their project outcomes. More sources spotlight the absence of methodical apprenticeship practices among the vocational and industrial training organisations of such countries to address this significant problem (TVEC, 2018; Anil et al., 2019; Manoharan, Dissanayake, Pathirana, Deegahawature, & Silva, 2020). On the other hand, this study reveals the factuality that even though some earlier studies have identified these problems, they lack to come up with systematic actions to solve or reduce the impacts of those problems. Consequently, this study finds the gaps in industrial knowledge on how to approach the apprenticeship components and attributes connected with the English proficiency of construction supervisors and what generalised outcomes need to be achieved intending to enhance communication flows and productivity-related benefits/outcomes in a sustainable manner.

### **1.2. The study's aim and significance**

Commensurate with the above-stated problems and requirements, the intention of this study is to assess the competency elements and quality characteristics associated with construction site supervisors' proficiency in English for efficient communication in the industrial flows in the Sri Lankan construction context within a methodical frame. By comprehending the proficiency levels of site supervisory attributes/qualities in this track, the study may provide useful procedures and systematic ways to upgrade the industrial practices towards filling the industrial knowledge gaps stated above up to a certain level.

## **2. Literature review**

Communication across cultures is hampered by inherent constraints like language and culture (Sapar & Abuisaac, 2015). Many factors, including books, magazines, newspapers, the internet, radio and movies, all contributed to the disparities in language, as the socio-cultural environment is a key factor in defining one's skill in English (Shabani & Alipoor, 2017). English for specific purposes (ESP) has a similar learning process to other teaching methods, according to Ahmadi and Bajelani (2012). Even though the contents of ESP differ from those of common English, there is no accounting for distinctions between teaching processes. As a result, ESP embraces all forms of communication in a cross-cultural situation and does not solely focus on vocational communication (Ahmadi & Bajelani, 2012).

The percentage of people who use English in a professional setting has grown significantly (Chien & Hsu, 2010). In terms of international workers, their goal is to carry out the precise instructions provided by their clients. They need to be proficient in the English language to do this since the industry they work in expects them to grasp terms specific to that industry (Chien & Hsu, 2010). The constraints that cultural variation put on cross-cultural communication led to a number of issues at work (Jenifer & Raman, 2015). If these obstacles are not removed, they will eventually have an impact on the organisation's productivity.

The ability to read materials and comprehend the instructions given for activities to be taken is the most crucial quality for international workers. They will be accustomed to working with manuals, instructions/procedures and invoices throughout their careers in the construction industry. Olanrewaju et al. (2017) state that efficient worker communication is crucial to the site's productivity. Early intervention is necessary to resolve issues that cause communication barriers, which impede project performance

and on-site productivity. According to Sapar and Abuisaac (2015), organisational performance cannot be improved unless these communication impediments are eliminated.

Ne'matullah (2017) investigated the communicative barriers to the productivity of the construction industry in Malaysia and highlighted the following unfavourable outcomes due to the lack of proficiency in English among construction site supervisors.

- Causing project completion delays
- Lowering work qualities
- Putting foreign workers at greater risk
- Resulting in the wastage of resources and supplies

Ne'matullah (2017) have observed that there were numerous instances in which construction projects have requested extensions of time (EOT) or are being disregarded since construction companies are unable to finish the project by the deadline as a result of the above-highlighted significant outcomes. This indicates the necessity for language corpus research and language training to be carried out to reduce misunderstandings, miscommunications and carelessness within the construction industrial process flows.

On the other hand, it is significant to note the findings of Serpell and Ferrada (2006), who proposed a useful competency framework for construction site supervisors employed in developing nations. Importantly, the following work attributes are emphasised by Serpell and Ferrada (2006) among the supervision job roles to coordinate and organise the execution of the essential operational tasks in accordance with project plans.

- Organising the work site and operational procedures in compliance with the construction project's tactical plan and organisational policies

- Organising and carrying out work teams' operational actions in accordance with time, cost, safety and quality indicators
- Controlling resource distribution to ensure that it complies with process plans and quality standards for basic site operations
- Coordinating the execution of site tasks in various directions according to the operational strategical characteristics
- Leading both internal and external teams performing different construction project flows in compliance with the human resource management rules of the organisation
  - Distributing roles and responsibilities throughout the various stages of the construction process according to the human resources plan
  - Implementing safety, quality and environmental standards among internal and external construction employees connected to organisational policies
  - Developing the skills of construction workers engaged in fundamental construction processes and assessing their proficiency under corporate and project policies
- Overseeing the development and execution of construction operations while assuring adherence to the quality system, safety and environmental standards of the organisation
  - Monitoring the completion of construction goals while assuring adherence to legal, safety, environmental and corporate principles

- Measuring how well construction is going in relation to the project's operational and tactical schedule
- Reporting the progress status of operational tasks according to the measures of the operational plan and performance indicators
- Devoted to the organisational values and ideals of the company
- Devoted to ensuring the security of both human beings and material resources
- Adaptable and flexible in the face of hostile circumstances and conditions

Moreover, in order to assure the above-listed work attributes, Serpell and Ferrada (2006) presented the critical competency characteristics under the three categories, which are education and training, abilities and performance and attitudes, as shown below.

- Education and training
  - Recognise the ideas and components involved in a construction project's tactical and operational planning
  - Identify and assess construction tools and materials that are regularly utilised in site operations.
  - Recognise various construction methods
  - Distinguish and employ standards for environmental protection, safety and quality
- Abilities and performance
  - Oversee and incorporate operational working teams in operational planning
  - Involve individuals in quality, environmental and safety standards
  - Outline operationally-level plans for construction projects
  - Use management technologies to assess the quality and progress of construction projects
- Attitudes
  - Oriented toward the project's vision, mission and strategic objectives

Besides, Manoharan et al. (2020) have investigated the critical factors influencing construction productivity and determined supervisory skills as a leading significant factor in the list. It is important to note that Manoharan et al. (2020) presented a set of supervisory training programme outcomes (STPOs) that can be very useful for skill development authorities and construction industry organisations to take the necessary steps for the enhancement of supervisory abilities in construction. This study emphasises that English language proficiency and communication characteristics are essential to a quarter of the STPOs presented by Manoharan et al. (2020), and such STPOs are highlighted below.

- Carryout self-learning on modern theories, advanced technologies and practices related to construction works (STPO1)
- Assist in conducting field investigations, surveys and tests required for feasibility studies of construction works (STPO2)
- Maintain the records of the construction tasks and help in preparing the reports effectively (STPO3)
- Be a good communicator and team player among the construction workers (STPO4)

On the basis of the STPOs of Manoharan et al. (2020), a construction supervisory training guide model was comprehensively designed by Manoharan, Dissanayake, Pathirana, Deegahawature, and Silva (2021a) to upgrade the supervisory attributes with the intention of

providing productive ways to handle evolving challenges and opportunities of the industry in the current and next normal conditions. The site supervisory training guiding model of Manoharan et al. (2021a) importantly comprises 12 competency units (CUs), where one of those CUs significantly focuses on the supervisory characteristics of proficiency in English for efficient communication in the industrial flows. Noticeably, the competency characteristics of the relevant CU are subdivided into four competency elements (CEs), as shown in Table 1 and Table 2. Additionally, Manoharan et al. (2021a)

presented the mapping and distributed weights of relevant CEs and CU, along with learning domains of Bloom’s taxonomy, as described in Table 1. The scheme of this weighting displays the sectional view of site supervisory competencies under cognitive/knowledge, skill and affective/attitude attributes when it takes on their proficiency in English required for efficient communication in the industrial flows. Overall, it indicates a ratio of 6:9:5 between those three attribute categories, respectively.

**Table 1.** Mapping and distributed weights of the competency elements (CEs) and competency unit (CU) relevant to proficiency in English for efficient communication in the construction industrial flows, along with learning domains of Bloom’s taxonomy, presented by Manoharan et al. (2021a)

Competency Elements (CEs) / Competency Unit (CU)	Weight (%)	Learning Domain and Domain Levels																		
		Cognitive/ Knowledge Levels (C)				Psychomotor/Skill Levels (P)							Affective/Attitude Levels (A)							
		C1	C2	C3	C4	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5			
CE[i] – Follow grammatical aspects at the word, phrase, sentence and paragraph levels in writing	20	14				2	2									2				
CE[ii] – Search the texts and key areas in the books/articles/documents	20	7				4	7									2				
CE[iii] – Write notes, emails, formal letters, notices, survey reports, laboratory reports, biographies and personal profiles	30	4	5			2	3	5	5							3	3			
CE[iv] – Listen, speak and communicate with others in English	30					2	3	5	5							8	7			
CU – Proficiency in English for efficient communication in the construction industrial flows	100	25	5	0	0	10	15	10	10	0	0	0	0			15	10	0	0	0
		30				45										25				

C1 – Remembering and Understanding, C2 – Applying, C3 – Analyzing and Evaluating, C4 – Creating, P1 – Perception, P2 – Set, P3 – Guided Response, P4 – Mechanism, P5 – Complex Over Response, P6 – Adaptation, P7 – Origination, A1 – Receiving Phenomena, A2 – Responding to Phenomena, A3 – Valueing, A4 – Organization, A5 – Characterization

Additionally, Table 2 shows the mapping levels of relevant CEs and CU, along with the STPOs of Manoharan et al. (2020). The following statement categories were considered by Manoharan et al. (2021a) for

deciding the mapping levels between CEs and STPOs. In the process of deciding these mapping levels, the supervisors’ skill capacities required in the next normal, the learning demands, the industry’s expectations

and the practicalities were all carefully assessed by Manoharan et al. (2021a).

- Introduced (I): The learnt contents give an overview of the intended outcomes.
- Emphasised (E): The learnt contents assert the needed results or outcomes.
- Reinforced (R): The learnt contents act as pillars for strengthening the materials in the direction of the desired result.

- Advanced (A): The learnt materials represent a vigorous level of interaction with the resources in order to achieve the desired results.

As per the obtained mapping levels between CEs and STPOs, the level of mapping of CU against each STPO was determined by Manoharan et al. (2021a) whether it is considerably (C)/ moderately (M)/ slightly (S) accomplishing the needed characteristics, as shown in Table 2.

**Table 2.** Mapping levels of competency elements (CEs) and competency unit (CU) relevant to proficiency in English for efficient communication in the construction industrial flows, along with the supervisory training programme outcomes (STPOs) of Manoharan et al. (2020), presented by Manoharan et al. (2021a)

Competency Elements (CEs) / Competency Unit (CU)	Supervisory Training Programme Outcomes (STPOs) of Manoharan et al. (2020)			
	1	2	3	4
CE[i]				E
CE[ii]	E	I	E	I
CE[iii]	E	E	R	R
CE[iv]		E	E	R
CU – Proficiency in English for efficient communication in the construction industrial flows	M	M	C	C

STPOs of Manoharan et al. (2020):

STPO(1): Carryout self-learning on modern theories, advanced technologies and practices related to construction works

STPO(2): Assist in conducting field investigations, surveys and tests required for feasibility studies of construction works

STPO(3): Maintain the records of the construction tasks and help in preparing the reports effectively

STPO(4): Be a good communicator and team player among the construction workers

Mapping between CEs and POs: I – Introduced level; E – Emphasised level; R – Reinforced level

Mapping between CU and POs: S – Slightly accomplishing; M – Moderately accomplishing; C – Considerably accomplishing

### 3. Methodology

Figure 1 shows the layout design for the flow of the mechanism associated with the research plan/methodology based on the research aim/objectives. Continuous consultative processes with different academic and industry professionals were held, as illustrated in Figure 1, with a specific focus on the essential measures in construction site supervisory qualities for the facts and difficulties outlined in the above sections (introduction and literature review).

Notably, the consultative discussion sessions were carried out connected with different flows shown in Figure 1, and the participants were considered into three categories, where each category consisted of around 10 experts. University academics with a PhD or master’s degree in the field of civil engineering and more than five years of professional experience took part in these consulting sessions (Category 1). Additionally, these consultative discussion sessions included participation from industry specialists who held chartered engineering credentials and extensive experience working as project



directors, managers and engineers (Category 2). Moreover, academics and industry professionals who have expertise in the English language and communication aspects also played some key roles in these consultative sessions (Category 3). Problem-

focused and action-oriented communication strategies were applied at every stage of the consultative process, particularly to identify the problematic areas, understand the effects and establish necessary actions/solutions using the expertise.

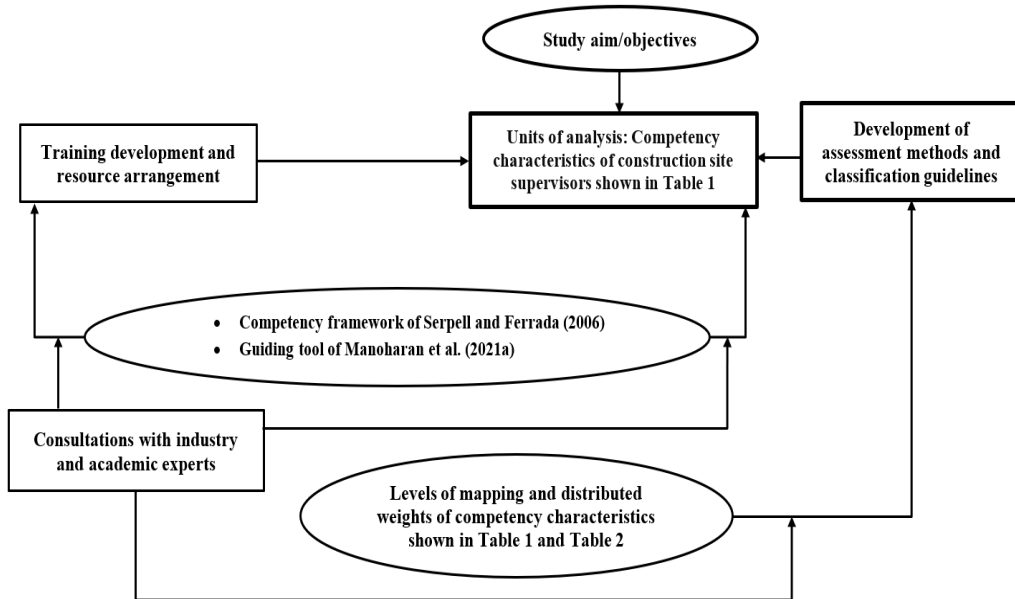


Figure 1. The flow of the mechanism associated with the study methodology

### 3.1. Validation of the applicability of the competency framework of Serpell and Ferrada (2006) and the supervisory training guiding tool Manoharan et al. (2021a) for supplying a foundation that is consistent with the characteristics of the current research aim/objectives

It was found that only a few studies have offered models or methods to carry out apprenticeship aspects at construction project sites, despite the literature evaluation of the current research revealing a wide range of factors that affect diverse construction systems. According to the needs and peculiarities of the industrial environment, there are significant restrictions when employing such models or tools, according to the current research. Despite discussing

productivity development, the major shortcomings of those models and technologies are the absence of specific competency traits and performance evaluation processes. At present point, the primary causes of this constraint are the limited capital resources and the inability to adopt the current technology of many construction businesses in underdeveloped countries. The construction sector in industrialised nations often uses the computerised tools provided by Hai et al. (2018). A fundamental issue in the design of these models and tools is that they disregard techniques for making work activities broader.

As per the analysis of the flaws, gaps and limitations in the past study findings, the

competency framework of Serpell and Ferrada (2006) and the construction site supervisory apprenticeship manual by Manoharan et al. (2021a) served as the foundation for the layout design of the study mechanism, as can be seen in Figure 1. The above-mentioned consultative results and reviews from industry experts were used to support the emphasis on using these apprenticeship tools while also taking into account the aim/objectives of the study and other important factors, as per the factors outlined in the later part of the literature review section. Importantly, the expert reviews validated the consideration of competency characteristics of construction site supervisors (CEs and CU) shown in Table 1 as the major units of analysis for achieving the aim/objectives of this study. The expert reviews chiefly stated that these CEs and CU are fully essential for achieving the work attributes of supervisory workers emphasised in the competency framework of Serpell and Ferrada (2006), as well as considerably matching with the critical competency characteristics highlighted by Serpell and Ferrada (2006) under the categories, namely education and training, abilities and performance and attitudes, as discussed in the above literature review section.

### **3.2. Training development and resource arrangement**

An advanced construction supervisory apprenticeship with a diploma qualification level of the Sri Lankan National Occupational Qualification Framework (SLQF) was comprehensively designed in accordance with the use of the apprenticeship manual of Manoharan et al. (2021a). This apprenticeship development followed a number of methods while taking into account innovative qualities in light of the new typical situations in the construction business. It is significant to note that the intended apprenticeship qualification level was SLQF

level 3, which is comparable to the National Vocational Qualification Framework (NVQF) level 5 in Sri Lanka. Therefore, the admission standard for the criteria of NVQF level 5 or SLQF level 3 was followed by the selection of site supervisory personnel. Notably, the Tertiary and Vocational Education Commission of Sri Lanka authorises the NVQF, which is a nationally uniform framework that upholds the legitimacy of vocational educational certification awarded in Sri Lanka based on internationally benchmarked norms and procedures (TVEC, 2021). On the other hand, the University Grant Commission (UGC) of Sri Lanka authorises the SLQF, a framework that awards higher education qualifications produced by both public and private higher education institutions (UGC, 2015). Surprisingly, the SLQF includes the lateral mobility pathways for higher education and the workforce that are tied to the NVQF.

The apprenticeship-providing institution was chosen by conducting a SWOT analysis and consulting with experts. Institutional directors and academic heads from several departments made significant contributions to the consultative talks surrounding this SWOT analysis. Before the apprenticeship began, the essential approvals for the detailed design of the curriculum, ethics, quality control and financial aspects were obtained through a series of procedures carried out with several academic and administrative committees operating in the selected institution. With the intention of providing systematic apprenticeship delivery at the institution with a long-term emphasis, other significant resource arrangements were made, including the creation of a new Board of Study, the creation of program by-laws, the appointment of human resources assigned to various academic tasks and administrative work processes, etc.

The potential site supervising staff were first identified and encouraged to apply for the suggested apprenticeship using the snowball

sampling technique. This sampling strategy is useful in overcoming the challenges of obtaining samples with the appropriate traits for the study's applications. In order to locate more construction supervisory workers who could be interested in applying for the planned apprenticeship, a noticeable number of supervisors were first included in the sample by running a series of awareness sessions within a number of well-known industrial enterprises. By following the guidelines outlined in the programme by-laws, 62 construction supervisors were ultimately selected for the proposed apprenticeship based on their educational and professional backgrounds as well as the scores received during the selection interview session. In particular, a panel of academics used the interview sessions to assess the candidates' cognitive and self-management qualities relating to communication, commitment, curiosity and self-discipline. Notably, 40% of the chosen supervisory staff were working on building construction projects, whereas the same percentage can be implied to the supervisory staff employed in road construction projects. A notable percentage (around 15%) of the selected supervisory staff were involved in water supply project work. Taking into consideration of the chosen supervisory staff, it was also apparent that there was a large representation of each of Sri Lanka's nine provinces among their group, whereas none of them fit into the category of workers with less than one year's worth of experience.

### **3.3. The significance of the inclusion of the pertinent competency unit that carries out the elements of the research applications**

More importantly, the newly developed apprenticeship included a specific competency unit that used a number of job-integrated learning approaches to site supervisory abilities in line with the primary

goals of the current research. The relevant competency unit primarily addressed the characteristics of all the CEs stated in Tables 1 and 2. Noticeably, the components of this specific competency unit were assessed by a panel of subject matter experts. Here, the panel was made up of nine experts with an equal composition between the three categories of experts who participated in the consultative discussions, as stated in the first paragraph of the methodology section. The review of the proposed competency unit specifically focused on competency factors and objectives, training outcomes and their weights, training contents, delivery methods, assessment strategies, as well as the relevant mapping level outcomes and the types of resources that were required.

The proposed apprenticeship's academic delivery components were uniformly distributed among the selected supervisory staff in accordance with the programme's by-laws and institutional quality assurance procedures. For the purpose of evaluating the traits of supervisory work qualities, a grading criterion was meticulously created, as demonstrated in Table 3. The weighting of CEs in relation to the learning domains listed in Table 1 was tied to the grading criteria that were constructed. The CEs with the relevant STPOs presented by Manoharan et al. (2020) (shown in Table 2) and the advanced site supervisory work attributes of supervisory workers emphasised by Serpell and Ferrada (2006) in their competency framework were also taken into consideration by this collective mechanism of the competency evaluation process. Within the base of this mechanism/framework, written examination, oral tests, listening exercises, speaking activities, group work activities, activity-oriented tasks, work-based assignments and other interactive tasks were carried out for evaluating the supervisory competencies and qualities.

It is significant to highlight that the expert review panel confirmed the validity of the

designed grading guide and the detailed designs of the competency evaluation components. Surprisingly, the pertinent competency unit states that 30% of the apprenticeship was devoted to enhancing the cognitive (knowledge-based) qualities of site supervision, notably in terms of assessing how the supervisory work qualities perceive problems and apply solutions. Also, 45% of the apprenticeship was used to assess site supervisory psychomotor qualities, with a focus on perceptions and action mechanisms related to problem identification and resolution. The emotional (attitude and

emotion-based) site supervisory qualities were the emphasis of the final quarter of the apprenticeship, particularly how their work qualities connected with paying attention to and willingly acting on the problem-solving parts. The overall ratio of the construction supervisory cognitive, psychomotor and emotional qualities to the necessary aspects of competency characteristics was 6:9:5. The chosen supervisors were given a grade level that came within the range of scores presented in Table 3 after being evaluated for each and every CE according to the grading standards and descriptions.

**Table 3.** The developed criteria for the classification of construction supervisors into different groups/grades

Score Range	Group/Grade	Standard Levels	Descriptions
>=85	A+	Superior	Higher in status, quality and rank
75-84	A	Excellent	Incredibly good; outstanding
60-74	B	Good	Having adequate qualities with high standards
45-59	C	Pass	Demonstrates potential
35-44	D	Conditional Pass	Demonstrates potential but lacks the necessary groundwork in some important areas
<=34	E	Fail	Unsuccessful in achieving the requirements

**3.4. Validation of the method of applying research tools**

It is noteworthy to state that the experts mentioned in Section 3.3 were involved in the overall evaluation process of validating the methods of applying research tools. The evaluation process crucially included a series of observations and evidence-based discussions centred on the plans drawn up and the research tools utilised for the research objectives’ direction within the processes illustrated in the above sub-sections.

**4. Results and discussion**

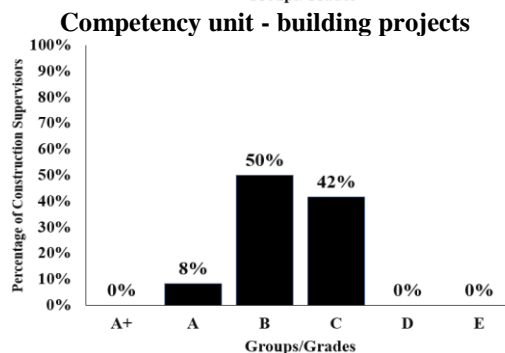
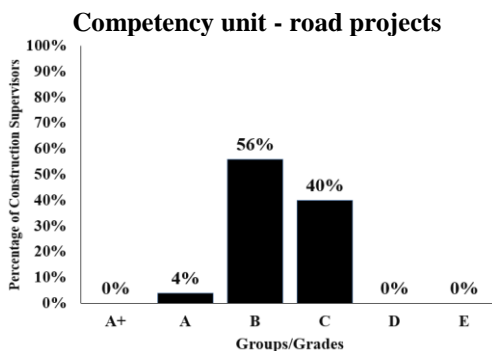
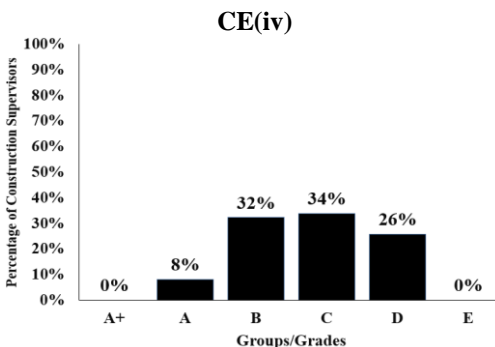
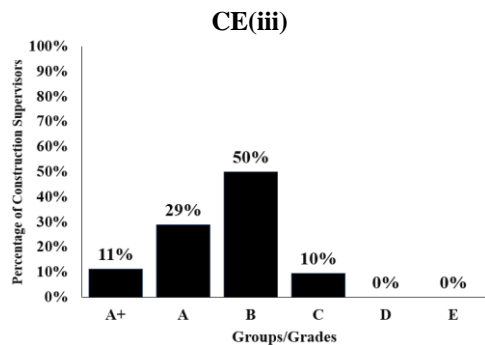
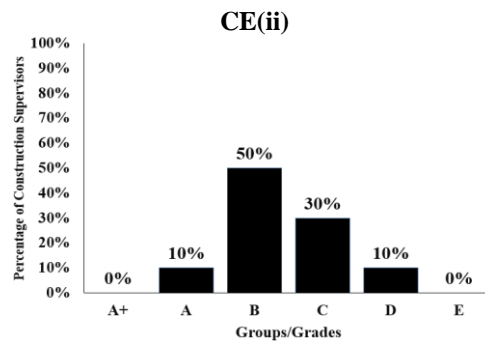
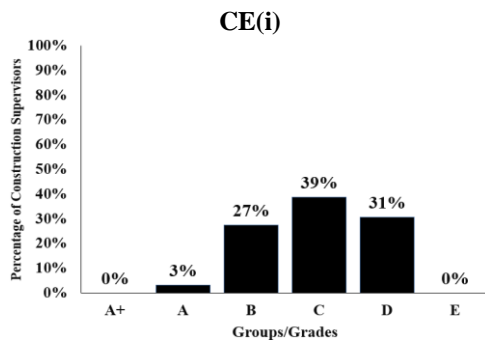
**4.1. Classification of construction supervisors’ competency traits and work qualities with the performance ratings and grades**

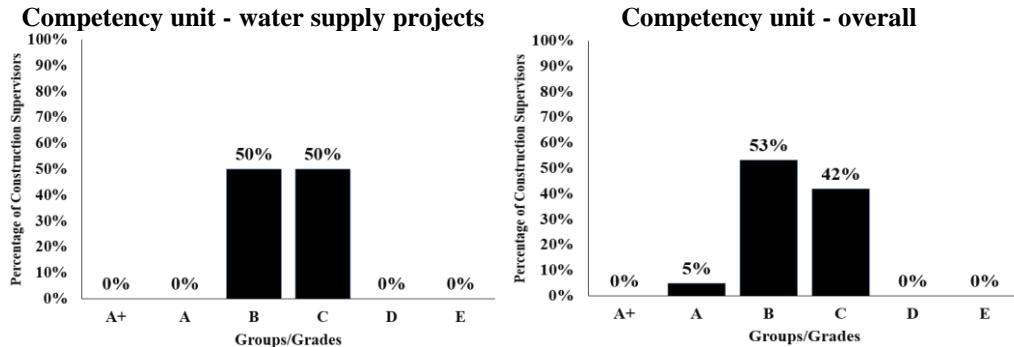
Figure 2 demonstrates the classification of construction supervisory work qualities with the percentages of construction supervisors for each competency feature or factor at different grade levels while also taking the entire competency unit into account when allocating the apprenticeship components.

Taking into the supervisors’ qualities in following grammatical aspects at the word, phrase, sentence and paragraph levels in writing (CE[i]), 30% of the supervisors showed that they have adequate qualities with high standards, whereas the remaining 70% were found at the pass or conditional pass level. When it comes to supervisors’ quality attributes in investigating the texts and key areas in the books/articles/documents (CE[ii]), the supervisory qualities seem better

compared to CE[i]. Considering the major reason for this difference, the discussions with the experts underlined the intensification of the awareness and understanding of the supervisory workers on the significance of work-oriented searching practices associated with their regular work process and demands of learning. In CE[ii], the work qualities of one-tenth of supervisors were incredibly

good, whereas half of the supervisors' qualities were found to be adequate with high standards. Among the remaining supervisors, three-quarters of them were found to be at demonstrated potential level, and a quarter of the supervisors were identified with a lack of the necessary groundwork in some characteristics of CE[ii].





**Figure 2.** Classification of construction supervisors' competency traits and work qualities into different groups/grades

Compared to the first two CEs, the supervisory qualities were identified much better in CE[iii], which relates to writing notes, emails, formal letters, notices, survey reports, laboratory reports, biographies and personal profiles. Taking into consideration this significant difference, the expert discussions drew attention to the significance of the work process and responsibilities associated with the characteristics of CE[iii] than the learning demand for a wide range of tasks in relation to communication aspects where the supervisory staff are involved in their daily work routines. Under the characteristics of CE[iii], 40% of the supervisors showed their qualities at an excellent or superior level, whereas half of the supervisors showed their proficiency at an adequate level with high standards, and the remaining 10% of the supervisors were found to be at demonstrated potential level. Noticeably, none of the supervisors was found with lacking part of the groundwork in any characteristics of CE[iii]. On the other hand, two-fifths of the supervisors proved their competence in listening, speaking and communicating in English (CE[iv]) with adequate qualities and high standards, whereas 25% of this portion were outstanding in the competency characteristics associated with CE[iv]. Here, among the remaining

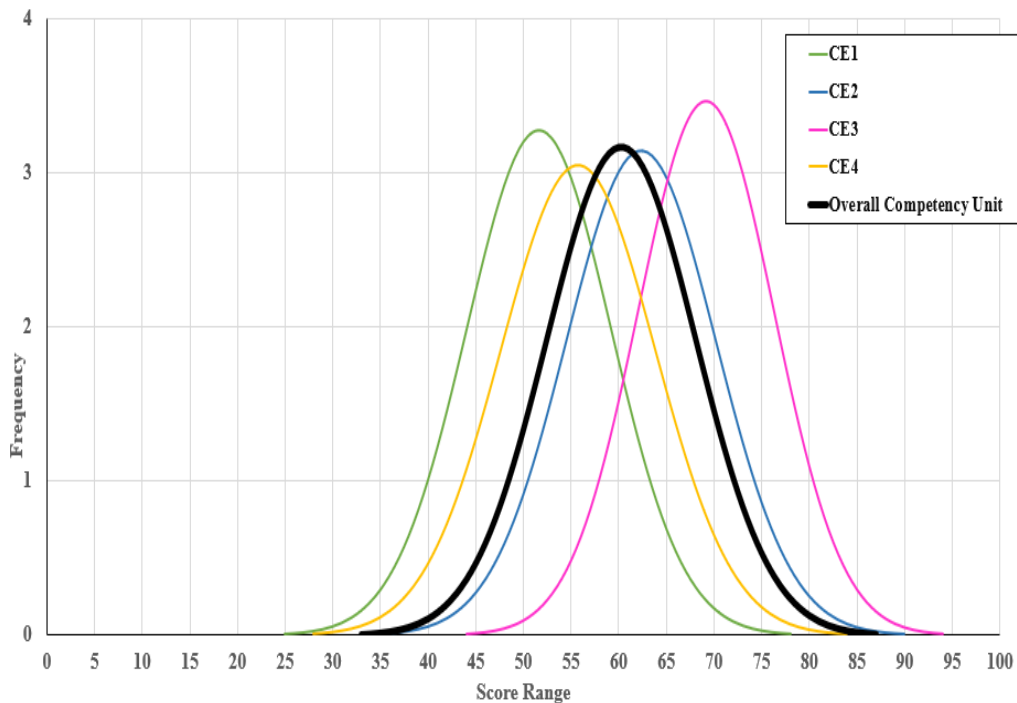
three-fifths of the supervisors, nearly a 4:3 ratio was reported between the supervisors who were at the pass and conditional pass levels, respectively. Noticeably, none of the supervisors was found to be unsuccessful in achieving the requirements under the characteristics of any CEs at any stage.

Taking on the whole competency unit category, 5% of the supervisors were at grade A which signifies their excellent/outstanding level of quality of communication attributes associated with English proficiency in the industrial work processes. In addition, 53% of the supervisors were at grade B which implies that they have an adequate level of work qualities and high standards of communication attributes associated with English proficiency in the industrial flows, whereas the remaining 42% of the supervisors were at grade C indicating such qualities/attributes of them at a demonstrated potential level. In the matter of the whole competency unit category, none of the supervisors was found at the conditional pass or failure stage. The results shown in Figure 2 further reveal that there are no significant differences in the results when comparing the proportions of the supervisors in each grade level based on the types of projects where they are employed.

**Table 4.** Average score values of construction site supervisors under the required competency characteristics relevant to proficiency in English for efficient communication in the construction industrial flows

Competency Elements (CEs) / Competency Unit (CU)	Road Projects			Building Projects			Water Supply Projects			Overall		
	AVS	STD	CV	AVS	STD	CV	AVS	STD	CV	AVS	STD	CV
CE[i]	50.15	6.56	0.13	50.46	6.14	0.12	58.11	9.57	0.16	51.63	7.56	0.15
CE[ii]	63.52	7.45	0.12	61.42	8.46	0.14	61.84	8.14	0.13	62.36	7.86	0.13
CE[iii]	70.06	6.82	0.10	70.64	6.61	0.09	63.12	8.35	0.13	69.14	7.14	0.10
CE[iv]	55.61	8.21	0.15	56.44	7.85	0.14	52.01	7.89	0.15	55.78	8.11	0.15
CU – Proficiency in English for efficient communication in the construction industrial flows	60.44	7.18	0.12	60.50	8.34	0.14	58.53	8.22	0.14	60.27	7.81	0.13

AVS – Average score, SDV – Standard deviation, CV – Coefficient of variation



**Figure 3.** Curves showing frequency distributions of construction supervisors' scores under the required competency characteristics

Table 4 displays the average performance ratings they received for each competency factor, whereas Figure 3 demonstrates the curves that show frequency distributions of construction supervisors' scores under the required competency traits. The lowest average score overall was recorded by CE[i],

which was nearly 52 (indicating middle levels of grade C). The expert discussions pointed to the lack of foundation given to the grammatical use in Sri Lankan secondary/school education and the lack of significance considered by other parties to the grammatical aspects in the usual work

practices and communicational flows of supervisory job roles, as the major causes for the lowest score values in CE[i]. On the other hand, the highest average score was obtained by CE[iii], which was nearly 69 (indicating upper levels of grade B). The overall average scores for the various project types did not significantly differ from one another and were almost closer to the average score value of the supervisors' overall competency unit, which was around 60 (indicating the lower marginal levels of grade B). This highlight that the given apprenticeship components can be particularly adaptable and transferrable to the supervisory methods used in all different sorts of construction project practices by following this procedure connected with the study aims/objectives.

Considering the further depth of analysis on all CEs, the mean values are almost closer between the supervisors working in building and road construction projects for each CE, whereas some notable differences can be seen in the average scores of supervisors working in water supply works compared to other project types, especially in the competency factors of CE[i] and CE[iii]. When it comes to finding out the major reason for these differences, it can be justified that the characteristics of different types of project practices, working patterns and site policies might influence the work qualities of supervisors in following grammatical aspects in writing (CE[i]) and writing notes, emails, formal letters, notices, survey reports, laboratory reports, biographies and personal profiles (CE[iii]).

**Table 5.** The developed new guideline generalising the results associated with the construction supervisory attribute levels in English language proficiency for efficient communication in the construction industrial flows

Competency Elements (CEs) / Competency Unit (CU)	Road Projects	Building Projects	Water Supply Projects	Overall
CE[i]	C	C	C	C
CE[ii]	B	B	B	B
CE[iii]	B	B	B	B
CE[iv]	C	C	C	C
CU – Proficiency in English for efficient	B	B	C	B

**4.2. Assurance of the results and outcomes concerning adaptability, generalisability and reliability**

The coefficient of variation (CV) values of the scores were under 16% in all the categories, and this assures that the outcomes are comparable between raters and that they fall within the range of CV values set forth by Statistics Canada (2020). This increases the reliability that the provided apprenticeship components will be extensively applicable to the industry sector's long-term purposes. The observations of a group of experts on the outcomes (detailed in Section 3.4) must also be given special consideration. The pool of specialists determined that all of the competency factor categories were sufficient as a whole, intriguingly emphasising the importance of broadening the applications of this research process in numerous emerging industries and nations for their quick adoption of industrialised practices.

An important result of this study is the formation of a new generalised guide that may be useful in forecasting and understanding what degrees of attributes can be taken into consideration in supervisory qualities, as demonstrated in Table 5. This could significantly enhance the procedures for decision-making, knowledge management, performance management and communication management components of resource planning in terms of improvements in proficiency and work outputs.



communication in the construction industrial flows				
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The construct validation of the current case study applications was wonderfully evident according to the conceptualised rules for case study techniques supplied by Yin (2002) since the study exhibits the evidence and justifications with the locations of each instance of the units of analysis (CEs). The findings, demonstrated in Table 5, unquestionably show how haphazardly the case study's units of analysis are connected. The illustration of patterns of variance in each CE while taking into account various project practices has ensured the internal validity of the results. Most importantly, the findings of the expert interviews, reviews and data analysis demonstrated that the suggested applications and methods could be generalised, valid and used for various scopes and boundaries within the site practices. This guarantees both the measured outputs and the external verification of the proposed uses/mechanisms. It also demonstrates that the suggested techniques and applications can be used as initiatives in other emerging industries.

#### 4.3. Discussion on the current research findings compared with past studies

The current research findings can be very helpful for the construction industry in emerging countries like Sri Lankan contexts to take systematic approaches to handle a wide range of challenges highlighted by Valitherm (2014), Weerakkody (2019) and Manoharan et al. (2021b) due to the increase of foreign employees, as described in the introduction and literature review sections. Considering numerous studies (Jenifer & Raman, 2015; Sapar & Abuisaac, 2015; Windapo, 2016; Ne'matullah, 2017; Olanrewaju et al., 2017; Nwosu, 2018; Silva et al., 2018) highlighted that the language barriers and communication impediments significantly impact the organisational

performance and productivity, the current study findings provided generalisable ways to polish out the communication flows within the project practices. In particular, the generalisability of the current study findings will lead to open a way for addressing the psychological issues, such as fear of making errors, lack of drive, lack of confidence, anxiety and shyness (listed by Juhana (2012)), that prevent the local site supervisory workers from communicating with foreign workers. This may lead to avoiding misunderstandings, miscommunications and carelessness within the construction industrial process flows, as well as making construction organisations experience the reduction of project delays, reduction of wastages of resources/supplies, advancement of work qualities and lower risks of working with foreign resources. More importantly, the current study findings strengthen the external validity of the competency framework presented by Serpell and Ferrada (2006) and the training guide tool of Manoharan et al. (2021a) for construction site supervisors employed in developing nations. As described in the methodology section, the competency evaluation methods are well connected with the internal structure of such tools. Additionally, the current research findings may also support the application of the advanced computerised models proposed by Hai et al. (2018) for upgrading skill evaluation methods in apprenticeship practices. According to the recommendations provided by Hai et al. (2018), computerised sophisticated technologies can be used in the future to further enhance the existing study applications.

In addition to the above, the current study outcomes will have considerable influences on polishing up the construction site supervisory qualities to perform the professional job with the capability to manage various construction processes towards

achieving the following competency outcomes of Bachelor's level degree qualifications (the qualification level of SLQF 5 / NVQ 7) suggested by Manoharan et al. (2022).

- Compare, analyse and categorise diverse management and technology applications using the optimisation approaches with the purpose of enhancing productivity and performance in the industry sector
- Use pertinent codes of practice for designing concrete, steel, masonry and timber structures
- Use computerised procedures in modeling techniques of architectural and structural designs
- Identify suitable research-based approaches for solving industrialised challenges
- Use construction techniques with a proper grasp of the factors causing environmental change on a global scale, which results in hazards from both nature and human activity
- Execute the assessment and decision-making procedures pertaining to production and operation as well as evaluate the quality of the processes and products in accordance with the organisational needs
- Execute the methods to maximise the value and quality of construction practices by lowering supply chain logistics costs and inventories
- Use the services of banks and insurance providers to make proper decisions for achieving productivity and profitability-related benefits in industrial operations
- Investigate the economic literature on guided technical advancement and behavioural modification for raising the effectiveness and productivity of business operations

- Analyse the demands for business and service environments to execute marketing strategies for organisational activities
- Manage entrepreneurial ventures in the construction sector to attain the anticipated levels of productivity and profitability
- Implement resource arrangements, awareness campaigns and promotional efforts for worker apprenticeship initiatives to strengthen relationships between industrial and institutional businesses on a national and worldwide level

## **5. Conclusion**

By adding new qualities of construction site supervision, which may be crucial in improving the effectiveness and productiveness of construction operational flows, this research has partially filled the industry's knowledge gap related to skill upgrading issues. By polishing out the communicational qualities of site supervisory attributes, the research has opened the pump to allow the highly workable characteristics to flow in and improve the site communication structures of site management. The current study has laid a reinforcement layer to upgrade the supervision roles to deal with international practices and industrial communication channels for handling the challenges associated with technological advancement towards obtaining benefits related to higher performance, quality, productivity, safety and sustainability of the industrial flows in the next normal conditions. The results of this study may stimulate changes to different training curricula in tertiary and vocational education institutions as well as the field of vocational training to accommodate the changing needs and problems of the industry under the new normal characteristics.

It is significant to note that only relatively modest differences were found in the results, despite the fact that project conditions, organisational policies/instructions, operational characteristics, size and quality of resources, financial scales and ethical regulations varied significantly among the selected construction projects where the applications of this research were processed. This ensures that the applications of this research will provide sustainable advantages to a number of construction-related sectors, assuring the adaptability, dependability and generalisability of the overall results.

Only those employed as site supervisors in the construction industry, whose level of competence ranges from technician to managerial level, are qualified to enter into this study applications as the samples, which is a notable limitation that this research emphasises on the use of site supervisors. Furthermore, a thorough analysis of the supervisory qualities in the context of Sri Lankan construction served as the basis for the grading levels shown in Table 5. Anyhow, the peculiarities of construction supervision procedures may differ in various contexts of growing economies and sectors. So, taking into account the circumstances of various developing countries, there might be minor discrepancies in such grade levels, but such differences are not anticipated to be of a significant magnitude. The results of the expert consultation also showed that the grade levels shown in Table 5 can generally agree with the opinions of other emerging nations. Taking into account these factors, it is appropriate to state that this research has provided a contemporary manual that summarises the capability levels of construction site supervisory workers associated with the pertinent aspects of the research problem replicating the settings of developing countries. Yet, this study suggests that future research examines the variations in these grade levels by comparing the managerial responsibilities and work habits

of other countries and industrialised sectors. Future studies can benefit greatly from the generalised methodologies and mechanisms that the current study provided for such a purpose. As a result, the findings of the current study have the potential to significantly influence how site planning, stakeholder management, supply chain management and communication management aspects are currently practised in other developing industrial regions and countries. The current research also suggests that future studies may use mixed-method approaches to examine productivity variations in relation to changes in site supervisory work qualities. Furthermore, this research highlights the necessity for other competency-based characteristics and working approaches/patterns in site supervision and other job categories to be evaluated in future studies under varied conditions.

The consultations with the experts revealed that the structure of the current study's competency framework can be further polished out by adding more supervisory competency factors associated with the ESP characteristics for performing the business and marketing related needs of the industry matters in order to achieve the higher levels of competency outcomes suggested by Manoharan et al. (2022). Within this concept, this study conclusively emphasises the consideration of the following competency elements that future studies may focus on to expand the current study applications/findings.

- Communicate verbally in practical business contexts with greater fluency, accuracy and confidence
- Express supervisory attributes effectively on business-oriented written aspects
- Use words and phrases related to business and marketing to express supervisory characteristics

- Develop strategic competence that helps in efficient communication in English

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## EXPERIMENTAL STUDY ON SOFT CLAY SOILS TO IMPROVE SETTLEMENT AND ULTIMATE STRESS USING THERMOS MECHANICAL LOADS

**Abstract:** *The electrothermal method was used to treat soft clay soil under load in this study. The experiment model was adopted to study settlement behavior. The effect of heat on settlement and maximum stress, of soft clay soils, were studied. The variables studied are the distance between the heaters, the heating time, and the temperature of the source. A model was used with dimensions (60 \* 40 \* 60 ) cm, and heaters were used in each model, and the power of each heater was 925 watts, and the number of models used was 37 models. The first examination was without heat treatment, and settlement was measured in it directly. As for the rest of the tests, heat treatment was used in it, and the tests were divided into two phases. The first stage is the heat treatment stage, and the second stage is the stage of placing the mechanical load on the soil. The mechanical load is weights placed on the soil through the footing. The tests were divided according to the research structure into three cases and according to the distance between the two heaters (20,30,40) cm. In each case, the tests are conducted according to the heating time, where the heating time was used (4,8,12) consecutive hours, and each time 4 tests were used at different temperatures (200,300,400,500) degrees Celsius. An improvement value of 99.8% in the settlement was obtained when the source temperature was 500°C, with a heating time of 12 hours, and the distance between the heaters was 20 cm. An improvement in maximum stress of 425% was obtained when the source temperature was 500 °C, the heating time was 12 h, and the distance between the heaters was 20 cm. The conclusions of the study are that the settlement decreases with increasing temperature and the ultimate stress increases with increasing temperature.*

**Keywords:** *Experimental stud, soft clay soils, ultimate stress, thermos, mechanical loads*

### 1. Introduction

Soft clay soils make up much of the land in southern Iraq. It is necessary to strengthen this soil, especially in these places, to

stimulate economic development and to create projects in various disciplines because the formation of projects on this soil is difficult. As a result, the technology used to improve these soils must be financially

efficient, rapid, and durable.[1] Many regions of the world also have soft loamy soils, which have the maximum stress and lead to large settlements when loaded.[2] Dirt properties can be improved by using various techniques, including chemical treatment, artificial soil reinforcement, removal, replacement with different filling materials, etc., to reduce excessive settlements and improve maximum stress.[3] However, there are several things to consider when selecting a technique to measure the degree of improvement. It includes the area and volume of soil to be treated, soil type, access to raw materials, access to necessary equipment, disposal of waste and water pollution, effects on nearby structures, local experience, amount of time available, and cost [4],[5]. Since 1955, the heat treatment method has been used only by the Soviets, and in particular in Russia and Ukraine, and the use has decreased due to high fuel prices.[6] Clay-rich soil and stones form the basis for many towns, cities, transportation lines, and structures. Due to their capacity to contract or expand in response to variations in water content, the clays composed of montmorillonite pose a serious risk to technical construction. The underground water table's diffusional flow of moisture via the soil's pores, rainfall's gravity flux of water into the ground, and other sources might all play a role in the moisture shift. Soft soils require more damage than floods, volcanoes, tornadoes, earthquakes, or other natural disasters. By improving the soil or utilizing specific types of foundations, the detrimental effect of expansive soil on structures can be avoided or mitigated.[7] Heat treatment was one of the suggested types of improvement techniques utilized to address the issue of building on expanding soil. Investigating the physical characteristics of the soft soil existing in particular locations of Iraq is vital to ascertain the remedies for reducing damages.[8] The electric heating method

was used recently in Korea, where a researcher used the heating method in one of the locations in Korea, and he used temperatures between (70 and 110) °C. The researcher obtained good results for the maximum stress and slump in the soil [9] also [10], [11] investigated fine clay's ultimate bearing capability and final settlement after thermal treatment. After combining Baghdad clay with enough water to give it a shear strength of 7 kPa, he conducted seven typical experiments on clay soil inside a square steel box with a length of 750 mm after heat treatment, two of which were used as a standard without treatment. for reference. This innovative gas-heating system uses wells to heat. Four square patterns of boreholes with 3.5 cm diameters, 30 cm lengths, and 3d, 4d, 5d, 6d, and 7d distances (d being the well diameter) were heated for six hours each. A 150 mm long, 20 mm thick square aluminum plinth was placed in the soft clay surface area and loaded monotonously until the settlement reached 10% of the foot width. The results showed that as spacing rises, bearing capacity increases and stability falls until a maximum limit (5d), when it declines and stability increases. 5d space has the best bearing capacity and settlement.

In this study, a model was used in which soft clay is used to study settlement behavior, and heat treatment is done with two heaters for each test. It put several variables in the treatment, which are the time factor, the distance between the heaters, and the change in the source temperature. The study aims to study the effect of heating on the settlement of the model, find out the optimal distance between the heaters and the base, and find out the optimum temperature.

## 2. Methodology of study

The research structure relied on heating the soft clay soil with heaters, as two heaters it

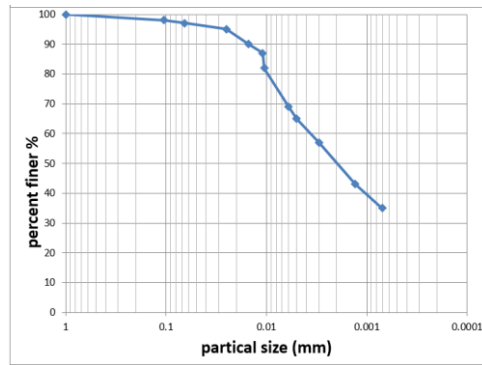


can be used in each test at a specified distance. The distances between the two heaters it (20,30,40) cm, and in each of these distances, 4 tests were used, with a temperature of (200,300,400,500) degrees Celsius for each test, and a heating time of 12 hours. After heating the model the model is loaded with cumulative loads and settlement is measured.

### 2.1. Materials used in the model

Soft soil. The samples used in the investigation were taken from a site in the east of the city of Nasiriyah, which is located within the coordinates (31.05238, 46.20908). The ground was excavated to a level of 1.5 m to obtain this soil. Table 1 shows the types

of soft soils used in this research. The USCS classification indicates that the soil is CL soil. Figure. 1 shows the particle size.



**Figure 1.** Plate (2) Soil improvement using Heaters [11]

**Table 1.** Physical properties of natural soil used

Properties	Value	Specification
Initial water content (WC) %	13%	-----
Liquid Limit (L.L)	% 46	ASTM D 4318 -2003
Plastic Limit (P.L)	% 21	ASTM D 4318 -2003
Plasticity Index (I.P)	% 25	-----
Specific Gravity (Gs)	2.60	ASTM D 854 -2007
Percent of Clay	67	ASTM D 422 -2006
Percent of Silt	27	ASTM D 422 -2006
Percent of Sand	6	ASTM D 422 -2006
Unified Soil Classification System	CL	ASTM D 2487 -2006 (USCS)
Optimum Moisture Content (O.M.C) %	19	ASTM D 698 -2007
Maximum Unit Weight (kN/m <sup>3</sup> )	15.5	ASTM D 698 -2007
Shrinkage limit	15	

### 2.2. Heating system

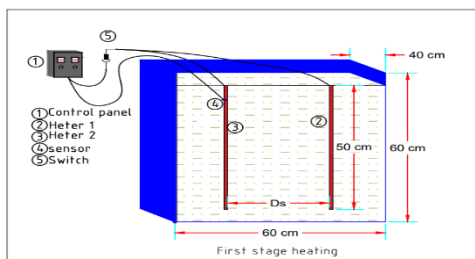
To improve the soil, generate heat within the soil, and conduct sample tests, try to be as close as possible to what is happening in the field. A special heating system was made. This system has a powered panel with temperature control systems and sensors on the edge of the heater that plugs directly into the electrical panel. The heater is an electric heater with a length of 50 cm and a diameter of 1 cm with a maximum power of 925 watts connected to the heating system. As shown

in Figure 2.

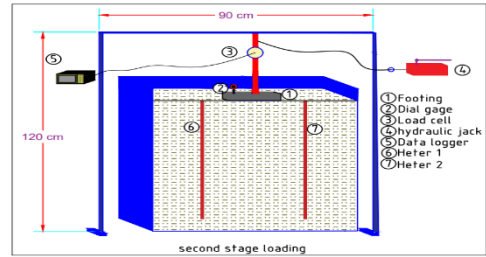
### 3. Preparation of soil bed and testing

Several tests of soil physical properties, including soil, liquid limits, plastic limits, and density tests, are performed before the preparation stage to ensure the effectiveness of the preparation procedures. It also performed a series of soils requiring a shear strength (C) of 40 kPa with a moisture

content of 34%. The soil was moistened and mixed with water according to the moisture content. The moist soil was stored in airtight plastic bags for 2 days to ensure even moisture distribution [10]. Then, the soil was compacted in a cubic form, the dimensions of which are 60 cm x 40 cm x 60 cm, in the form of layers, and the thickness of each layer was 10 cm. Thirteen typical tests were then performed. The first model is without the use of heat. The following four models were investigated at different temperatures (200,300,400,500) °C and heaters were used. After that, the distance from the center of the base was changed. used four tests at the same temperatures as above and a distance of 15 cm from the center of the base for each variable. Then a distance of 20 cm from the center of the foundation was used. The mechanical load is an iron foundation with dimensions of 15 cm in length, 5 cm in width, and 2 cm in thickness. Various vertical loads are placed on it. These loads come from the foundation pressure via a pipe connected to it by a jack. The load cell is used to read the results through the Data Logger. Figure 2 shows the first stage of the test and Figure 3 shows the second stage of the test.



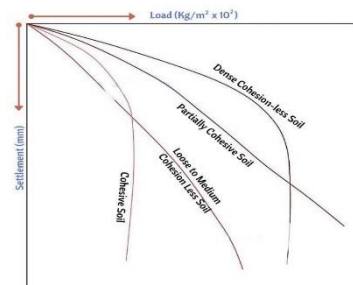
**Figure 2.** Dimension box test with installing heating system



**Figure 3.** Preparer clay soil with installing static load and heaters

## 4. Results and discussion

Depending on how one interprets Terzaghi's proposal (1943),[12]. The failure rate threshold is 10% of the baseline width in all model testing. The maximum amount of failure allowed in any of the model tests was 10% of the total width of the structure. Furthermore, load location was verified using standards from the American Society for Testing and Materials (ASTM), namely the 1195 and 1196 editions.[13]. Soil is also characterized by the degree of cohesion, which is measured by park [9]. That's what's on the plate, by the way.



**Figure 4.** The change in the degree of soil cohesion according to the shape of the curve obtained from the plate load test

### 4.1. Heating system

The heaters were placed at a distance of 20 cm from the center of the footing and in the longitudinal direction, that is, the distance

between the two heaters was 40 cm. In this case, the heaters in the models were run for different times for each model (4,8,12) hours, depending on the figure (4). Soil cohesion was rated for all tests. Figures (5), (6), and (7) are curves between stress and settlement for times (4, 8, and 12) hours, respectively.

4 models were tested at different temperatures (200,300,400,500) °C,

From Figure (5) and footing on what Terzaki said about the collapse when flattening 5 mm, the maximum stress of the model without the use of heating was very small and was about 42.5 kN / m<sup>2</sup>, after the application of heat there was a stress tolerance and the maximum stress tolerance is ( 44.5, 58, 68, 61) kN/m<sup>2</sup>. For the tests (200, 300, 400, 500) ° C, respectively, also, based on the curve of the model without temperature, the failure occurred with a maximum stress of 42.5 KN / m<sup>2</sup>, and when compared with the tests models whose temperature was (200, 300, 400, 500) °C. the settlement at this point is (4.2, 2.6, 1.2, 0.9) mm, respectively, and the percentage of improvement it (16%, 48%, 76%, and 82%, respectively).

For Figure (6), which resulted from an increase in the heating time to 8 hours, the maximum stress is (48.5, 56.3, 65.6, 70) kN / m<sup>2</sup>. (200, 300, 400, and 500 degrees Celsius, respectively, also, based on the curve of the model without temperature, the failure occurs with a maximum stress of 42.5 KN / m<sup>2</sup>, and when compared to the models whose temperature was (200, 300, 400, 500) degrees Celsius, the settlement at this point it (4.3, 2.4, 1, 0.9) mm, respectively, and the percentage of improvement in flattening it (14%, 52%, 80%, and .82%, respectively).

For Figure (7). Where is the maximum stress (79, 91, 102, 116) kN/m<sup>2</sup>. For the tests (200, 300, 400, 500) degrees Celsius, respectively.

Also, footing on the curve for the model without temperature, it can be noted that the failure occurred with a maximum stress of 42.5 kN/m<sup>2</sup>, and when compared to models whose temperature was (200, 300, 400, and 500) °C. the decrease at this point was (1.5, 0.6, 0.5, 0.5) mm, respectively, and the percentage of improvement in the settlement was (70%, 88%, 90%, and 90%, respectively). This means that settlement is reduced by increasing the heating time and increasing the temperature of the heaters. Temperatures from the source,

For Figure (8), the settlement values are taken at different temperatures at all times. It is noted that the settlement values decrease with increasing temperatures as well as with increasing heating time.

For Fig. (9), the maximum stress values increase with increasing temperatures and heating time. It is also noted from Figures (5) and (6) that the best value for settlement is 0.5 mm, and this value is when the heating time is 12 hours and the temperature is 500°C and 400°C. It is also noted that the best value for the maximum stress is 116 kN/m<sup>2</sup>, and this also occurs when the temperature is 500 °C with a heating time of 12 hours.

It is also noted from Figures (5), (6), and (7) that all curves contain crumbs, and these crumbs increase with increasing temperatures and heating time. The reason for this is that the models, after heating, lose the amount of water they contain due to the exit of water vapor, as the place of water is replaced by voids, and these voids have not been settled, and the examination is carried out immediately. after heating. Referring to figure (4), the soil did not change its condition and remained somewhat cohesive in all shapes.

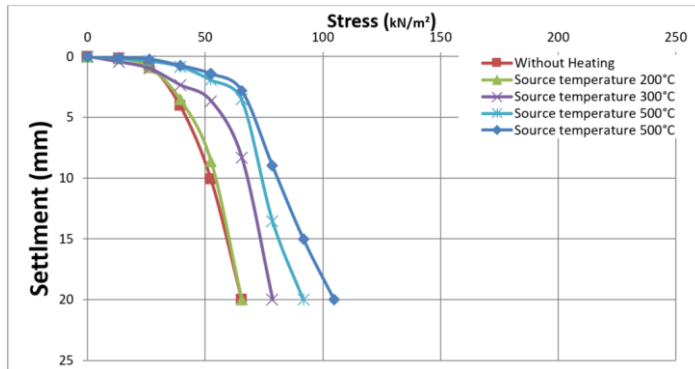


Figure 5. The relationship between stress and settlement when the heating time is 4 hours and the distance between the heater and the center of the base is 20 cm

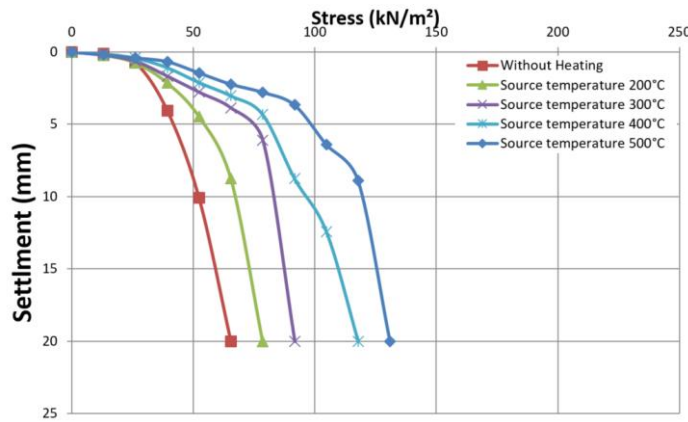


Figure 6. The relationship between stress and settlement when the heating time is 8 hours and the distance between the heater and the center of the base is 20 cm

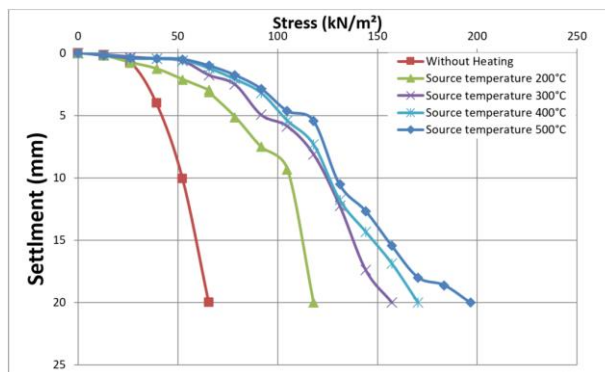
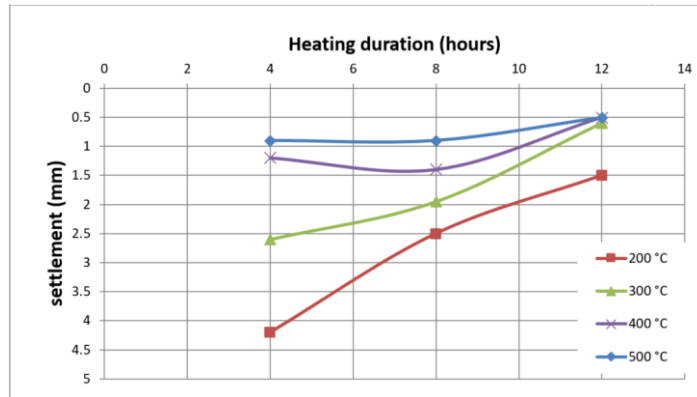
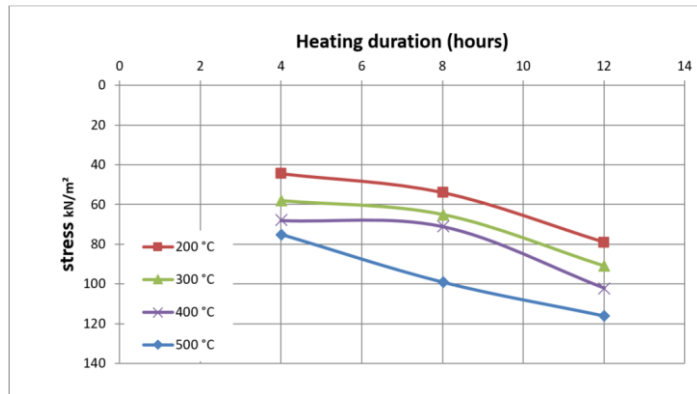


Figure 7. The relationship between stress and settlement when the heating time is 12 hours and the distance between the heater and the center of the base is 20 cm



**Figure 8.** The relationship between settlement and heating time for temperatures (200,300,400,500) degrees Celsius



**Figure 9.** The relationship between the maximum stress and the heating time for temperatures (200,300,400,500) degrees Celsius

#### 4.2. The Distance between the Heater and the Center of the Footing is 15 cm

The distance between the two heaters is approximately 15 cm from the center of the footing, and the rest of the variables are studied, including the duration of heating at different temperatures. And 12 models were tested, each of these models carries a constant heating time and constant temperature, and the time and temperature are changed for each model. As in the previous case

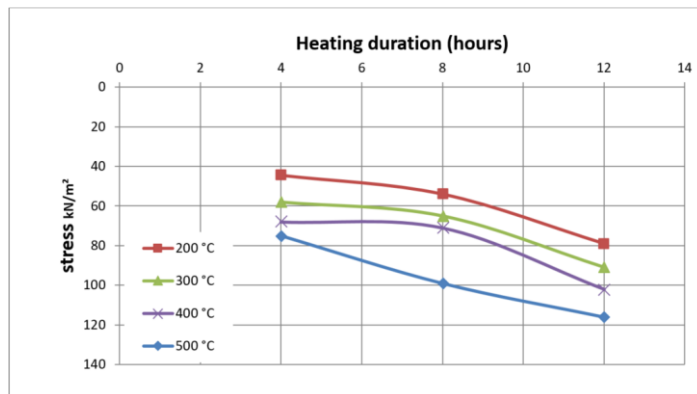
For Figure (10) and based on what Terzaki said about the failure when flattening 5 mm, the maximum stress of the model without using its heating is very small and was about 42.5 kN / m<sup>2</sup>, after applying heat the maximum stress (53, 49, 60, 71 ) kN/sqm. For the tests (200, 300, 400, 500) °C, respectively, also, footing on the curve of the model without temperature, the failure occurred with a maximum stress of 42.5 kN / m<sup>2</sup>, and when compared with models whose temperature was (200, 300, 400, 500) degrees Celsius. The settlement at this point was (2.7, 3.8, 2.9, 2.4) mm, respectively, and

the percentage of improvement was (46%, 24%, 42%, and 52%, respectively). Noting that the percentage of improvement in settlement increases with increasing temperatures from the source as shown in Figure (10). It is noted that the highest percentage of improvement in settlement is when the model is heated by 500 degrees Celsius and that the differences between the rest of the other temperatures are slight. It is noted that all the curves in Figure (10) classify the soil within the composition of cohesive clay and as classified (Figure 4).

For Figure (11) by increasing the heating time to 8 hours after applying heat, the maximum stress is (66, 89, 95, 111) kN/m<sup>2</sup>. For the tests (200, 300, 400, 500) degrees Celsius. , respectively, also, footing on the curve of the model without temperature, it can be noted that the failure occurred with a maximum stress of 42.5 kN/m<sup>2</sup>, and when compared with the models whose temperature was (200, 300, 400, 500) degrees c. It is noted that the settlement at

this point was (1.4, 1.2, 1.5, 1) mm, respectively, and the percentage of improvement was (72%, 76%, 70%, and 80%, respectively). It is noted that the soil in this case transformed after being heated from a cohesive substance to a less cohesive one.

For Figure (12), and by increasing the heating time to 12 hours after applying heat, the maximum stress is (80, 108, 117, 122) kN / m<sup>2</sup>. For the tests (200, 300, 400, 500) degrees Celsius. , respectively, also, based on the curve of the model without temperature, the failure occurred with a maximum stress of 42.5 kN/m<sup>2</sup>, and when compared to the models whose temperature was (200, 300, 400, 500) °C. The settlement at this point was (0.9, 0.8, 0.75, 0.75) mm, respectively, and the percentage of improvement was (82%, 84%, 85%, and 85%, respectively). As the soil moved from a state of cohesion to a less dense cohesion for all tests



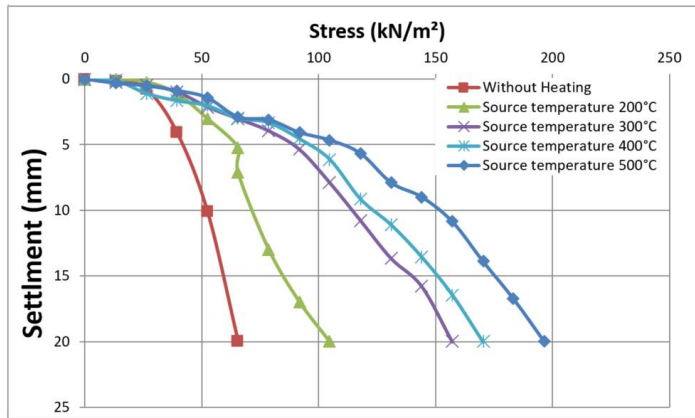
**Figure 10.** The relationship between stress and settlement when the heating time is 4 hours and the distance between the heater and the center of the base is 15 cm

All different times and settlement values and temperatures are taken. It is noted that the settlement value decreases with increasing temperature, as well as a significant increase in the maximum stress value with varying values. Referring to Figure (13), it is noted

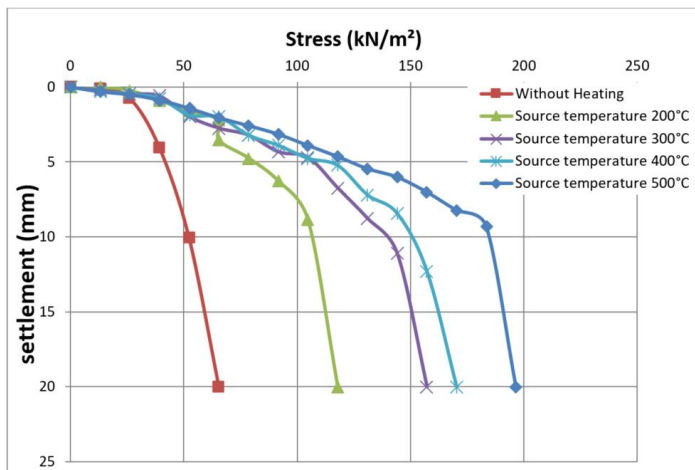
that the settlement values decrease with the increase in temperature as well as with the increase in the heating time; Also, concerning Fig. (14), the maximum stress values increase with increasing temperatures and increasing heating time. It is also noted

from Figures (13) and (14) that the minimum value for settlement is 0.75 mm, and this value is when the heating period is 12 hours and the temperature is 500 °C. It is also noted that the best value for the maximum stress is 112 kN/m<sup>2</sup>, and this also occurs when the temperature is 500°C with a heating time of 12 hours. It is also noted from Figures (11), (11), and (12) that all

curves contain crumbs, and these crumbs increase with increasing temperatures and heating time. The reason for this is that the models, after heating, lose the amount of water they contain due to the exit of water vapor, as they replace the place of water with voids, and these voids have not been settled, and the examination is carried out immediately after heating.



**Figure 11.** The relationship between stress and settlement when the heating time is 8 hours and the distance between the heater and the center of the base is 15 cm



**Figure 12.** The relationship between stress and settlement when the heating time is 12 hours and the distance between the heater and the center of the base is 15 cm

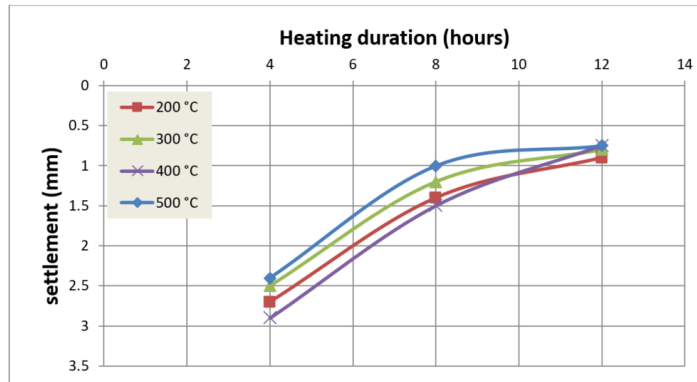


Figure 13. The relationship between the settlement and the heating time for temperatures (200,300,400,500) degrees Celsius

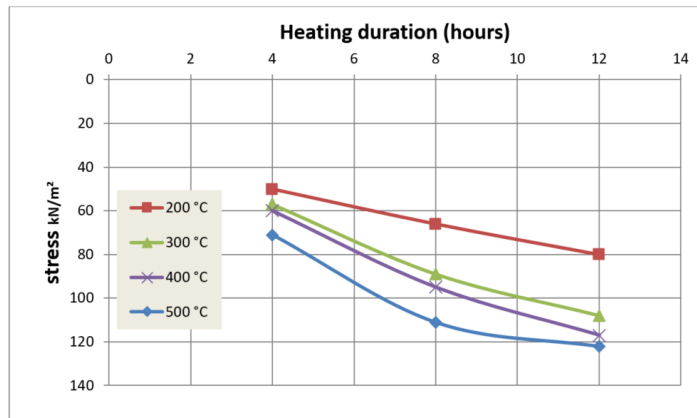


Figure 14. The relationship between the maximum stress and the heating time for temperatures (200,300,400,500) degrees Celsius

#### 4.3. The Distance between the Heater and the Center of the Footing is 10 cm

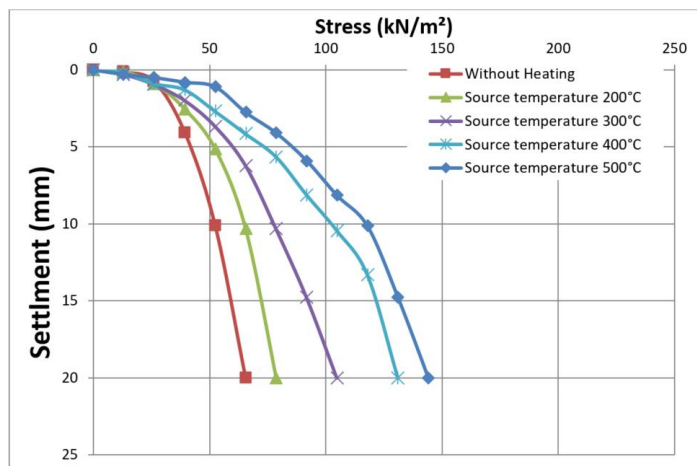
Figure (15) and footing on what Terzaki said about the collapse when flattening 5 mm, the maximum stress of the model without the use of heating was very small and was about 42.5 kN / m<sup>2</sup>, after applying heat there was a stress tolerance and the maximum stress tolerance reached (52, 60, 73, 96) kN/sqm. For the tests (200, 300, 400, 500) °C, respectively, also, based on the curve of the model without temperature, it can be noted that the failure occurred with a maximum

stress of 42.5 kN / m<sup>2</sup>, and when compared with the models whose temperature was (200, 300, 400, 500) °C. it can be noted that the settlement at this point was (2.9, 2.2, 1.5, 0.9) mm, respectively, and the percentage of improvement was (42%, 56%, 70%, and 82%, respectively). Noting that the percentage of improvement in subsidence increases with increasing temperatures from the source as shown in Figure (3.18). It is noted that the highest percentage of improvement in the settlement is when the model is heated by 500 °C and that the differences between the rest of the other

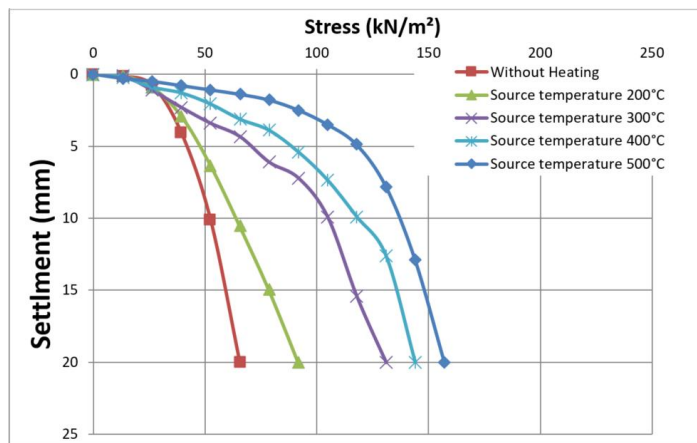


temperatures are slight. It is noted the curves the curve in Figure (4.18) classifies the soil within the composition of less cohesion clay For Figure (16) and by increasing the heating time to 8 hours after applying heat, the maximum pressure was (49.9, 60, 69.9, 119) kN/m<sup>2</sup>. For the tests (200, 300, 400, 500) °C, , respectively, also, based on the curve of the model without temperature, it can be noted that the failure occurred with a maximum stress of 42.5 kN/m<sup>2</sup>, and when compared

with the models whose temperature was (200, 300, 400, 500°C). It is noted that the decrease at this point was (3.7, 2.5, 1.5, 0.9) mm, respectively, and the percentage of improvement was (26%, 50%, 70%, and 82%, respectively). It is noted that when the soil is heated to temperate and res (500, 400,300) °C, it changes after being heated and moves from a cohesive substance to a less dense cohesion. As for a temperature of roof 200 °C, it turns into less cohesion.



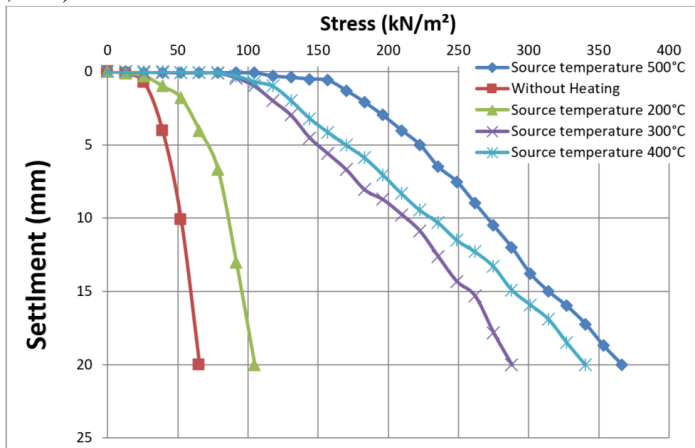
**Figure 15.** The relationship between stress and settlement when the heating time is 4 hours and the distance between the heater and the center of the base is 10 cm



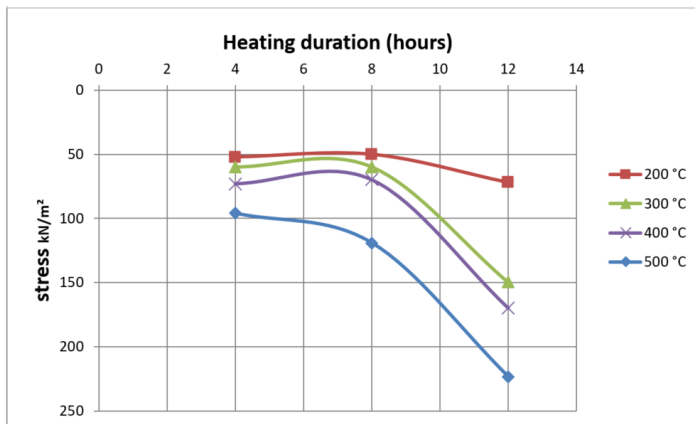
**Figure 16.** The relationship between stress and settlement when the heating time is 8 hours and the distance between the heater and the center of the base is 10 cm

For Figure (17) and by increasing the heating time to 12 hours after applying heat, the maximum stress was (72, 149.8, 170, 223) kN/m<sup>2</sup>. For the tests (200, 300, 400, 500) °C, respectively, also, based on the curve of the model without temperature, it can be noted that the failure occurred with a maximum stress of 42.5 kN/m<sup>2</sup>, and when compared with the models whose temperature was (200, 300, 400, 500) °C. It is noted that the

settlement at this point was (1.1, 0.03, 0.02, 0.01) mm, respectively, and the percentage of improvement was (78%, 99.4%, 99.4%, 99.4%, respectively). It was observed that the soil moved from a state of cohesion to a partially cohesive soil for temperatures (500,400,300) °C. While it remained coherent at a temperature of 200 °C.



**Figure 17.** The relationship between stress and settlement when the heating time is 12 hours and the distance between the heater and the center of the base is 10 cm



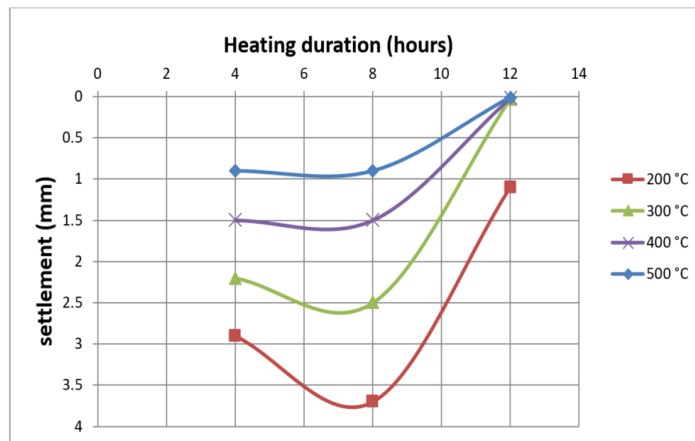
**Figure 18.** The relationship between the maximum stress and the heating time for temperatures (200,300,400,500) degrees Celsius

At all different times, values and temperatures are taken. It is noted that the settlement value decreases with increasing

temperature, in addition to a significant increase in the maximum stress value with varying values. Referring to Figure (18), it is

noted that the settlement values decrease with increasing temperature as well as with increasing heating concerning respect to Fig. (19), the maximum stress values increase with increasing temperatures and increasing heating time. It is also noted from Figures (18) and (19) that the lowest value of the

settlement is 0.01 mm, and this value is when the heating period is 12 hours and the temperature is 500 °C. It is also noted that the best value for the maximum stress is 223 kN/m<sup>2</sup>, and this also occurs when the temperature is 500°C with a heating time of 12 hours.



**Figure 19.** The relationship between the settlement and the heating time for temperatures (200,300,400,500) degrees Celsius

It is also noted that the best value for the maximum stress is 223 kN/m<sup>2</sup>, and this also occurs when the temperature is 500°C with a heating time of 12 hours. It is also noted from Figures, (15), (16) and (17) that all curves contain crumbs, and these crumbs increase with increasing temperatures and heating time. The reason for this is that the models, after heating, lose the amount of water they contain due to the exit of water vapor, as the place of water is replaced by voids, and these voids have not been settled, and the examination is carried out immediately after heating.

## 5. Results Observed During the Tests

Since the best settlement ratio occurred when the distance between the two heaters

and the footing center was equal to 10 cm and when the temperature was 500 °C, we are now attaching pictures showing the shape of the model upon examination multiple times t is noted that the cracks increase with the increase of the heating time and that the width of the largest crack was 2 cm. By measuring the depth, it was found that the largest depth is 3 cm, as the cracks were in the surface layer only. It is also noted that there is a white layer surrounding the heater, and the diameter of this layer increases with the increase in the heating time, which indicates This region has lost its water content and also indicates that the heat transfer is in a diagonal direction, that is, it surrounds the heater from all sides and evenly.

## 6. CONCLUSION

Preliminary results from examining the results of empirical models are summarized in this paragraph. The following proposal may be considered for subsequent endeavors.

1. The settlement value increases with the increase in the source temperature and increases with the decrease in the distance between the heaters. It increases with the increase in the heating time as well, as the best settlement is when the distance between the heater and the heater is 20 cm, the temperature of the heater is 500 degrees Celsius, and the heating time is 12 hours, where the settlement improvement rate is 99.8%.
2. The value of the maximum stress increases with increasing temperature and decreasing the distance between the heaters, where the best improvement ratio for the maximum stress reaches 425% when the temperature is 500 °C and the distance between the heater and the base center is 10 cm and the heating time is 12 hours
3. Cracks that occur in the soil due to heat are ineffective and are only on the surface

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## **MONITORING SIMPLE LINEAR PROFILES IN PRODUCING POLYMER CONCRETES**

***Abstract:** Statistical monitoring of one or more critical parameters of a process is an effective measure to identify and prevent assignable cause(s). Often it is appropriate and even necessary to monitor a function or profile related to various quality characteristics of the underlying process. In recent years, several studies have been presented on successful applications of profile monitoring. In this research, we investigate and analyze the polymer concrete process by means of simple linear profile monitoring. In this context, quality control tests for the production process of polymer concrete are carried out as an industrial case study. The functional relationship between fracture toughness and fracture energy as a response variable and the combination of the constituent factors of polymer concrete as an explanatory variable is monitored through profile approaches and the effectiveness of each method is evaluated. Fracture toughness experiments under mode I have been conducted on symmetric semi-circular bend (SCB) specimen.*

***Keywords:** Simple linear profile, Polymer concrete, Semi-circular bend specimen, Fracture behavior*

### **1. Introduction**

Currently, most of the methods used for quality monitoring are product testing and are not designed to control the design process. Therefore, the quality characteristics of the product can be defined as a relationship or profile and controlled accordingly. If this relationship or profile is under control over time, it can be concluded that the process is under statistical control and thus meets the defined quality specifications. If this relationship is not under control, it indicates the existence of one or more specific causes in the process that should be extracted and considered as potential causes of changes in the process in terms of quality characteristics of the profile through analysis.

The use of profiles in researches such as

Noorossana et al. [1], Woodall et al. [2], and Kang and Albin [3] has been accepted as comprehensive research in the field of profile monitoring. Since monitoring profiles is a relatively new area in statistical process control (SPC), Woodall's review article [4] examines the concepts and definitions related to this knowledge of process control and various methods used in monitoring profiles. In the 2018-2008 period, a conceptual classification based on categorization and evaluation of articles was also carried out in Maleki et al.'s review article [5]. For each category of articles, the approaches, methods, and algorithms used in profile monitoring were examined, and analysis and review of research results were provided. One of the most commonly used types of profiles is the simple linear profile, which is used to investigate the relationship

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between two variables with the assumption that they have a linear relationship. Some approaches have been developed for simple linear profiles in phases I and II, including Mahmood et al. [6], Aly et al. [7], Soleimani et al. [8], Saghaei et al. [9], Abbasi Ganji and Sadeghpour Gildeh [10], Khalafi et al. [11], Haq et al. [12], Abbasi et al. [13], Dirbaz et al. [14], and Yeganeh et al. [15].

Multiple scientific studies published in recent years have demonstrated the success of using profiles in various real-world and operational processes. One of the most important and fundamental studies is the investigation and control of aircraft stability in wind tunnels by Parker et al. [16]. Their monitoring method is based on multivariable profiles, which has been examined in various sources, including reference [17]. Mahmoud et al. [18] developed their research to detect shifts and time changes and investigated the change point technique based on Parker et al.'s work. Huwang et al. [19] presented an example of the application of their proposed method in the field of monitoring and detection in the semiconductor production industry. In this industry, the quality of a printed wafer is measured by electron microscopy during the DRIE process in laboratories. Zeng et al. [20] also studied the application of non-normal data in the production process of low-friction glass. Low-friction glasses are effective types of energy-efficient glasses produced by physical or chemical processes in which solid materials such as metal, metal oxide, or metal nitride sit on flat glass. Amiri et al. [21] showed an application of multivariate profiles in examining the quality of automobile engines in the automotive industry. Montgomery [22] showed that in the process of manufacturing car engines, there is a Quadratic polynomial relationship between the engine torque and its speed. To monitor the quality of pharmaceutical products, Dawod et al. [23] used a linear profile within the Bayesian approach

framework with two equally weighted moving average charts,  $HWMA_R$  and  $HWMA_{PT}$ . In their research, the main objective was to investigate the stability of pharmaceutical product quality and control variance. These mentioned cases are some examples of research carried out over the past two decades in the area of profile implementation in industry and its practical applications.

Therefore, considering industrial production and the approach to quality improvement, emphasis on quality control and improvement, as well as increasing efficiency, seems to be of great importance. In the next section, the research method and data validation will be examined. The third section discusses monitoring profiles using three different methods in phase I, and the fourth section examines monitoring profiles in phase II. Finally, the fifth section presents the results and future recommendations.

## 2. Research Methodology

Polymer concretes are actually a new generation of efficient and chemically resistant materials whose weight percentage is related to mineral fillers, aggregates, and polymeric carriers. Polymer concrete has properties such as high resistance to corrosion, lighter weight than traditional concrete, high resistance to impact and fracture, ability to be produced in various shapes, high resistance to fire, and high resistance to temperature changes.

In 2022, Aliha et al. [24] conducted an optimization of epoxy concrete mixtures using the Taguchi method. In this study, a Taguchi experimental design was presented for optimizing the ratio of different materials in the epoxy concrete mixture to achieve maximum energy and fracture toughness. Experiments were conducted on various mixtures of epoxy concrete with different ratios of different materials. The results showed that by optimizing the ratios of



different materials in the epoxy concrete mixture, it is possible to achieve the maximum energy and fracture toughness. In other words, using optimal ratios of different materials produces epoxy concrete surfaces with higher fracture resistance and greater fracture energy.

In this upcoming study, 15 polymer concrete profiles with specific dimensions and equal weight were evaluated for fracture toughness using the optimal ratios presented in the study by Aliha et al. [24]. Each profile is optimized in four optimal combinations. Given the chosen method of simple linear profile monitoring, all breaking load

experiments were conducted under identical conditions. The output of the experiment data under the 4 optimal combinations of epoxy resin (25-28%), fine aggregate (28-31%), and coarse aggregate (41-44%) are presented in Table 1.

The recorded data from the process was investigated in terms of the independence and normality of errors. The output, verified using EViews software, confirms acceptable levels for the following cases. The calculated value for the Durbin-Watson test statistic is 2.17, and the Jarque-Bera test statistic is 0.44, confirming the independence of errors.

**Table 1.** Design of experiments of average values mode I fracture toughness

Profile	Plan	Epoxy resin (%)	Fine aggregate (%)	Coarse aggregate (%)	The ratio of epoxy resin to fine and coarse aggregate	Results
1	1	25	31	44	0.33	5
	2	26	30	44	0.35	5.2
	3	27	29	44	0.37	4.7
	4	28	30	42	0.39	4.4
2	1	25	31	44	0.33	4.4
	2	26	30	44	0.35	4.9
	3	27	29	44	0.37	4.5
	4	28	30	42	0.39	4.8
3	1	25	31	44	0.33	4.9
	2	26	30	44	0.35	4.6
	3	27	29	44	0.37	4.8
	4	28	30	42	0.39	4.8
4	1	25	31	44	0.33	4.4
	2	26	30	44	0.35	4.5
	3	27	29	44	0.37	4.8
	4	28	30	42	0.39	5
5	1	25	31	44	0.33	5.3
	2	26	30	44	0.35	4.9
	3	27	29	44	0.37	4.5
	4	28	30	42	0.39	5.2
6	1	25	31	44	0.33	4.9
	2	26	30	44	0.35	4.9
	3	27	29	44	0.37	4.6
	4	28	30	42	0.39	5
7	1	25	31	44	0.33	4.6
	2	26	30	44	0.35	4.4
	3	27	29	44	0.37	4.4
	4	28	30	42	0.39	4.3

8	1	25	31	44	0.33	4.7
	2	26	30	44	0.35	5.1
	3	27	29	44	0.37	4.8
	4	28	30	42	0.39	4.9
9	1	25	31	44	0.33	4.5
	2	26	30	44	0.35	5.2
	3	27	29	44	0.37	4.5
	4	28	30	42	0.39	4.5
10	1	25	31	44	0.33	4.5
	2	26	30	44	0.35	4.4
	3	27	29	44	0.37	5.2
	4	28	30	42	0.39	4.6
11	1	25	31	44	0.33	4.4
	2	26	30	44	0.35	4.5
	3	27	29	44	0.37	5.2
	4	28	30	42	0.39	5
12	1	25	31	44	0.33	4.4
	2	26	30	44	0.35	4.5
	3	27	29	44	0.37	4.4
	4	28	30	42	0.39	4.8
13	1	25	31	44	0.33	4.4
	2	26	30	44	0.35	4.5
	3	27	29	44	0.37	5.2
	4	28	30	42	0.39	4.8
14	1	25	31	44	0.33	4.9
	2	26	30	44	0.35	5.3
	3	27	29	44	0.37	4.8
	4	28	30	42	0.39	4.4
15	1	25	31	44	0.33	5.1
	2	26	30	44	0.35	4.9
	3	27	29	44	0.37	4.7
	4	28	30	42	0.39	4.3

### 3. Linear profile monitoring in phase I

#### 3.1. Hotelling's T<sup>2</sup> control chart by Mestek et al. in phase I

Therefore, Mestek et al. [25] used this method for monitoring the stability of Fe<sup>3+</sup> photometric determination with sulfosalicylic acid for the first time in 1994. This method is used when the independent variable X is under control and its value is constant for different samples. The T<sup>2</sup> statistic of Mestek et al. [25] based on the random variable vector Y is as follows:

$$T_j^2 = (Y_j - \bar{Y})^T S^{-1} (Y_j - \bar{Y}), \quad j = 1, 2, \dots, m.$$

The T<sup>2</sup> statistic follows a beta distribution, therefore the upper control limit in this method is calculated as follows:

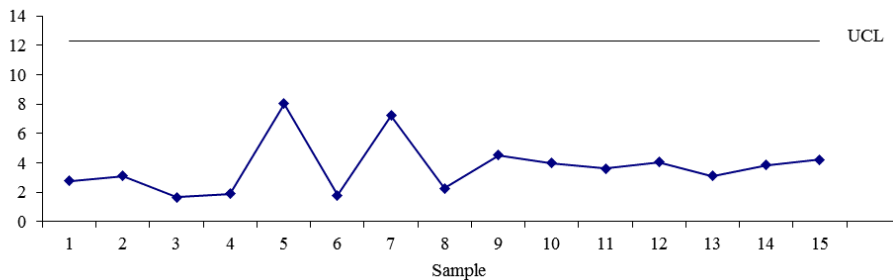
$$UCL = \frac{(m-1)^2}{m} B_{n/2, (m-n-1)/2, \alpha_1}$$

In such a way that  $B_{n/2, (m-n-1)/2, \alpha_1}$  represents the beta distribution with shape parameters  $n/2$  and  $(m-n-1)/2$ .  $\alpha_1$  is the false-alarm probability which is obtained based on the overall false-alarm probability. Therefore, T<sup>2</sup> statistic for the data in Table 1 is shown in Table 2 and the control chart is obtained as Figure 1.

According to Figure 1, it is evident that all values are within control limits. Therefore, the estimated model can be used for monitoring in phase II.

**Table 2.** The values of the  $T^2$  statistic of Mestek et al. [25]

Profile	$T^2$ statistic
1	2.76
2	3.10
3	1.66
4	1.89
5	8.02
6	1.79
7	7.22
8	2.26
9	4.51
10	3.99
11	3.61
12	4.04
13	3.10
14	3.84
15	4.22



**Figure 1.** Performance of the  $T^2$  statistic of Mestek et al. [25]

### 3.2. Hotelling's $T^2$ control chart by Stover and Brill in phase I

The monitoring of profiles in the Hotelling's  $T^2$  Stover and Brill [26] control chart is based on using estimated values for the intercept and slope of the profile. This means that, by placing the Hotelling's  $T^2$  statistic as a reference, a vector of intercept and slope parameters is used to form the final statistic. In other words, instead of using a response vector as in Mestek et al.'s method [25], a

vector containing the intercept and slope values is used. The  $T^2$  statistic in the Stover and Brill [26] method and the upper control limit are given by equations 3 and 4.

$$T_j^2 = (z_j - \bar{z})^T S^{-1} (z_j - \bar{z}), \quad j = 1, 2, \dots, m.$$

$$UCL = \frac{(m-1)^2}{m} B_{1, (m-3)/2, \alpha_1}$$

In a way that  $B_{1, (m-3)/2, \alpha_1}$  represents the percentile of the beta distribution with shape parameters 1 and  $(m-3)/2$ . In this case, after

calculating the distance from the intercept and slope for each of the sample profiles and presenting it in Table 3, the  $T^2$  statistic was calculated using Stover and Brill's method

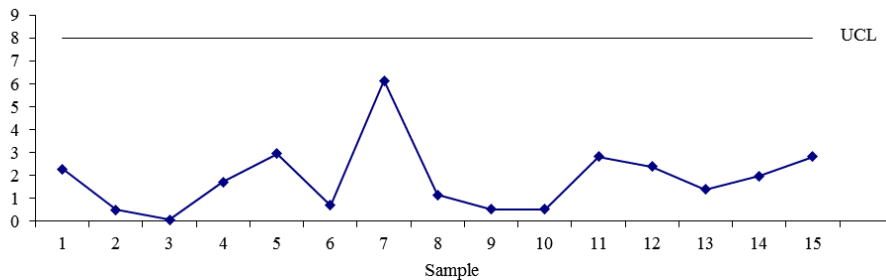
[26], which is shown in Table 4 and Figure 2. In this case, similar to the control chart by Mestek et al. [25], all profile values are within control limits.

**Table 3.** The values of the intercept and slope of the sample profiles

Profile	$a_j$	$b_j$
1	9.33	-12.49
2	3.10	4.29
3	4.95	-0.50
4	0.58	11.35
5	6.28	-3.62
6	4.83	0.06
7	6.17	-4.84
8	4.31	1.58
9	6.08	-3.88
10	2.56	5.86
11	-0.08	13.45
12	2.37	5.98
13	1.05	10.18
14	8.79	-10.92
15	9.83	-14.07

**Table 4.** The values of the  $T^2$  statistic of Stover and Brill [26]

Profile	$T^2$ statistic
1	2.28
2	0.50
3	0.08
4	1.72
5	2.95
6	0.71
7	6.14
8	1.16
9	0.52
10	0.53
11	2.82
12	2.38
13	1.40
14	1.97
15	2.83



**Figure 2.** Performance of the T<sup>2</sup> statistic of Stover and Brill [26]

Kang and Albin [3] also introduced a statistic based on the Hotelling's T<sup>2</sup> statistic for monitoring profiles in phase I. The T<sup>2</sup> control chart of Kang and Albin [3], similar to the T<sup>2</sup> control chart of Stover and Brill [26], is based on sequential vectors obtained from least squares estimates, for the intercept and slope of the variable response function Y. The methods of Kang and Albin [3] and Stover and Brill [26] are similar to each other, but the difference in their calculation of the variance-covariance matrix leads to a difference in the marginal distribution of their statistics. Therefore, the Kang and Albin [3] chart will be briefly discussed in the next section, and the T<sup>2</sup> method based on sequential differences will be examined.

### 3.3. Hotelling's T<sup>2</sup> control chart based on the successive differences estimator in phase I

One of the methods used to estimate the variance-covariance matrix in calculating the T<sup>2</sup> statistic is using successive differences. This method was introduced by Williams et al. [27] in 2006, which resulted in a new statistic called the successive T<sup>2</sup> control chart due to the difference in estimating the variance-covariance matrix. The T<sup>2</sup> statistic is calculated in this method as follows:

$$T_j^2 = (Y_j - \bar{Y})^T S_D^{-1} (Y_j - \bar{Y}), \quad j = 1, 2, \dots, m.$$

If in phase I, the observations consist of a sequence of independent random variables

with the identical distribution, then S<sub>D</sub> is an unbiased estimator for Σ, obtained as follows:

$$S_D = \frac{V^T V}{2(m-1)}$$

Since in this method, V<sub>j=z<sub>j+1</sub>-z<sub>j</sub></sub> is obtained for each sample, there is no independence between samples. Therefore, precise control limits cannot be used based on the beta distribution [27]. To calculate the upper limit of the control chart, the following formulas have been proposed by Noorossana et al. [1] for the overall false alarm probability of 0.01, 0.05, and 0.1, respectively. These formulas were derived using 7-9 equations after performing the simulation process for different sample sizes and overall false alarms.

$$UCL_{\alpha=0.01} = 7.38 + 2.33 \log_e m$$

$$UCL_{\alpha=0.05} = 5.51 + 2.01 \log_e m$$

$$UCL_{\alpha=0.1} = 4.39 + 1.93 \log_e m$$

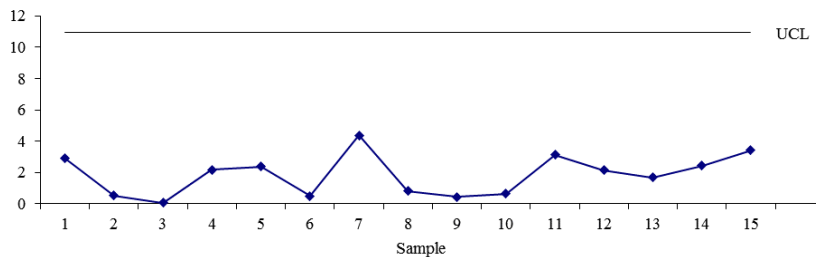
Using the calculated values of intercept and slope in Table 3, the matrix of successive differences can be formed as follows:

$$V_j = \begin{pmatrix} -6.23 & 16.78 \\ 1.85 & -4.79 \\ -4.38 & 11.85 \\ 5.70 & -14.97 \\ -1.45 & 3.68 \\ 1.34 & -4.90 \\ -1.87 & 6.42 \\ 1.77 & -5.46 \\ -3.52 & 9.75 \\ -2.64 & 7.59 \\ 2.45 & -7.47 \\ -1.32 & 4.20 \\ 7.74 & -21.10 \\ 1.04 & -3.15 \\ -5.15 & 14.23 \end{pmatrix}$$

The values of the calculated statistical parameters, along with control chart, are listed in Table 5 and Figure 3 in order.

**Table 5.** The values of the  $T^2$  control chart based on the successive differences estimator

Profile	$T^2$ statistic
1	2.89
2	0.53
3	0.07
4	2.18
5	2.37
6	0.51
7	4.36
8	0.82
9	0.45
10	0.65
11	3.12
12	2.14
13	1.69
14	2.44
15	3.42



**Figure 3.** Performance of the  $T^2$  control chart based on the successive differences estimator

### 4. Monitoring simple linear profile in phase II

The process of monitoring and control is practically carried out in the first and second phases. Generally, the main objective in the phase I is to identify out-of-control data among the in-control process data, estimate the process parameters based on the in-control data, and create phase I control limits accordingly. In the phase II, the main goal is to quickly identify changes in the parameters from in-control state [1]. In this study, after performing statistical control of the polymer concrete manufacturing process in phase I, the focus is on monitoring and statistical analysis under controlled conditions in phase II. Following the estimation of regression parameters and statistical control of the process in phase I, other methods are used for process control in phase II in order to provide alerts for any changes with a reason

in the process that cause it to go out-of-control as soon as possible. The use of the  $T^2$  control chart for phase II control of simple linear profiles was first introduced by Kang and Albin [3]. When a process is under statistical control, the  $T^2$  statistic follows a chi-square distribution with two degrees of freedom in equation 10.

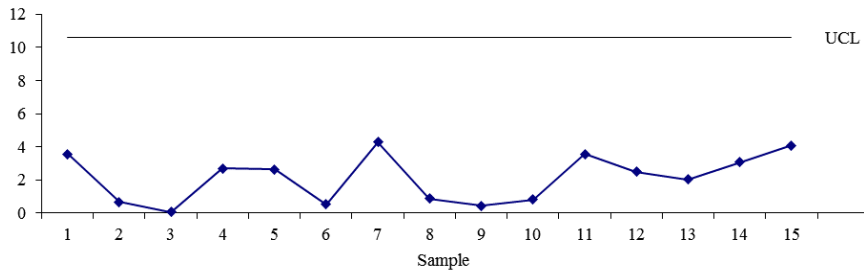
$$T_j^2 = (z_j - \mu)^T \Sigma^{-1} (z_j - \mu), \quad j = 1, 2, \dots, m.$$
 The upper control limit is obtained according to the equation 11.

$$UCL = \chi_{2, \alpha}^2$$

In phase I, necessary investigations were conducted to ensure the process control of polymer concrete manufacturing based on the data shown in Table 1. Hence, the process control can be ensured for phase II by using the  $T^2$  chart for analysis. The results of the calculations are presented in Table 6 and Figure 4.

**Table 6.** The values of the  $T^2$  control chart in phase II

Profile	$z$		$(z_j - \mu)$		$T^2$
	$a_j$	$b_j$	Part 1	Part 2	
1	9.33	-12.49	4.65	-12.65	3.57
2	3.10	4.29	-1.58	4.13	0.67
3	4.95	-0.50	0.27	-0.66	0.06
4	0.58	11.35	-4.10	11.19	2.69
5	6.28	-3.62	1.60	-3.78	2.63
6	4.83	0.06	0.15	-0.10	0.54
7	6.17	-4.84	1.49	-5.00	4.28
8	4.31	1.58	-0.37	1.42	0.87
9	6.08	-3.88	1.40	-4.04	0.43
10	2.56	5.86	-2.12	5.70	0.82
11	-0.08	13.45	-4.76	13.29	3.56
12	2.37	5.98	-2.31	5.82	2.48
13	1.05	10.18	-3.63	10.02	2.02
14	8.79	-10.92	4.11	-11.08	3.07
15	9.83	-14.07	5.15	-14.23	4.09



**Figure 4.** Title Performance of the  $T^2$  control chart in phase II

The Figure 4 shows profiles that are under control. In all examined cases in this section, the profiles were in-control. It is advisable to use a Shewhart control chart to monitor the variance of the process when using  $T^2$  control charts for phase I monitoring. Therefore, it can be ensured with confidence that the estimated predictors are accurate for controlling the regression parameters.

## 5. Conclusion

If it is determined in a specific process that there is a functional relationship between technical characteristics, then controlling this category of processes using traditional statistical process control methods does not have the necessary effectiveness. Therefore, monitoring profiles and selecting a suitable model can be a very important and fundamental approach in increasing the accuracy of process monitoring. For each model, monitoring methods should be designed that effectively identify the presence of changes and are also suitable for interpreting out-of-control alarms.

In this article, statistical process control of the production process of polymer concrete components was addressed using simple linear profile monitoring methods. One of the most important quality characteristics in the process, namely the functional relationship between the amount of load at which the produced component breaks as the response variable and the optimal changes in

the combination of polymer concrete ingredients as the explanatory variable, was controlled using a simple linear regression model. The aim of this article was to investigate all stages of phase one and two of profile monitoring. First, the normality and independence of errors were examined, and after ensuring confidence in them, linear profile monitoring in phase one was carried out using several well-known methods including  $T^2$  Mestek et al. [25], Stover and Brill [26], and  $T^2$  chart based on successive differences. After ensuring stability and estimating the process parameters, the monitored chart conditions were examined.

The outputs of the results indicate that the performance of these methods differs slightly, although the results of the charts confirm their accuracy and validity. The evidence shows that the Stover and Brill [26] method is more sensitive for this issue, while the Mestek et al. [25] method and successive differences have less sensitivity in their outputs. Additionally, the control chart in phase II showed that it could indicate changes in the process to an acceptable degree. It is recommended that for future research, other simple linear profile monitoring methods in phases I and II, such as the F-test method in phase I and control chart methods like MCUSUM, MEWMA, and others for simultaneous monitoring of simple linear profile parameters in phase II can be used and the resulting data analyzed. Furthermore, by adding other explanatory and response variables to this issue or similar



cases, multiple linear profiles or multivariate linear profiles can be monitored and analyzed.

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## **MODEL BASED SIX SIGMA CONCEPT AND PROCESS CAPABILITY INDICES: THE RESEARCH STUDY OF OIL INDUSTRIAL CASE IN YEMEN**

***Abstract:** Process capability indices are utilized extensively in the quality control inspection process, both at the level of production and for general business operations. They take into consideration both the location and the deviation from the specified limits and targets. Several literatures have contained contributions on this issue. Existing PCIs based on Six Sigma, on the other hand, merely displayed a range of quality levels rather than a single quality level value. Thus, previous studies have found the insufficient and ineffective deployment of Six Sigma to process control and yield process. Motivated by industrial Aden oil refinery process performance case study, we discuss the density characteristic of oil to estimate the process yield, and the capacity of the process. In addition, an effort to identify the level of quality in which the refinery operates. By investigating two different methods for estimating process yield, the sigma level, which are by extends the indices to estimate capacity, level of sigma, and yield process. The analyses and findings indicated that the indices outperformed the existing indices. Ultimately, Six Sigma-based process yield index represents a potential approach that other industries and practitioners can utilize to assess process performance and quality control.*

***Keywords:** Quality level and process capability; industrial process performance; performance precision; quality control; density characteristic, tolerance limit*

### **1. Introduction**

In today's competitive enterprises are expected to provide high-quality and cost-effective products that continuously fulfill the engineering design specifications and consumer desires (Felipe et al, 2017; Krolczyk et al., 2015). So, companies must focus on quality and process capabilities to gain a competitive edge in a world of informed customers (Leiva, et.al, 2014; Lupo, 2015; Krolczyk et al., 2015). Manufacturers have always tried to identify

variation sources to reduce it (Goodwin, 2015). Process capability means a process can consistently fulfill customer expectations and design criteria (Felipe et al, 2017). It is a scientific and methodical method that employs control charts and capacity indicators to identify and eliminate artificial causes of variation until statistical control is achieved. where the variation hinders process capability and output, according to Kotz et al, (1998); Shahriari et al, (2009) "Since process variation can never be entirely eliminated, the management of such

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variation is the key to product quality, “Process capability indices PCIs are sophisticated statistical tools used by industry to evaluate manufacturing process performance and analyze variability compared to specification limitations (Chakraborty & Chatterjee, 2016).. They utilize the mean and variation of a product attribute to assess manufacturing tolerance. PCIs are easy and useful tools for engineers to communicate and provide numerical measurements of whether a manufacturing process can produce consistent products within set specification boundaries (Pan, et al 2016; Srinivasan, et al, 2016; Pearn, et al 2014; Pham, 2015).

(PCIs are intended for industry to quantify how successfully a production process can reproduce items within factory specification limits (Pearn, et al, 2011). PCIs are sophisticated statistical tools used by industry to evaluate manufacturing process performance and analyze variability compared to specification limitations (Chakraborty & Chatterjee, 2016). They are utilizing the mean and variation of a product attribute to assess manufacturing tolerance. They are utilizing the mean and variation of a product attribute to assess manufacturing tolerance. PCIs are convenient and effective tools for engineers to communicate and provide numerical measures of whether a manufacturing process can produce consistent products within predetermined specification limits (Pan,et al 2016; Srinivasan, et al, 2016; Allam, et al, 2014; Parchami, et al, 2014; Pearn, et al 2014). PCIs are intended for industry to quantify how successfully a production process can reproduce things within factory specifications (Pearn, et al, 2011).

Several PCIs, including as together with other essential statistical tools for quality assurance, are utilized in order to evaluate the performance of the production process for cases containing a single quality characteristic feature (Chakraborty et. al 2016; Coetzer et al, 2016; Dianda, et al 2017; Felipe, et al 2017; Lupo, 2015; Pearn, et al 2011). PCIs are a type of statistical measurement that is used in industrial enterprises to assess the performance of processes for scenarios that include a particular product attribute (Goodwin, 2015).

Quantitative quality control relies heavily on the assessment of the process capability, and process capability indices (PCIs) are statistical measurements of the process capability (Chakraborty et. al 2016; Coetzer et al, 2016; Dianda, et al 2017; Felipe, et al 2017; Lupo, 2015; Pearn, et al 2011). In the most recent decades, a great number of PCIs have been presented, and they have found widespread use in a variety of sectors. Many studies have used process capacity indices to determine process quality levels in line with the Six Sigma concept. Existing PCIs based on Six Sigma, on the other hand, merely displayed a range of quality levels rather than a single quality level value. As a result, past studies have found insufficient and ineffective deployment of Six Sigma to process control and yield process.

## 2. Process Actual Yield Indices Based on Six Sigma - $6\sigma$

According to Kane who presented the  $C_{pk}$  process capability index, which is defined as following

$$C_{pk} = Cp \left( 1 - \frac{|T - \mu|}{U - L/2} \right) = \frac{U - L}{6\sigma} \left( 1 - \frac{|T - \mu|}{U - L/2} \right) \quad (1)$$

where,  $L$  and  $U$  are the tolerance limits  $\sigma$  is standard deviation  $\mu$  is the mean  $T = (U + L)/2$  is the target  $|\mu - T| = \delta\sigma (0 < \delta \leq 1.5)$  variation coefficient and that the  $\delta$  is equal to a constant value which is 1.5, Hence, based on Six Sigma concept, assuming the attendance of the idea of six Sigma, this means that the symbols are interpreted as follows  $T = (U + L)/2, U - L = 2L\sigma, |\mu - T| = \delta\sigma (0 < \delta \leq 1.5), \sigma = \frac{(U - L)/2}{6}$ , thus  $C_{pk}$  can be extended to  $SSC_{pk}$ , and the  $SSC_{pk}$  index can be computed as follows:

$$SSC_{pk} = \frac{2L\sigma}{6\sigma} \left(1 - \frac{2\delta\sigma}{2L\sigma}\right) = \frac{L - \delta}{3}$$

After that, many analyses of the yield process. According to Boyles, (1994); Chen et al., (2003); Perakis & Xekalaki, (2003); Vännman & Albing, (2007); Wang (2013) the  $C_p, C_{pk}$  have the relationship with rate :  $\%Y \geq 2\phi(3C_i) - 1$  Where  $C \in (C_p, C_{pk})$  Furthermore  $C_p, C_{pk}$  the Possess, have a rate relationship that is one-to-one, which represents the true values that are generated by the process.  $Y \geq 2\Phi(3C_i) - 1$  Where  $C_s \in (C_p, C_{pk})$  Process yield  $Y$  is the most prevalent quality standard in manufacturing. The index determines yield. This allows these indices to accurately reflect yield characteristics and serve as an external product quality reference and quality control employees. Chen et al., (2016) Process yield  $Y$  equals the proportion of product units that meet standards as the equation (3)

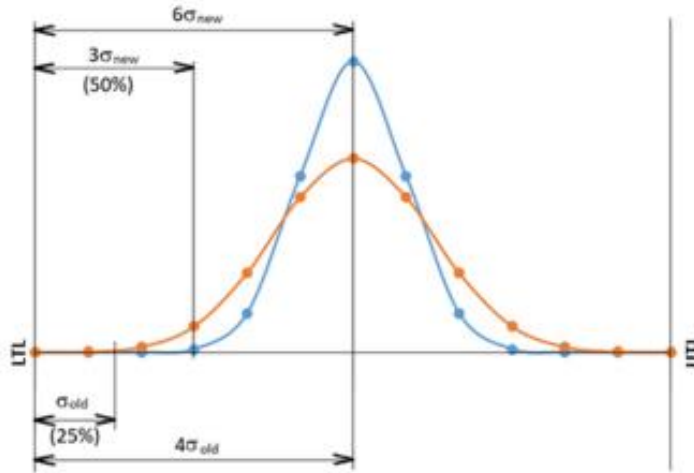
$$Y = \int_{LSL}^{USL} 1 dF(x)$$

Where a cumulative distribution function  $F(x)$ . Process yield states that each product within control boundaries is certified and has the same quality criteria. Loss happens when a product doesn't fulfill quality criteria.

Equations (2) and (3) demonstrate the link between process yield and Cpk index for different, where process yield is substituted by PPM non-conformities. Process yield cannot be predicted using Cpk. 1986 saw Motorola's Six Sigma Strategy. The term "six sigma process" stems from the idea that the upper and lower specification limits are two times six standard deviations apart,  $(USL - LSL) = 12\sigma$ .

In 1986, Motorola launched a quality improvement effort under the direction of engineer Bill Smith [14–16] to address product quality issues. Smith advocated that products be built more precisely to specification and set the following goal: To achieve higher accuracy, the tolerance interval limits ( $L$  and  $U$ ) should be  $\pm 6\sigma$  new from the centered procedure mean. The former accuracy (equivalent to a minimal capacity  $C_{pk} = 1.33$  assuming tolerance limitations were only  $\pm 4\sigma$  old off the process average. The statistical quality control 3 sigma rule states that no problems occur outside the interval  $\pm 3\sigma$  of the average. The ratio of the domain outside the tolerance range without defects (beyond  $\pm 3\sigma$  compared with mean) then the tolerance interval will increase 25% (result from the ratio  $\sigma_{old} / 4\sigma_{old}$  to 50% (result from  $\pm 3\sigma_{mww} / 6\sigma_{mww}$  (Boroiu et al., 2023). Hence, the safety zone is doubled.

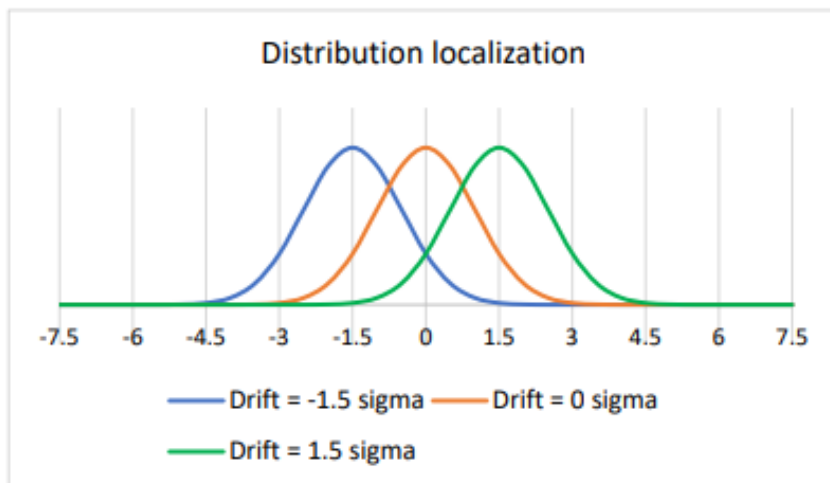
Figure 1 shows key components of process precision: The picture shows two value distributions—the initial one (precision  $4\sigma_{old}$ ) and the new one (precision  $6\sigma_{NEW}$ ) because quality is improved by increasing process precision, not tolerance interval.



**Figure 1.** Process precision improvement:  $6\sigma$  versus  $4\sigma$

Even Michael Harry, who implemented Bill Smith's proposal and is connected with the newly concept and other authors who portray the notion's beginnings (Raval & Muralidharan, 2016) don't emphasize this. Montgomery (2009) agrees that improving accuracy improves quality. "Variability: The root of defects," Bass (2007) says. Nevertheless, This is the optimum situation, which may be true immediately after modifying the process,

short-term performance, where the fraction of non-conformities is  $2 \cdot F(6) = 2, 0.0001 = 0.0002$  PPM, where  $F(x)$  integral Laplace function. (Boroju et al., 2023). But, with time, the process will wander from its original location. Based on this hypothesis, Bill Smith advocated using the  $1.5 \sigma$  process drift depicted in Figure 2. This process drift value was chosen without much scientific justification, supposing that a specific cause caused it.



**Figure 2.** 1.5 Shift process distribution



In this case, the level sigma process is six if specification limits interval is twice  $U - L = 2L\sigma$  and  $T - \mu = \delta = 1.5$ , then the  $C_{pk} = 1.5$ . also according to Six Sigma,  $C_{pk} = 2$  if sigma=6 and  $T - \mu = \delta = 0$ . This analysis assumes that  $\delta = 1.5$  has a stable value of 1.5 (constant value) and the level sigma = 6. Additionally, process centering  $\mu$  can estimate:  $T + 1.5\sigma \geq \hat{\mu} \geq T - 1.5\sigma$  thus, the level of the Sigma can be calculated according to the following equation

$$L_c = \hat{L}\sigma = \min\left[\frac{1-\delta}{\lambda} + 1.5, \frac{1+\delta}{\lambda} + 1.5\right]$$

Where,

$$\hat{\lambda} = \frac{((U-L)/2)/6}{(U-L)/2} = \frac{\sigma}{d}, \hat{\delta} = \frac{|\mu-T|}{d} = \frac{1.5\sigma}{d}$$

According to Equations (3) and (4) Assuming Motorola and Six Sigma, process yield can be calculated:

$$SSY = \int_{L^*}^{U^*} N(\hat{\mu}, \hat{\sigma}) dx = \Phi(1.5 + L_c) - \Phi(1.5 - L_c)$$

Where

$$U^* = U + 1.5\sigma = \hat{\mu} + 4.5 \hat{\sigma}_{ss} / \sqrt{n},$$

$$L^* = (L - 1.5\sigma) = (\hat{\mu} - 4.5 \hat{\sigma}_s) / \sqrt{n},$$

$\Phi(\cdot)$  is the cumulative distribution of the standard normal random variable,

$$T - 1.5\sigma \leq \hat{\mu} \leq T + 1.5\sigma. \quad \hat{\sigma}_{Si} = \frac{Si}{C_4(V)}$$

and  $\hat{\sigma} = \frac{(U-L)/2}{6}$  also There are different ways to estimate standard deviation  $\hat{\sigma}$  but the best way can be defined as a mathematical expression:  $\hat{\sigma}_{Si}$  is used for

S.D estimation. Here  $V = \sum_{i=1}^q n - q + 1$ , and

$$Si = \sqrt{\frac{1}{n-1} (X_{ij} - \bar{x}_i)^2}$$
 are unbiased.

According to equations 2 and 3, the yield process is:

$$2\Phi(3SS\hat{C}_{pk}) - 1 \leq SS\hat{Y} \leq \Phi(3SS\hat{C}_{pk})$$

When  $SS\hat{C}_{pk}$ ,  $L\sigma$  and  $SSY$  are have one to one relationship. In light of value  $SS\hat{C}_{pk}$  index, there is a guideline to interpreting the results of this index and the yield process. For example, if  $SS\hat{C}_{pk} = 0.5$  the process is capable and guarantees that the level sigma equals there sigma and when  $SS\hat{C}_{pk} = 1.5$ , the process is super and guarantees that the yield process will be not less than 0.999996602268 equivalently not more than 3.5 defect per million opportunities DPMO.. Six Sigma estimates process yield in two ways:

$$\left. \begin{aligned} \text{way (A) } SS\hat{Y} &= \Phi(1.5 + L\hat{\sigma}) - \Phi(1.5 - L\hat{\sigma}), \\ \text{way (B) } SS\hat{Y} &= 2\Phi(3SS\hat{C}_{pk}) - 1 \leq SS\hat{Y} \leq \Phi(3SS\hat{C}_{pk}). \end{aligned} \right\}$$

Boyles (1994) proposed the yield index  $S_{pk}$ . The index  $S_{pk}$  establishes a relationship between process performance and tolerance limits to accurately evaluate yield process, and it is defined as follows:

$$S_{pk} = \frac{1}{3} \Phi^{-1} \left[ \frac{1}{2} \Phi\left(\frac{U-\mu}{\sigma}\right) + \frac{1}{2} \Phi\left(\frac{\mu-L}{\sigma}\right) \right]$$

where  $\Phi(\cdot)$  is the cumulative distribution. The relationship between yield (Y) and index  $S_{pk}$  is:

$$Y = 2\Phi(3S_{pk}) - 1$$

By use Equations (7), (8), and (9) can be expanded  $S_{pk}$  to  $SSS_{pk}$  as follows:

$$SSS_{pk} = \frac{1}{3} \Phi^{-1} \left[ \frac{1}{2} (\Phi(3SS\hat{Y})) + 1 \right]$$

The  $SSS_{pk}$  is a useful tool for estimating the yield process at the 6 sigma level. It has a one-to-one correspondence with the yield process, in a similar way to the index  $S_{pk}$ , the following relationship describes how the two are related:

$$SS\hat{Y} = 2\Phi(3SSS_{pk}) - 1$$

In this study's the index  $SSS_{pk}$  is connected to process yield by six sigma since Equations (7), (10) and (11) may be rearranged as follows:

$$\begin{aligned} \text{way (A) } SSS_{pk} &= \frac{1}{3} \Phi^{-1} \left( \frac{1}{2} [\Phi(1.5 + L\hat{\sigma}) - \Phi(1.5 - L\hat{\sigma})] + 1 \right) \\ &= \frac{1}{3} \Phi^{-1} \left( (\Phi(SS\hat{Y}) + 1) / 2 \right) \end{aligned}$$

$$\begin{aligned} \text{way (B) } SSS_{pk} &= 2\Phi(3SS\hat{C}_{pk}) - 1 \leq SS\hat{Y} \leq \Phi(3SS\hat{C}_{pk}) \\ &= \frac{1}{3} \Phi^{-1} \left( (\Phi(SS\hat{Y}) + 1) / 2 \right) \end{aligned}$$

$SS\hat{C}_{pk}$  index or  $L\sigma$  and  $SSY$  have one to one relationship when  $T - \mu = \delta = 1.5$ . Follow this idea the yield process This way generates a yield by

$$SSY = \frac{1}{3} \Phi^{-1} \left[ \frac{1}{2} \Phi(3SS\hat{C}_{pk}) + 1 \right] \quad \text{where}$$

$$SS\hat{C}_{pk} = \frac{(L\sigma - 1.5)}{3} = \left( \frac{L\sigma}{3} - 0.5 \right). \text{ Here for a}$$

process achieving the level of quality or  $\hat{L}\sigma$  level of Sigma can be calculated as shown in equation 4 or  $\hat{L}\sigma = \Phi^{-1}(SSY)$

### 3. The Methodology of this Study

This study uses Process Capability Indices (PCIs) and Six Sigma (SS) to improve

industrial process performance evaluation. This research technique focused on finding current performance and then extensive examination of performance evaluation indices to develop performance. Measuring current process performance is vital to discover the process's capabilities and reasons of faults and variability. The industry should use data gathering, data characterization, statistical tests, and generic estimators to measure and improve process performance using Six Sigma. Figure 3 (Appendix) shows this study's methodological flowchart.

### 4. Measurement and Evaluation of Six Sigma Process Performance in Aden Refinery

The first thing that has to be done in order to ascertain the state of the process performance in any industry is to measure the present performance. There are a lot of different indicators that may be used to figure out how well the process is doing right now. The majority of these indicators are evaluated using a wide number of estimating techniques, each of which results in a unique set of findings. As a result, it is very necessary to make use of the right estimating methodologies and measuring instruments while evaluating the performance of the process. This is basically the primary focus of a great number of research, and the purpose of this study is to produce accurate indicators for monitoring and assessing the performance of processes in industrial settings. As a result, the purpose of this study is to provide a case study that measures and evaluates the process performance of an oil refinery in Yemen.

#### 4.1. Data Acquisition and Collection

Controlling petrol properties requires similar density. Its physical liquid feature makes density important. Oil density should be

between 0.70 and 0.73. Thus, density affects fuel quality. Density determines the kind, volume, and transport or distillation of fuel. Thus, if the density is over 0.73, the oil is kerosene, but below 0.70, it becomes vapors and gases. (Ali & Ahmed, 2017; Aden Refinery 2016). This method obtains density relative data: First, a hydrometer is used to randomly sample oil from the tank's upper, middle, and lower regions. Since tank density varies, the sample is mixed. After mixing, the material is examined for density in the lab. 50 product samples, each with four items, were taken at even intervals (every 8 h) after the random data was gathered to 200 size samples. Important statistical tests were done to validate the data for further study. It includes normality, stationary, autocorrelation, heteroscedasticity (autoregressive model), and process capacity tests. The gasoline characteristic tests for density, normalcy, and stationary showed no unit root. Also, the density characteristic data does not have autoregressive and the results indicate that the process is capable at density characteristic, so the results for density characteristic concluded that normality, stationary, not autoregressive, and capable that means the tested on density characteristic are statistically reliable for further analysis we implement the process actual yield indexes based on six sigma concept and the results are discussed in the next section

## 4.2. Results and Discussions

According to the calculated and the guide to interpret the output of the process yield

index and level process of sigma are explained in Table (1). Here, it should be noted that, the existing PCIs had not considered the probability of a  $1.5\sigma$  process mean change when assessing product or service quality. Many studies have used process capacity indices to determine process quality levels in line with the Six Sigma concept. Existing PCIs based on Six Sigma, on the other hand, merely displayed a range of quality levels rather than a single quality level value. As a result, past studies have found insufficient and ineffective deployment of Six Sigma to process control and yield process. This necessitates investigating indexes in this study based on Six Sigma idea to evaluate product quality characteristic for our results on an index evaluate and measure the process based on the idea of six sigmas as evidenced in the paragraphs under section 2 of the process actual yield indications based on six sigmas –  $6\sigma$ . The result of the process yield index SSSPK for the A and B cases of estimation, for density characteristic is the same results where and also for percentage of yield was achieved for density characteristic for A and B cases of estimation is the same results where and . So, there is a one-to-one correspondence between the process yield index, level sigma and yield process In both cases the A and B the judge to interpret the outcomes of a process when as following: if the is 1.5, then the sigma level is 6 and the yield percent is high at 0.999996681. According to the calculated cases, A and B provide a guide to interpret the outcomes of the process yield index, and Sigma levels are explained in Table 1.

**Table 1.** Grading description for cases A and B with sigma levels

yield index value	Grading	levels Sigma
$SSS_{pk} < 0.5$	Inadequate	$LS < 2.5$
$0.5 \leq SSS_{pk} < 0.833$	Capable	$3 \leq LS < 4$
$0.833 \leq SSS_{pk} < 1.17$	Satisfactory	$4 \leq LS < 5$
$1.17 \leq SSS_{pk} < 1.5$	Excellent	$5 \leq LS < 6$
$SSS_{pk} \geq 1.5$	Super	$LS \geq 6$

Aside from this, it has been clear during the course of the previous discussion and analysis that there is a correlation of one to

one between the  $SSY_i$  yield and the  $SSS_{pk}$  yield index in both of the processes that are used to calculate yield.

**Table 2.** The comparison between process performance indices

Oil Quality Characteristic	Traditional indices		indices beads Sigma		
	$C_{pk}$	$S_{pk}$	$SSC_{pk}$	$L\sigma$	$SSS_{pk}$
Density	0.785	0.904	0.874	4.12	0.951

Based on Table 2 it can be seen that the indices  $SSC_{pk}$ ,  $SSS_{pk}$  and  $L\sigma$  reflect the results of the capacity, yield and sigma level of the process according to the idea of Six Sigma. Also based on Table 2, it can be seen that the proposed  $SSC_{pk}$ ,  $SSS_{pk}$  indices, produced better results when compared to the traditional indices using the two different cases of estimation for the characteristic oil density, where the guideline for traditional indices  $C_{pk}$ ,  $S_{pk}$  annotated in Table 1. Meanwhile the indices  $SSC_{pk}$ ,  $SSS_{pk}$  provide a guide to interpret the output of the process: capacity indices, yield and level of sigma process are explained in the Table 2.

## 5. Conclusion

Six-sigma, a quality improvement technique, uses indices to measure sigma for a quality feature. The indicators help quality control and engineering staff identify sigma process levels. This study provided a statistical method using PCIs and SS to measure and improve industrial process performance evaluation. This industrial case study evaluates Aden's oil refinery process performance. To do this, density data from

200 random samples was gathered to measure process quality. Data normality, stationary, and non-autoregressive were found via density characteristic statistical tests. Table 3 shows that Six Sigma indicators outperformed conventional indicators. Process yield  $SSY$  matches performance index.  $SSC_{pk}$ ,  $SSS_{pk}$ , and  $L\sigma$  hence, when consumers require high process quality for a certain quality attribute, boost product process yield. Yield increases with performance index value and decreases with performance index value. These indices can accurately depict yield characteristics to provide a baseline for quality control or manufacturers and a product quality reference for outside parties. This study developed a viable way to analyze process yield that engineers in manufacturing or quality control may use to evaluate yield processes and quality.

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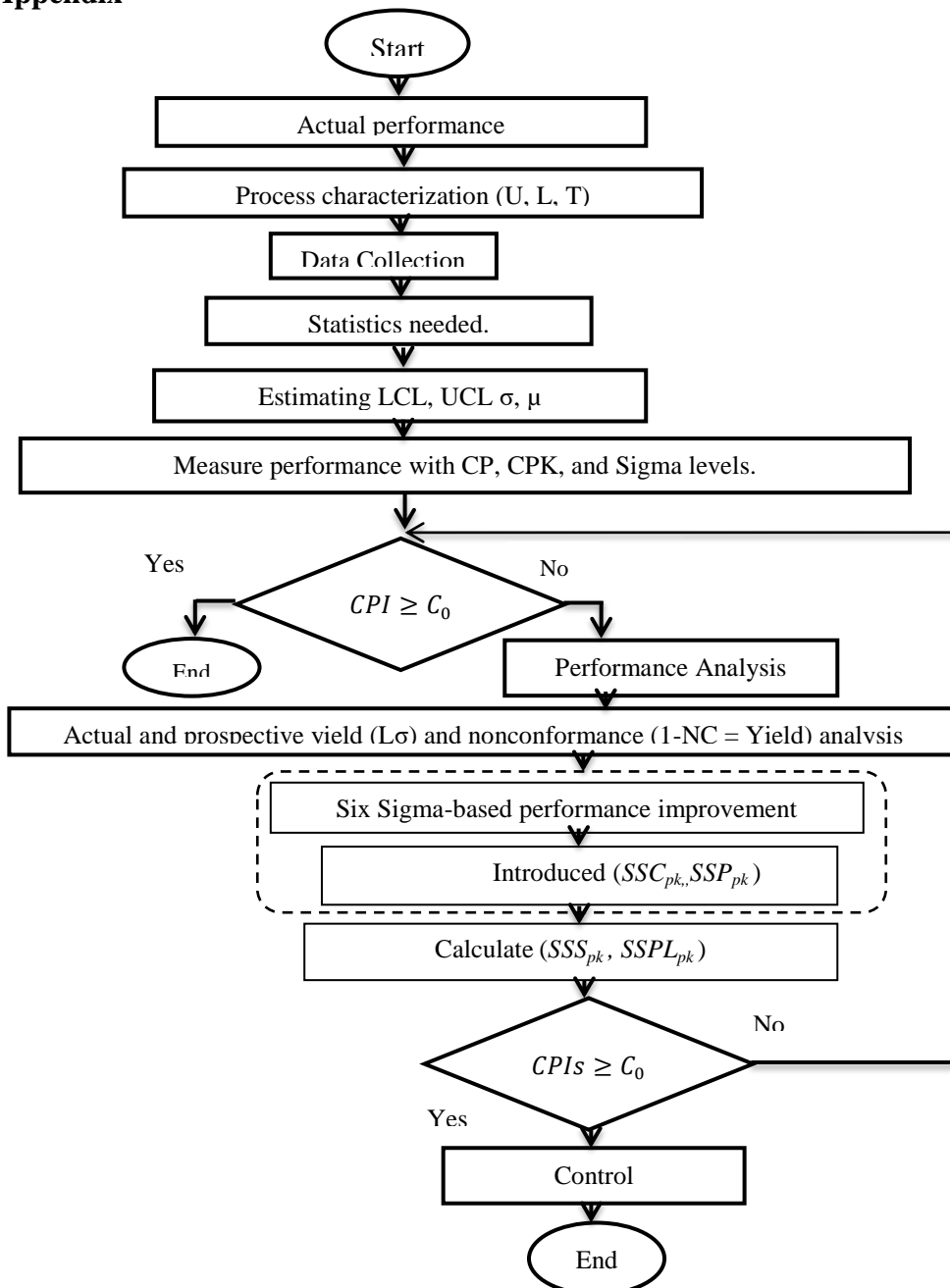
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## Appendix



**Figure 3.** Methodology flowchart

**14<sup>th</sup> IQC**  
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## TAILORABILITY OF FABRICS – A REVIEW

**Abstract:** *Tailorability is the ability of fabrics to be shaped, cut, and sewn to fit a particular body shape or garment style. In recent years, there has been a growing interest in developing fabrics that are highly tailorable to meet the diverse needs of consumers. This paper provides an overview of the current research on the tailorability of fabrics. The review focuses on the methods used to measure the tailorability of fabrics, factors affecting tailorability, and predicting tailorability. The paper concludes with a discussion of the challenges and opportunities for further research in this area.*

**Keywords:** *Tailorability, fabric, garment style, body shape*

### 1. Introduction

The main purpose of the clothing is to protect human beings or individuals from atmospheric conditions. Fabric properties are the result of fibre and yarn characteristics and the fabric geometry, which include fabric structure, number of yarns per inch and tension on yarn components. Fibres, yarns, fabrics, dyes, pre-treatments and finishes all are directed to the end use of a product. They are to be worn, used upon, and walked on. They protect the man as well as enhance his appearance and his environment [1].

Presently the end fabric can be manufactured by different fabric formation technologies from the fibres. One of the most common ways of fabric formation is weaving by interlacing the warp and weft yarns. The tailorability properties of the fabrics are mostly related to the conversion of the fabric into the garment with ease means without more problems with the conversion of flat fabric material into the 3D garment [2].

### 2. Background

Tailoring is the process of converting the 2-dimensional flat sheet type fabric into its intended end product which is usually a garment i.e., three-dimensional in shape when in use [3]. Tailorability is the term used synonymously to 'making - up' properties [4]. Throughout history, it could be found that the human being is the creature who invested much time, thought and energy in dressing and adorning the human body. Tailoring is the process which by means of sewing and clothing may be made more or less to fit the human frame. The very idea of tailoring is "fit", and "well-tailored" means more fit rather than less [6]. Quality is the important aspect of a tailored garment which is moulded to fit the body and can be achieved by formation of seams of supportive fabrics. These are shaped and formed by various construction techniques into the lines of the garment as they fit the body. A well-tailored garment maintains the dimensional stability of the garment on and off the body throughout the life garment. As a thumb rule to test the fabric quality and tailoring quality the fabric is gathered in

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hand and crushed, and good quality fabrics springs back into shape quickly and smoothly. A good quality tailored garment must be made of such fabric [7].

The garment is formed by various processes like design and construction of patterns for the components of the design. The fit of the garment to the contour of the body is considered while patterning, so that the proper fit patterns can be produced. The fit of the garment related to the shape and size of the garment will be strongly influenced by the physical and mechanical properties of the fabric. This means that certain fabric properties such as the tendency of the fabric to stretch, shrink, distort and drape due to stresses induced during use under static and dynamic situations are to be taken into account while drafting patterns for a garment [2]. In the cutting and spreading process, the layers of the fabrics are superimposed on a cutting table, this permits layers to be cut simultaneously into the components for further processing. Any stretch in fabric layers produced by in-place or lateral stresses on superimposed fabric layers will affect the stress-free dimensions of garment patterns [7]. Apart from the colour and pattern the performance of the apparel fabrics is generally not specified in objective terms, though satisfactory wear performance requires certain minimum values of mechanical strength, e.g., tensile, burst and tear strength and resistance to abrasion [8]. In practice, the satisfactory performance of apparel fabrics depends on subjective characteristics such as comfort, appearance and drape. Researchers have tried to correlate the fundamental fabric properties to the subjectively assessed performance characteristics of fabrics. There are some reports on the relationship between the subjective and objective evaluation of fabrics [9].

### 3. Sewability of the fabrics

Sewability is characteristic of the fabric which allows it to be seamed at the full limit of performance during a high-speed sewing machine without weakening or degrading the fabric [10]. Seam formation is the process of joining two or more pieces of fabric material with different stitches. Seam quality is measured by the stitching quality parameters such as size, slippage and strength. It is measured in terms of a Seam Efficiency Index (SEI) [11] and the garment quality is depending on the quality of the fabric as well as the seams [12]. The SEI could be used to optimise the sewing conditions, for various factors and needles of different types, such as type of seam, type and number of stitches per unit of length, and selection of sewing thread. The durability of a seam depends largely on its strength and its relationship with the elasticity of the material. Besides, a seam must be durable so that it will not abrade or wear easily during everyday use, including laundering [13]. It has been observed that the loss in breaking strength is up to 30 - 40% owing to friction and wear during the thread movement through the needle eye.

### 4. Sewability of Threads

Thread is the important factor while forming the seams as it holds two or more components of the fabric material, so it should work satisfactorily during the sewing process. The property of a thread to perform efficiently during the sewing operation is known as the sewability of the thread. The sewability of thread is extremely difficult to measure since it is affected by a limitless number of variables and combinations of variables. Therefore, when observing the performance of a specific sewing operation, it is impossible to determine whether one is measuring the sewability of the fabric or the performance of the sewing machine [14].

## 5. Fabric properties and performance

Mechanical properties such as tensile, bending, shear, compression, and surface properties are considered important in deciding the utility and mechanical comfort performance of a fabric. However, analysis of the tailoring process reveals that these properties are equally important in the making-up process of the garment. For garmenting, a flat two-dimensional fabric is converted into a three-dimensional garment. The conversion requires complex mechanical deformation of the fabric at very low loads. This conversion of the fabric's formability depends on the mechanical properties as well as on the skills of the garment manufacturer [15].

Low-stress fabric mechanical properties are important in tailoring because of the following two reasons [16].

- Fabrics are more extensible in the low-load region, these are more related to the tailoring process and the comfort of the wearer.
- The second reason is that fabric extensibility at low loads causes difficulty in the handling of fabrics during the cutting and sewing processes. Fabrics having high extensibility cause dimensional distortion

It can be said that the fabric's tensile and longitudinal compressive and shear properties are the main mechanical properties relevant to the tailoring performance.

### 5.1. Modes of Deformation

Fabric distortions are commonly the combination of two or more fundamental modes of deformation. The four main fundamental modes of fabric deformation at low levels of stress are tension/longitudinal compression, shear, bending and lateral compression. These terms may be defined as

follows:

#### *Tension/longitudinal compression*

This mode of deformation represents extension or longitudinal compression in the pre-buckling region, along one of the major fabric directions (warp or weft for woven fabric). True uniaxial fabric extension is difficult to achieve for fabrics because extension in one of the major thread directions is accompanied by a contraction of fabric in the direction applied to the normal force.

1. LT, the linearity of load elongation, affects fabric extensibility in the initial strain range; low values of LT give high extensibility but fabric dimensional stability is reduced.
2. RT, the tensile resilience; high values make the fabric more elastic.
3. EM, the tensile strain; larger values of EM in warp cause many problems in tailoring due to distortion of fabric during sewing; but in the weft, they are important for comfort in wearing and easier tailoring.

#### *Buckling*

Buckling of fabrics has been considered by many research workers, as an important property in so far as it can indicate stiffness and recovery [17]. The parameter longitudinal compression can be obtained from the buckling test.

#### *Shear*

For a woven fabric, a shear deformation refers to a rotation of one set of threads relative to the other at the yarn cross-over points in the weave. Many workers have determined this property.

1. G, the shear rigidity; high values cause difficulty in tailoring and discomfort in wearing.
2. 2HG5, the hysteresis of shear force at a higher shear angle (5); high values give

distortion in tailoring and wrinkling during wear.

### *Bending*

In the case of a bending deformation, a bending moment acts in one of the major thread directions of the fabric and is normal to the plane of the fabric. Pure bending occurs when the resulting fabric curvature is uniform along with a line of action of the bending moment

Bending properties influence the formability of a product of fabric bending rigidity and the longitudinal compressibility of fabric in its own plane prior to buckling. Bending rigidity is one of the basic fabric mechanical properties, and it also affects puckering and fabric cutting.

### *Lateral compression*

This deformation is the result of opposing forces applied from the two sides of the fabric in a direction normal to the plane of the fabric. The surfaces of fabric are typically highly compressible. Fabric surface frictional properties determine the physical behaviour of fabrics which is independent of fabric tensile, shear and bending properties, and is fundamentally different from, but not independent of, fabric compressional properties [18].

compression is measured as the degree of compressional force a fabric can sustain in a certain direction before the fabric buckling occurs. The lower the compressibility, the fabric is unable to accommodate the compressional load and the higher the chance of seam pucker. Tension is developed during sewing by the sewing thread, which tends to relax by shortening the thread path in a stitch. This is achieved by lateral and longitudinal compression. Fabric surface property, weight and thickness also influence cutting and sewing operations.

### *Fabric Tensile Test Instruments*

Since it is rare for an apparel fabric to be subject to a uniaxial tensile strain either in processing or in wear, biaxial properties are more relevant to fabric performance. Several testers have been developed which apply biaxial strains to a fabric sample [19]. The strip biaxial test can be regarded as an intermediate form of testing between the two extremes of a true biaxial tensile test and a uniaxial test. The KES-F tensile tester is suitable and is superior to the extensometer type tester in terms of the standard arrangement of the fabric gripping mechanism.

### *Fabric Shear Test Instruments*

A wide range of laboratory-built instruments and some commercially available testers, including the KES-F shear tester have been developed which measure the shearing behaviour of a flat fabric specimen. In these testers, a specimen is clamped in two jaws and a shear force is applied in the plane of the fabric in one of the major thread directions. A small tensile load is applied in a direction initially normal to the shear force to delay the onset of fabric puckering during shear testing. In Sweden during the late 1950's and early 1960's these instruments took the form of modifications to an Instron extensometer. Several purpose-built testers have also been developed. These testers can be distinguished as follows: Testers whose clamps are not maintained parallel during testing i.e., shear, and testers whose clamps are maintained parallel during testing. It has shown that the shear stress distribution is not homogeneous for testers whose clamps are not maintained parallel during testing. But while the shear stress distribution is homogeneous for the class of parallel clamps, the tensile stresses are not homogeneous in this case, being high at the free edges of the fabric [19]. These edge effects may be minimised by utilising an appropriate aspect ratio in the design of the

tester, i.e., the use of short, wide specimens as is also recommended [20]. The KES-F tester incorporates a short, wide specimen during testing, viz. nominal aspect ratio 4:1.

### Bias extension

Several authors have reported the relationship between fabric shear rigidity and the fabric "tensile" modulus in the bias direction based on a simple trellis model of fabric behaviour during shear deformation. The measurement of fabric extension in the bias direction is made difficult by the relatively large 'shearing' contraction of the fabric in the direction normal to the applied force. The ends of the fabric clamped in fixed jaws are not able to accommodate this contraction, and so provide non-homogeneous distribution over the fabric sample of both shear and tensile stresses. It is observed levels of shear stress are higher

(by over 200% in some cases) at the same levels of shear strain when calculations are based on bias extension results compared to conventional shear test results [21]. This result and its inexplicability in terms of the trellis model, or any other model, combined with the difficulty of testing noted previously, mean that the conventional shear test is currently the most accepted method of assessing the shear behaviour of fabrics on a large scale.

### 6. Control System: A tailoring chart

Control system A tailoring control chart developed in Japan is shown in Figure 1. If all the properties of a fabric fall inside the "non-control" zone, the tailoring of this fabric is easy and it will not have defects in appearance [15].

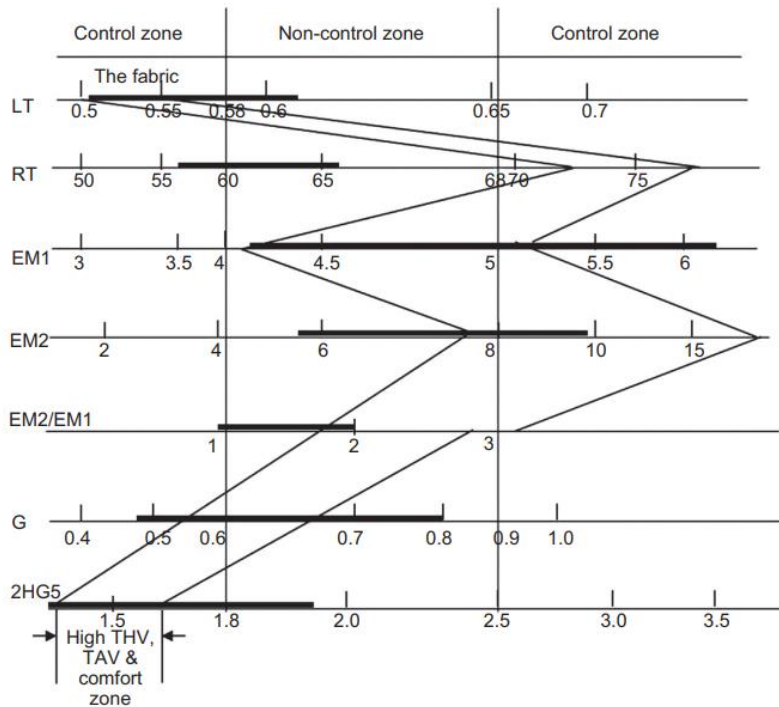


Figure 1. Interrelation between fabric mechanical parameters and tailoring processability

However, if it was found that the properties of the fabrics having good handles are not necessarily in the “non-control” zone, the fabric might not be suitable for tailoring. This means good suiting cannot be processed in tailoring. The dots and horizontal lines show the mean value and the range of distribution of the fabric properties. The control chart has been introduced for tailoring higher-grade fabrics, with special instructions for the tailoring process based on those mechanical properties that fall outside of the “non-control” zone. The difference in the smoothness of the seam line comes from the mechanical properties of the constituent fabrics. The mechanical property related to this problem is mainly the bending property in the weft direction. Another important property of fabrics for processing is fabric shrinkage caused by the steam-pressing process in the production-line system of suits. Inspection of fabric properties before tailoring is done to determine the fabric’s acceptance.

## **7. Experimental Studies on Fabric Tailorability**

In the late 1950’s and early 1960’s the first large-scale investigations of fabric tailorability were undertaken at the Swedish Institute for Textile Research (TEFO), and continued at the. Later work in this area has concentrated in Japan and at the University of New South Wales, much of this work has been directed at measuring fabric mechanical properties, notably fabric shear properties [22]. Other fabric properties investigated in relation to fabric tailorability include: fabric extensibility, fabric bending rigidity, fabric longitudinal compressibility; and fabric thickness and weight. The Japanese workers have included tailorability as an essential parameter in that it has relevance to the Garment industry. FAST, developed by CSIRO, Division of Wool Technology also gives a measure of formability. In addition, a

measure of total appearance value (TAV) is also provided by the KES-F system as an adjunct to the clothing industry. Many authors related fabric mechanical properties to subjectively assessed “making up properties”. Waesterberg concluded that fabric “adaptiveness” was correlated with fabric formability. Fabric tensile, bending and shear properties are related to the appearance of men’s summer suits [23].

## **8. Predicting Tailorability**

The production of high efficiency suits the Kawabata Evaluation system (KES-F) is a tool to that decide the fabric will be acceptability and, in some firms, a quality control system has been introduced on this basis. Fabric puckering and bubbling either during garment assembly or during the first month of wear can be predicted. The warp and weft extension under 500 g/cm load should preferably be 4% or above – otherwise, problems will be experienced on wool fabrics. In many countries, KES-F instruments are being used for quality control and product development in the textile industry. The behaviour of the fabrics during the garment construction can be predicted by the mechanical properties of fabrics.

## **9. Conclusion**

The tailorability of fabrics is an essential factor in the fashion and textile industry. The ability to modify fabrics to fit specific body shapes or designs is crucial for creating customized clothing that meets individual preferences. Factors such as fibre content, weave, weight, and stretchability influence the tailorability of fabrics. Tailors use various techniques such as cutting, sewing, and draping to modify fabrics. Advancements in technology have also revolutionized the process of altering fabrics, making them easier and more efficient. The

future of tailorability looks promising, with continued advancements in technology that

will improve the process of creating customized clothing.

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## COMPARATIVE STUDY ON PRODUCTION OF PAPER FROM BANANA FIBERS USING HYDRATED LIME AND CAUSTIC SODA AS PULPING AGENTS

**Abstract:** *Banana is a dominant fruit crop grown in tropical and subtropical regions and in Eritrea, Williams and Grand Nail are the two varieties cultivated in 1900 hectares around Gash-Barka region. Subsequently 76,000 tonnes of pseudo stem wastes dumped annually, which is a potential source of banana fibers for paper products and primarily they can be used in the production of packing paper. Different chemical pulping agents of 12.5% NaOH and 12.5% Ca(OH)<sub>2</sub> at varied proportions of 400 ml and 500 ml per every 50gm of dried grounded pseudo stem samples tested in the digestion. Bleaching of the pulp in each case performed using 150 ml of 2.5% calcium hypochlorite solution. Further, final pulps of 101.3 and 185.8 gm obtained for paper making from NaOH and Ca(OH)<sub>2</sub> digestions respectively. As a result, yields of the pulps are determined as 46.66 and 56.66 % (weight) in NaOH and Ca(OH)<sub>2</sub> pulping methods. Consequently, thin papers of 100 g/m<sup>2</sup>, 200 g/m<sup>2</sup> using 20gm pulp in each case and thick papers of 290 g/m<sup>2</sup>, 270 g/m<sup>2</sup> using 40 gm pulps are fabricated from NaOH and Ca(OH)<sub>2</sub> processes. Qualities of the papers in terms of appearance and strength approximated by simple physical assessments. Paper made from NaOH pulping good in strength and the paper of Ca(OH)<sub>2</sub> process bright in color.*

**Keywords:** *Banana Pseudo Stem, Chemical Pulping, Packing Paper, Pulp Bleaching, Paper Properties*

### 1. Introduction

Paper products are integrated into nearly every aspect of our daily lives. It is an undeniably important to the society. Approximately 90 percent of this paper is produced from wood pulp such as bamboo, hardwood, softwood, jute etc. The rising

demand in paper product consumption created additional pressure on the world's forest resources since more wood need to be cut to satisfy the demand of paper. Other than for paper use farmers also chop forests for agricultural land, building houses and firewood. Along with this matter the increased awareness of pressurizing the

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environment led many researchers worldwide to focus on finding potential alternative raw materials for paper making from non-wood resources (Pauzi, F. M, 2015).

Since plastics usage in packing practices restricted due to serious environmental issues the demand for paper based packing materials in food and other goods package is rising every year. The demand of global paper and paperboard packing market size surpass USD 243 billion by 2030 at an expected CAGR of 2.25 % [Globe Newswire Report 2023]. In other words, paper from banana paper market size is estimated to grow by USD 63.78 million from 2022 to 2027 at a CAGR of 5.05%. [Technavio, 2023]. In Eritrea, currently there are no paper making industries other than recycling industries. Some industries such as barka cannery, soap industry, Alebu tomato paste factory etc., use wrapping paper for packing purposes. However, those packing papers are all imported. Moreover, papers can be used as a substitute partially for plastic bags used in food and package industry to mitigate with non-degradability issue of plastics wastes. Further, plastic waste generated from food and package industry have a great effect on the environment as they create ecosystem imbalance on oceans and seas.

Papers are manufactured by pulping processes such as chemical, semi-chemical, chemo-mechanical and mechanical pulping. Pulping is the process by which plant material (wood, straw, grass and soon) is reduced to a fibrous mass. Pulp refers to a suspension of cellulose fibres in water and represents the raw material for producing paper and boards, and obtaining cellulose derivatives. There are two major Pulp grades: paper-grade pulp and dissolving pulp. The properties of paper-grade pulp refer to pulp yield, pulp brightness and strength properties. The properties of dissolving-grade pulp refer to the high cellulose content and to a high reactivity

towards derivatizing chemicals. The aim of all pulping process is to separate the fibres from the lingo-cellulosic materials in order to obtain pulp grades that are suitable for paper making. Cellulosic fibres can be separated from each other by mechanical, chemical or by a combination of both treatments (Popa V 2013).

Banana is a major fruit crop of the tropical and subtropical region of the world grown on about 5.6 million hectares in 2017, primarily in Asia, America and Africa (FAOSTAT, 2017). In Eritrea there are two varieties of banana exists, which are Williams and Grand nail introduced by Israel and Dwarf Cavendishi introduced during Italian colonization. It grows around Gash-Barka region specifically in Agordat, Dgle, Haykota and Tessenei round the year grows about 1900 hectare. Production rate of banana is greatly affected by climate change i.e. production during hot season is almost twice than production during cold season. Banana crops produce large quantities of post-harvest biomass waste like pseudo stem and leaves. Currently in Eritrea 76,000 ton of pseudo stem wastes and 14,166.6 ton of peel are dumped annually as wastes, from which banana fiber can be extracted (MoA, 2022). In other words, banana peels cause environmental problems such as bad smell, origin of human diseases, affects cleanness of cities and urban areas. The natural forests are in the process of being extinguished by logging. About 70% of produced paper are derived from wood and demand of paper increasing every year. It consumes an average of 17 trees to make a ton of paper, so more and more trees are needed to meet the increasing demand (Pauzi, F. M, 2015). As trees are cutting down, forests are cleared and leads to climate change and global warming. Banana pseudo stem wastes are the main by-product of banana cultivation and are usually discarded as agricultural wastes after harvesting despite of little amount of wastes used as fertilizer. But majority of the

pseudo stem are dumped on large land cultivation areas and become a source of pollution, causing the release of carbon emissions such as CO<sub>2</sub>, over time.

To tackle the aforementioned problems, banana fiber can be used as an alternative raw material for the production of paper as it has lower lignin content than wood and also it can be a cheaper alternative to wood as it doesn't take longer years to grow despite of its availability in the form of agro-wastes. This work majorly focused on the utilization of banana pseudo stem wastes (BPSW) for the production of packing paper to serve for the food and package industry. The paper produced by mechanical pulping practices has low strength as lignin interferes with hydrogen bonding between fibers when paper is made whereas the alkali chemical pulping methods remove the lignin effectively (Monica Ek et al 2009). This study also focused on comparison of conventional alkali pulping process in terms of quality of paper, waste discharges, yield of paper etc., with locally available alkali such as hydrated lime.

## 2. Materials and Methods

### 2.1. Collection of Banana Pseudo Stems

Approximately 40 kg of fresh banana pseudo stems were collected in the month of February, 2023 from Agordat, a place for banana farming in Gash Barka zone of Eritrea and it was brought to Chemical Reaction Engineering (CRE) laboratory, Mai-Nefhi College of Engineering and Technology (MCOETEC), Mai-Nefhi, for further processing of paper production. Further the chemicals and accessories adapted for different stages of paper making process are listed in the table 1.

### 2.2. Preparations of BPSW and Alkali Solutions

The banana stem is washed several times with tap water to remove dust and soil particles present on it. Then the outer layer is peeled off, the inner fiber is cut into 10 cm long slices. These slices are sun dried to remove 90% of the moisture and are cut into small pieces for the convenience of pulping process as shown in figure 1. After, for the preparation of alkali solution, 12.5% (weight) solution of alkali chemicals, which are NaOH and Ca(OH)<sub>2</sub> are required as cooking liquors. For the makeup of 500ml of 12.5% (weight) solution require 62.5 gram of alkali compounds. Thus, 62.5 grams of NaOH or Ca(OH)<sub>2</sub> are dissolved in distilled water and makeup to 500ml of cooking liquor.

### 2.3. Pulp Making Process

Once the cooking liquor is prepared, 50 grams of raw material (dried banana stem) is added to 400ml of cooking liquor in 1000ml beaker and the level is marked. The marking of the level done to identify the level of water as it evaporates with continuous heat supply and to maintain constant alkali concentration by the additional water to compensate the loss of water in the evaporation (Marella JBR, et al 2014). Further, it is heated to about 100°C (boiling) for 1 ½ hour with continuous stirring till the pseudo stem samples starts to break down or becomes soft.

The digested fiber (pulp) is rinsed with tap water and the cooked fibers are soaked and thoroughly rinsed with water to remove residual liquor. The mixture is filtered using a fabric filter to obtain black liquor as it contains cooking chemicals that can be recovered. The alkali free fiber is then transferred into a blender along with clean 700 ml of water for the convenience of blending and the blending continued until a

smooth slurry is achieved. The blended pulp is filtered using a muslin cloth.

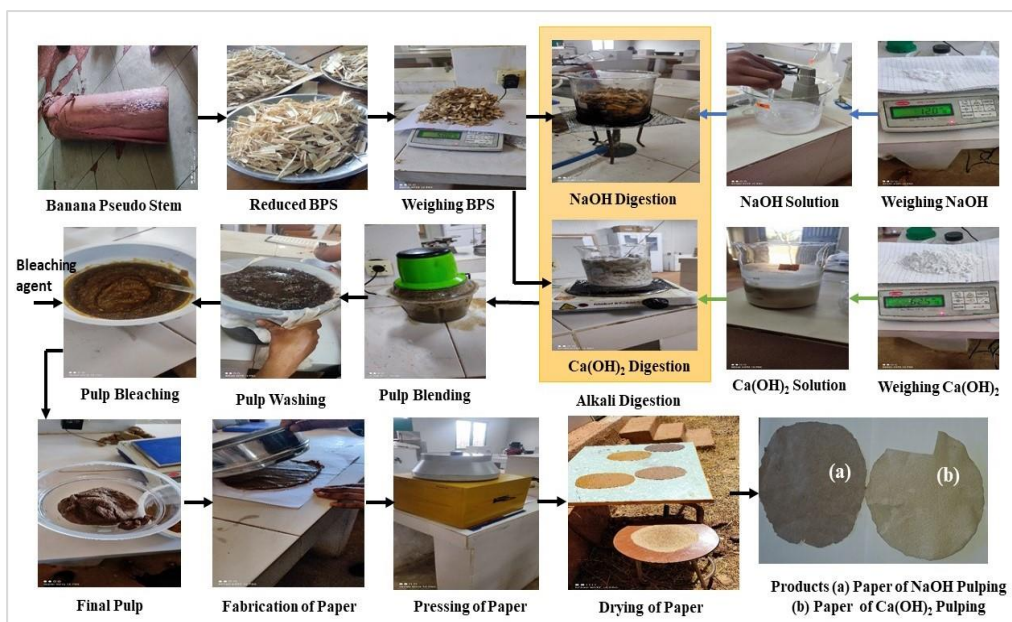
The pulp is bleached by soaking it in 2.5% of calcium hypochlorite ( $\text{Ca}(\text{HClO}_3)_2$ ) solution for 2 hours. Further, the bleached pulp is rinsed for the free of calcium hypochlorite. Then squeeze out excess water and roll up the pulp into a ball. The pulp is then ready for paper making process.

### 2.4. Paper Fabrication from Pulp

Different weights of pulp are taken to make paper of different thicknesses. The bleached pulp of 20g and 40g are weighed and blended with 500ml of water to separate fibers into a consistent solution. The blend is poured into a mold and deckle in a bowl as it allowed to drain completely prior to its removal.

**Table 1.** Chemicals or Utilities applied in Papermaking Process.

Chemical/ Utility	Purpose
Water ( $\text{H}_2\text{O}$ )	For the preparation of solutions and washing purposes
$\text{Ca}(\text{OH})_2$ and $\text{NaOH}$	Applied as alkali chemicals to remove the lignin content of the banana fiber
$\text{Ca}(\text{HClO}_3)_2$	Opted as a bleaching agent
KBr Powder	Utilized in FTIR analysis of Pulp



**Figure 1.** Production of paper from banana fibers at laboratory scale

The couch drained pulp is transferred to a felt material (pellow) and is prepared for pressing. Later, it is applied on the press to squeeze off the retained water. The felt/Pellow material removed and the semi dried pulp is transferred to a Formica covered boards, for drying overnight in the room without exposing to direct sunlight to prevent the deformation in the shape. Further, the paper products are characterized for physicochemical parameters.

## 2.5. Characterization of Pulp and Paper Products

The pulp used and the paper formed with different alkali compounds for varied masses of the pulp are tested to examine their physical properties as shown in the table below. Physical attributes of paper such as mass per unit area (GSM) and thickness, and the characterization of pulp including PH and Fourier Transfer Infra-red (FTIR) analysis for the identification of functional groups. Paper properties are determined at Eritrean Standards (ES), Asmara whereas the pulp was examined at National Drug Laboratory, Asmara. Further, thickness of paper products was determined using micrometer.

## 3. Results and Discussion

### 3.1. Material Balances & Determination Paper Yield

The banana pseudo stem applied has removed a moisture content of 90 % (by weight) under sun-drying and the remaining 10 % of fibers are chipped and consumed in the process. Based on the calculations accomplished at laboratory scale that are furnished in figure 2, Hydrated lime pulping process has witnessed with 3.6 times higher production rate of thin paper and 1.663 times higher thick paper production when compared with NaOH pulping process. In

addition, 45% less water consumption and subsequently accompanied with 45.45% of less wastewater generation are also added advantages of Ca(OH)<sub>2</sub> pulping process as provided by the Table 2.

From the annually dumped waste banana pseudo stem of 76000 tonnes, the production of pulp at rate of 77.37 ton/day can be expected from hydrated lime pulping process and 42.1 ton/day from the caustic soda pulping treatment. Further, a thinner paper product of 23.211 ton/day, 6.315 ton/day and a thicker paper product of 14.893 ton/day, 8.731 ton/day are estimated in the case of hydrated lime and caustic soda pulping treatments respectively.

To find the yield in both pulping processes, entire water in the bleached pulp must be removed by drying at a temperature of 60°C for one hour in hot air oven. [Taleat et al 2021]

$$\text{Pulp Yield} = \frac{W_2 - W_3}{W_2 - W_1}$$

Where,  $W_1$ -weight of the crucible

$W_2$ -weight of bleached pulp and crucible

$W_3$ . weight of pulp and crucible after oven drying

The calculated yield of Ca(OH)<sub>2</sub> pulping is 56.6% and for NaOH pulping the yield is 46.6%.

### 3.2. Effective Parameters on Pulping and Fabrication Processes

The optimum temperature and pressure required for cooking process are 100-120°C and 1 atm respectively. The cooking process take 1.5 hr for NaOH and 2hr for Ca(OH)<sub>2</sub>. Higher temperature causes faster delignification. There are limitations regarding how much alkali can be added to the system due to complications on the subsequent washing systems and on the recovery of the spent liquor. Excess alkali will hamper subsequent pulp washing and

overload the causticizing system [Popa,V 2013]. Further, it was noted that moisture content in the pulp and blending speed or time have direct impact on the flexibility of paper formation. In other words, molding technique and tools may limit the shape and thickness of the paper. Drying method adapted for paper product has direct impact on the shape of the paper product, direct sun-drying can restrain the shape of the paper which we have witnessed from the local paper recycling industry. Thus, drying of the paper product carried out in the room for overnight extended for 2-3 days.

### 3.3. Comparison of Paper Products

The  $\text{Ca}(\text{OH})_2$  pulping process for banana stem bagasse has a higher yield when compared to a typical soda process. The  $\text{Ca}(\text{OH})_2$  cooking process for the waste banana fiber, can be considered a technical alternative for the use of the banana stem due to its higher yield coupled with higher delignification rate when compared with a soda process.

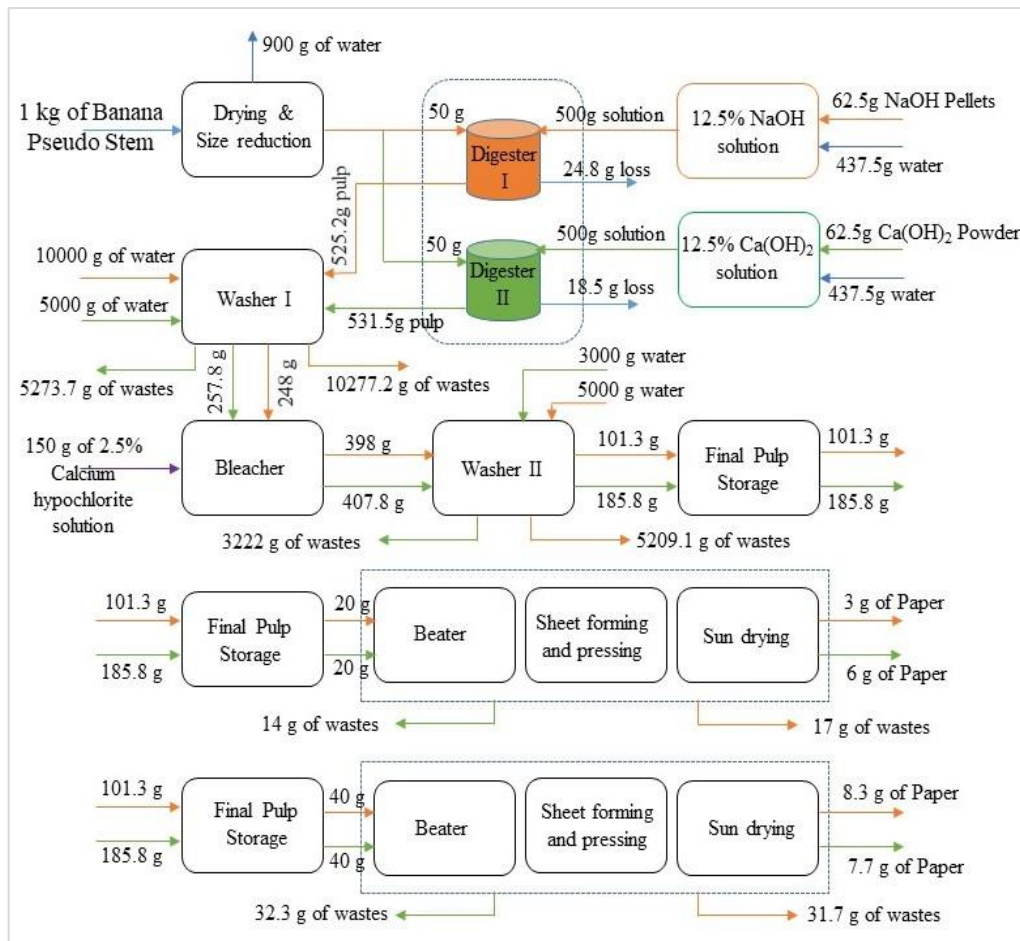


Figure 2. Material balance on paper making process at laboratory scale.

**Table 2.** Comparison of NaOH and Ca(OH)<sub>2</sub> pulping processes Per kg of BPSW

Parameter (kg)	NaOH Pulping	Ca(OH) <sub>2</sub> Pulping
Pulp	0.2026	0.3716
Thin paper	0.03	0.108
Thick paper	0.0415	0.069
Alkali required	0.125	0.125
Bleaching agent required	0.0075	0.0075
Total water consumed	31.1665	17.1675
Total wastewater generated	31.1478	16.9914

**Table 3.** Physical attributes of Paper Products

Test	NaOH		Ca(OH) <sub>2</sub>	
	20g	40g	20g	40g
GSM (g/m <sup>2</sup> )	100	290	200	270
Thickness (mm)	0.327	0.8	0.487	0.9
p <sup>H</sup>	8	8	7.5	7.5

**Table 4.** Comparison of different grades of commercial papers in terms of GSM

Reference for the Paper Product	Range of GSM	Potential Application
Sophie G. 2022	90-120	Office paper or copy paper
Sophie G. 2022	130-250	Promotional Posters usage
Sophie G. 2022	260-300	High end brochures or magazines
Sophie G. 2022, SBS (Solid Bleached Sulphate Board)	> 250	Mainly for Packing purpose
This work (Thin Paper)	100-200	Suitable for both office paper and promotional poster purposes
This Work (Thick Paper)	270-290	Suitable for high end brochures or magazines. And matches with the packing grade paper of SBS.

**Table 5.** Identification of functional groups in NaOH and Ca(OH)<sub>2</sub> treated Pulps by FTIR analysis

Frequency (cm <sup>-1</sup> )	Sample Type	Functional Group	Peak Type
1417-1559	NaOH treated pulp (a)	Nitrogen Compounds	Strong
1653-1717	NaOH treated pulp (a)	Aromatic Compounds	Medium
1350-1500	Ca(OH) <sub>2</sub> treated pulp (b)	Nitrogen Compounds	Strong
950-1200	Ca(OH) <sub>2</sub> treated pulp (b)	Carboxylic acid	Medium
860-875	Ca(OH) <sub>2</sub> treated pulp (b)	1,2,4-trisubstituted (or) alkenes	weak

Physical properties of different types of sheets prepared were compared, from the results it was observed that the tensile strength of paper made from NaOH pulping

is higher than that produced from Ca(OH)<sub>2</sub> experienced by the application of manually pulling forces. The residual alkalinity was reported as slightly higher in the case of

caustic soda derived paper. Weight of the paper per unit area were measured as GSM ( $\text{g/m}^2$ ), and the results revealed that for the case of thin paper that is formed from 20 g of the sample, hydrated lime treated paper has double weight than the case of caustic derived paper. Further, the thickness of the different papers measured revealed that,

NaOH treated paper facilitate thinner paper in both types of papers made when compared with  $\text{Ca}(\text{OH})_2$  treated paper whereas in case of thicker paper,  $\text{Ca}(\text{OH})_2$  treated paper has less GSM and more thickness that may be due to imbalance in the pressing force applied.

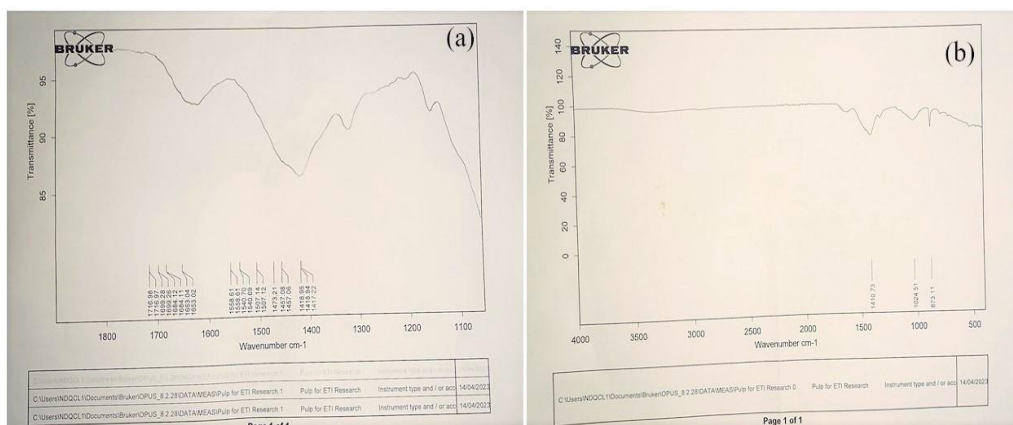


Figure 3. FTIR analysis of NaOH treated pulp (a) and  $\text{Ca}(\text{OH})_2$  treated pulp (b)

### 3.4. Economic Viability of Paper Production in Eritrea

There is high demand of packing paper in Eritrea in order to prevent the utilization of plastics in the packing industry and food industries such as Barka cannery, Alebu tomato paste factory, soap industry etc. along with commercial shops, super markets, cafes and restaurants are in need of such products for packing their goods. As per the local informants, currently, a rim paper used for colored packing imported from UAE at a price range of 88.235-92.307 Nakfa/kg, and a locally made card boards and belt papers are valued in the range 20-25 Nakfa/kg. If the production of paper by adapting the optimized process of hydrated lime digestion method have taken as a new startup, through making thin paper products that are suitable for the replacement of rim paper, could generate an income in range of 2.048 - 2.142 million Nakfa/day (0.136-

0.1428 million USD/day). Further, thick paper production could create 0.1263-0.158 million Nakfa/day. Thus, the preliminary assessment ensures that making paper from banana pseudo stem waste by hydrated lime digestion methods seems to be an economically viable business startup in Eritrea. However, detailed cost analysis which include the machinery, operations water and energy consumptions besides the treatment of the wastes are yet to be performed for further development.

### 4. Conclusions

Based on the experimental investigations on potential making of paper from BPSW using caustic soda and hydrated lime the following conclusions are drawn.

- Considering the cooking conditions applied in this research, the  $\text{Ca}(\text{OH})_2$  cooking step proved a



better delignification rate for the banana stem bagasse similar to a soda process.

- The  $\text{Ca}(\text{OH})_2$  cooking (12.5%  $\text{Ca}(\text{OH})_2$ ) using BPSW raw material can be considered as a technical alternative for pulp production.
- Hydrated lime pulping process has witnessed with 3.6 times higher production rate of thin paper and 1.663 times higher thick
- In addition, 45% less water consumption and subsequently accompanied with 45.45% of less wastewater generation are also added advantages of  $\text{Ca}(\text{OH})_2$  pulping process
- The GSM of the papers ensure their suitability in multiple applications.
- FTIR analysis has revealed that the strong presence of nitrogen compounds, medium presence of carboxylic acid and aromatic compounds and weak presence of alkenes.
- This paper production using hydrated lime pulping treatment promises a better economic

viability of an immediate local startup business.

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## THE INFLUENCE OF COVID-19 PANDEMIC ON FOOD SAFETY AND QUALITY ASSURANCE STANDARDS IN SELECTED COMPANIES IN POLAND

**Abstract:** *Food safety is the basic characteristic of food and the most important one because food has the direct impact on our health. Companies operating along the food chain are obliged by food law to implement the mandatory food standards such as HACCP, GHP, GMP. If they want, they can also use many voluntary food standards. The COVID-19 pandemic influenced the whole food chain and consumer behavior by the restrictions, shutdowns and fear of being infected. This paper presents the results of the survey conducted among 71 enterprises operating in the food industry in Poland in 2022. The representatives were asked to assess the influence of the pandemic on food safety standards and their usefulness during the pandemic. They were also asked about the positive and negative aspects of the pandemic from the perspective of the food industry. It was shown that the pandemic strengthened the need and understanding of the hygienic standards, collaborations with suppliers and employee training. On the other hand, caused the more frequent food quality and safety inspections, shortages of the employees and supplies, and economic losses. For some companies the pandemic was a chance for new form of sales and obtaining additional funding to minimize the negative effects.*

**Keywords:** *food, food standards, COVID-19 pandemic, pandemic effects*

### 1. Introduction

Codex Alimentarius is one of the basic document on food safety. It defined food as “any substance, whether processed, semi-processed or raw, which is intended for human consumption, and includes drink, chewing gum and any substance which has been used in the manufacture, preparation or treatment of “food” but does not include cosmetics or tobacco or substances used only as drugs”. Food safety is important for the

whole society as it has the direct influence on our lives and the lack of food safety causes big losses for the economy (Niewczas-Dobrowolska, 2020). Safe food is hazard-free food. "Hazard" means a biological, chemical or physical agent in a food or feed, or the condition of a food or feed that may cause adverse health effects (Regulation 178/2002).

Food safety - all conditions that must be met regarding in particular:

a) additives and flavorings used,

- b) the levels of pollutants,
  - c) pesticide residues,
  - d) conditions of food irradiation,
  - e) organoleptic characteristics,
- and actions that must be taken at all stages of food production or circulation in order to ensure human health and life.

Food safety is about preventing hazards to the health and life of consumers, caring for the welfare and health of plants and animals, caring for the human environment, surrounding, agricultural production and processing, as well as concern for the economic safety of consumers (Obiedziński, 2004). Food safety can be described as the strategies and activities aimed to protect foods from biological, chemical, physical, and allergenic hazards that may occur during all stages of production, distribution, and consumption (Paparella, 2020).

The COVID-19 pandemic has drawn the public's attention to the need for safety in various dimensions, for example: economic safety, food safety, safety of life. Before the pandemic we were got used to the feel of safety and stability of food production, food supply, consumer behavior etc. The COVID-19 pandemic introduced unexpected stresses on food systems, creating many immediate challenges. It has affected different stages of the food chain, simultaneously affecting farm production, food processing, transport and logistics, and final demand. Food processing was disrupted by labour shortages and shutdowns. Some employees were sick or some leaved their jobs out of fear from the infection (OECD 2020, Barman et al., 2021).

Dudek & Śpiewak (2021) said COVID-19 affected the functioning of all elements of the system and the relationships between them, involving the following segments: supply of means of agricultural and food production, primary production of agricultural raw materials and products, agri-food processing, wholesale and retail food trade, marketing, logistics and transport, food preparation and consumption, by-

product management, edible energy. Kalinowski & Wyduba (2020) and Zielińska-Chmielewska et al. (2021) concluded that the COVID-19 pandemic changed the whole food system in Poland.

## 2. The COVID-19 pandemic and food standards

In January 2020 the World Health Organization (WHO) announced the first appearance of COVID-19 virus. Since then the citizens around the world as well as the companies they had to face a situation they had never faced before. In Poland the first case of COVID-19 infection was dated on the 4<sup>th</sup> of March 2020. From this date the government introduced many restrictions, for example: close the restaurants, limit the number of clients in shops, limit the possibility to travel. In order to limit the transmission of the virus, remote work was recommended and many industries were closed or their activities were limited. These restrictions changed the reality we had known. Our basic activity as consumers that is buying and consuming was limited. We had to plan our shopping and started to prepare meals at home more often. For this reason consumers started to pay attention to products they eat.

Food processing, however, could not be shut down because it provides the basic goods necessary for survival. Therefore, companies operating in this industry had to quickly adapt to the new situation and implement mechanisms that would allow them to survive. The WHO published guidance documents addressed the food companies and the food authorities to support the food supply chain (WHO , WHOa). The main recommendations were: people who are feeling unwell should stay at home, staff working in food premises should be provided with written instructions and training on how to prevent the spread of

COVID-19, Food safety practices in food premises should continue to be delivered to the highest hygiene standards in line with established FSMS (Food Safety Management System), keep good staff hygienic practices, the primary focus of any additional hygiene and sanitation measures implemented by food businesses is on keeping the COVID-19 virus out of their businesses. The virus will enter business premises only when an infected person enters or contaminated products or items are brought into the premises. Tips for food authorities were the following: to preserve the integrity of the national food safety control system and to support international trade and the food supply chain, multi-agency cooperation and contingency, maintaining a functioning national food safety inspection programme planning, staff training. WHO also indicated the role of food safety standards in COVID-19 spread prevention. Prerequisite Programmes must ensure that COVID-19 infected workers and their contacts are excluded from food premises. Staff who are unwell or who have any symptoms of COVID-19 should not work. A procedure to allow staff to report illness by phone (or email) should be established so that workers with early stages of COVID-19 can receive reliable information and be quickly excluded from work environments. Very similar recommendations can be found in standard requirements in GHP (Good Hygienic Practice) and GMP (Good Manufacturing Practice) in staff hygiene requirements.

The COVID-19 pandemic showed the food industry the value and the meaning of hygiene restrictions as well as the role of staff behavior in the process of food safety assurance. As Djekic et al. (2011, 2021 ) wrote food safety management systems (FSMS) both obligatory (GHP, GMP, HACCP) or voluntary (ISO 22000, BRC, IFS) have several common elements: (1) prerequisite programs (PRPs) are the basis of

any FSMS, (2) HACCP or similar hazard-based approaches are important for identifying, controlling and decreasing food safety risks in the food supply chains; (3) food safety legal compliance is necessary; and (4) food-based crisis management is important to anticipate and respond to various threats such as incidents associated with the product (like recalls, withdrawals and food fraud), or emergencies affecting food companies such as natural disasters, food safety issues and food defense.

Hazard Analysis and Critical Control Point (HACCP) is a preventive programme aiming at producing and providing safe food products (Gehring & Kirkpatrick, 2020; Motariemi & Warren, 2023). It is an obligatory standard that has to be implemented by all food chain participants. HACCP is based on seven principles: (1) Conduct a Hazard Analysis, (2) Determine Critical Control Points (CCPs), (3) Establish Critical Limits, (4) Establish Monitoring Procedures, (5) Establish Corrective Actions, (6) Establish Verification Procedures, (7) Establish Record-keeping and Documentation Procedures. HACCP is implemented together with GHP and GMP practices which show the basic hygienic requirements at the work place and in the food manufactory. Food operators can also use the voluntary standards, for example ISO 22000, AiB, IFS, BRC and others. The main goal of each food standard is to ensure the food safety. Food safety is a complex issue and many external and internal factors implement it. These standards deal with food hazards mainly in a traditional division between biological, physical and chemical hazards. The pandemic appeared to be on of the external hazards that hadn't been considered. However, both in food standards and prevention of the pandemic the hygienic requirement/principles play the main role.

### **3. Changes in the food industry caused by the COVID-19 pandemic**

The major concern in food companies was to keep the production and health of their staff (Aday & Aday, 2020). Many companies had to face the labour shortage (Stephens et al., 2020). As Limon (2021) shows the pandemic allowed to increase the online sell of food goods as well as emphasized the need to maintain hygiene principles in the foodchain. Maiberger&Sunmola (2023) presented the important aspects of food safety standard that are useful during the pandemic: 1) FSMS knowledge; 2) rigorous prerequisite programmes; 3) FSMS verification and audit processes; 4) FSMS culture and 5) legal regulations. The restrictions and shutdowns resulted from the pandemic influenced the food suppliers and customers affecting jobs, economic growth, mobility (Rizou et al., 2020; Laborde et al., 2020; Knorr & Khoo, 2020). Covid-19 has also emphasized the role of human health as a core consideration in assessing supply chain resiliency. Attention to hygiene practices and social distancing measures within manufacturing plants reduce the risks of spread within the workforce, helping to protect the health and welfare of workers (Hobbs, 2021). Also the food standards helped to obey the rules of hygienic behavior. As Rejeb et al. (2020) showed pandemic poses unprecedented challenges for food supply chains. It has raised food insecurity and food safety concerns, increased supply chain and logistics costs and radically changed consumer behavior. On the positive side, the pandemic has improved the need for hygienic principles.

In the report EIT Food „Food Foresight: Impact of COVID-19 on the agri-food sector in Central and Eastern Europe” published in December 2020 four scenarios of COVID-19 impact on agri-food sector: (1) the most optimistic called “full recovery” in which the

lifting of restrictions facilitates the movement of labor, taking the pressure on farmers to earn money. At the same time, the pre-crisis scale of consumption returns, also in the HoReCa sector, driving related market segments. The agri-food industry is again experiencing the previous scale and directions of development, and the most noticeable change left after the restrictions of recent months is the continued development of e-commerce platforms; (2) “new consumer” - moderate scenario, emphasizing the long-term maintenance of pandemic consumer behavior, placing more emphasis on the nutritional value of food and how it is sourced locally. According to these assumptions, there will also be a shift from the use of catering establishments to home-cooked meals, which will result in an increase in demand for basic consumer goods and the need for the agri-food industry to adapt adequately; (3) “a new rulebook” - in this case, in opposition to the previous scenario, consumers are willing to return to their previous habits and ways of doing things, but they cannot do so due to the constraints they maintain. As a consequence, the scale of consumption is limited while maintaining the structure of the sector; (4) “distortion & disruption - this is the most pessimistic approach, in which both economic and political factors are arranged in the most unfavorable way. The simultaneous maintenance of restrictions, continued unfavorable trade conditions and the lack of sufficient political support result in a decline in consumer and business confidence and the persistence of domestic demand at a crisis level. As a result, a downward trend is growing.

Other scenarios elaborated by the Directorate-General for Research and Innovation (European Commission) in 2022 titled “After the new normal. Scenarios for Europe in the post-COVID-19 world” are consisted of five scenarios called: (1) The long recession, (2) The back to ‘normal’, (3)

Big tech shapes Europe, (4) Circular trials and real-life errors, (5) Green Utopia – New Hope. The long recession scenario is a very pessimistic, it shows the world under the crisis caused by the COVID-19 pandemic, and this crisis lasts for 20 years. The supply chains, travel industry and investment flows have not only been temporarily disrupted but at different times and for longer periods. They play a different economic role in 2040 compared to 2020. People, at least those with regular jobs, are saving and not spending their money, fearing even worse times. This behaviour is further fuelling a severe and long-term depression that defines the economy of 2040. In the second scenario people want to go back to “normal” so to the world we knew before the pandemic. This world is not ideal, characterized by social inequalities, varying levels of economic growth and food insecurity. The third scenario shows the possibilities and the need for the development of new technologies, also in everyday life. Companies focusing on innovation will gain an advantage, consumer behavior and forms will become more global. In the fourth scenario a focus on making chains resilient, and raising the quality of products and services to include more players in the markets, to provide many jobs, and to play on a level field, small and medium-sized companies hand in hand can be found. In emergent circular economies, adaptivity to find new customers and flexibility to react to offers or changing circumstances are more important principles than efficiency and lean production process optimisation. This scenario shows the need for circular economy and emphasis on national self-efficiency. The last scenario pays a big attention to the value of quality. Quality in many dimensions is more important than quantity, also the quality of food. Good quality food should be available for each consumer, the meaning of the local food will grow. People will take more responsibility for their own health.

Deloitte perceived changes in the food industry and food consumption caused by the pandemic. People will search for local food, natural, with a positive impact on their health. Globalization in the food industry will not be popular and increasing. The food chains will be then shorter. Moreover, safety will play the main role, that is why food standards and requirements will be tightened. The pandemic showed the meaning of safety as well as the need for food availability. Local and regional products will have a bigger share in the production and consumption. New IT technologies will be implemented to the food chain so it will be possible to trace the food very quickly, and also to avoid problems with food supply.

Local is the word that can be often found when we search for some recommendations toward food industry after the pandemic (DuPuis et al., 2022). Local food systems should be developed because they are more resistant to future crises as they were more resistant to the pandemic. Local chains also help to deal with disruptions in supply chains because these supplies are shorter so the risk can be controlled to a greater extent.

Some trends in the food industry were created as a result of the pandemic (Vandrunen farms). The first one is the growing demand for frozen and shelf-stable foods. Consumers will prefer this kind of food to prevent food waste and to minimize the time for food preparation. Consumers still expect high food quality and safety and the clean label. Food they buy should be as natural as it is possible and little processed. The second trend is food convenience. Food products should be convenient so easy to prepare. As a result of the pandemic and the restrictions consumers started to consume food at their homes as restaurants were closed or limited. The trend of food consumption at home will be continued as it is seen to be more safe and also cheaper. The food should also be easy to buy. The third trend shows the need for new tastes, from

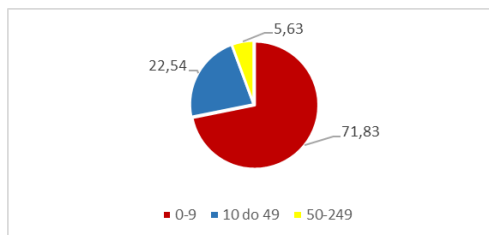
various countries. The food products should be healthy, convenient and offer a wide variety of products. It doesn't mean they should be globally produced, still local food is required but with new tastes. And the last trend is 'decadent indulgences' that means consumer are characterized by the desire for low-sugar and all-natural ingredients what will shape consumers' preference for decadent snacks and desserts.

#### 4. Method and results

71 enterprises operating in Poland in the food industry and food processing took part in the study. The survey was conducted using the CAWI method and was addressed to the managers of the quality department, managers and persons responsible for ensuring food quality and safety. The main purpose of the study was to determine the usefulness of the functioning of management systems and food quality and safety assurance systems during the pandemic and to identify the changes that the pandemic caused in this regard. In the preparatory phase of the study, a literature review and face-to-face interviews with 20 people responsible for ensuring food quality and safety were conducted in order to determine possible answers to be chosen in the survey. The first question asked about the impact (on a scale of 1 to 5) of the pandemic on selected aspects of the company's functioning in terms of ensuring food quality and safety, such as: remote audits, more frequent employee training on hygiene principles and preventing the spread of COVID-19, more frequent quality inspections, the need for tightening cooperation with suppliers (cooperation with suppliers for whom we are sure in terms of compliance with safety requirements, difficulties with the purchase of raw materials / timeliness of deliveries, difficulties in meeting production schedules, staff shortages, other. The second question asked about the usefulness of food quality

and safety assurance standards during the pandemic. The aim of the next questions was to determine the positive and negative effects of the pandemic in terms of food quality and safety and the functioning of the company. The survey was conducted in 2022. The companies participating in this survey were characterized by the number of the years of experience in business, the number of the employees (Fig. 1-2) and the branch. The operating in various sectors of food processing that reflects the real situation in the food industry in Poland.

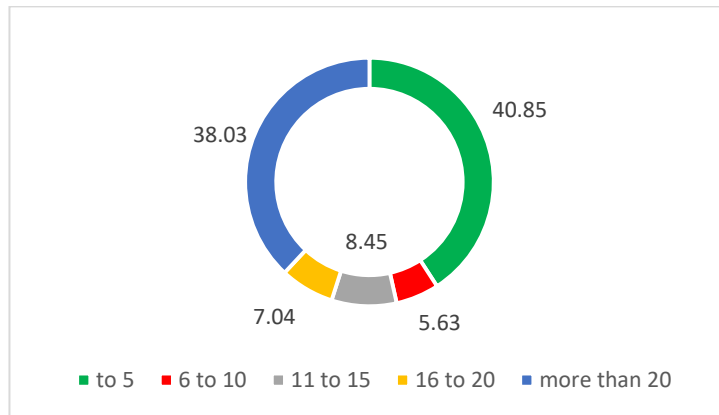
According to Statistics Poland in 2018, 16.9 thousand companies conducted production activities in the food industry, mainly of them were SMEs (67.6%). The food industry is one of the most important and fastest growing branches of the Polish economy. The Research and Markets analysis shows that by 2025 at the latest, the market of food products in Poland will break the barrier of USD 100 billion, but it may happen even faster. This is the most stable industry, the development of which even the COVID-19 pandemic did not have a major impact. The report "Data & Trends 2021" - the European organization of food producers Food Drink Europe - shows that Poland is the 4<sup>th</sup> largest food producer in the EU after France, Germany and Spain (PARP, 2022).



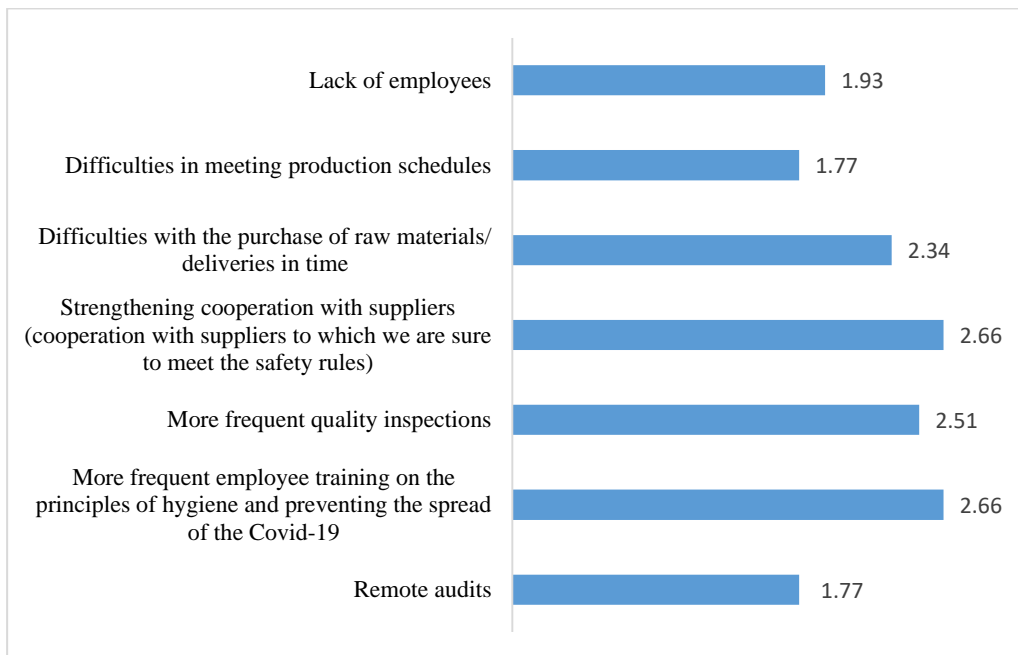
**Figure 1.** Number of the employees in the companies participating in the survey, in %.

Source: own elaboration.

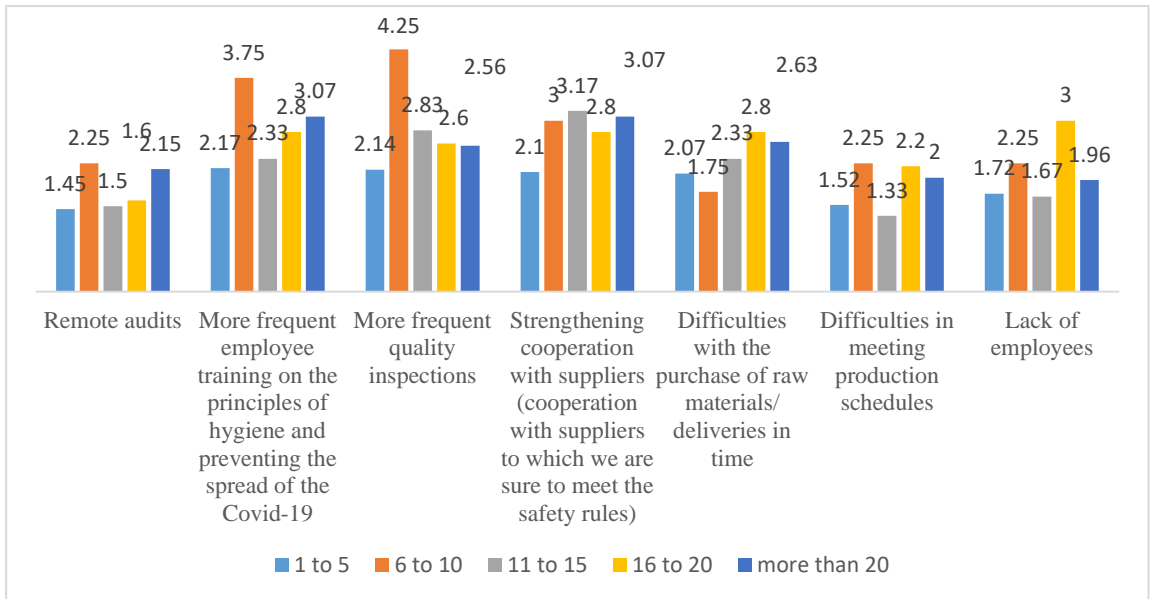




**Figure 2.** Number of the years of experience of the companies participating in the survey, in %. Source: own elaboration.

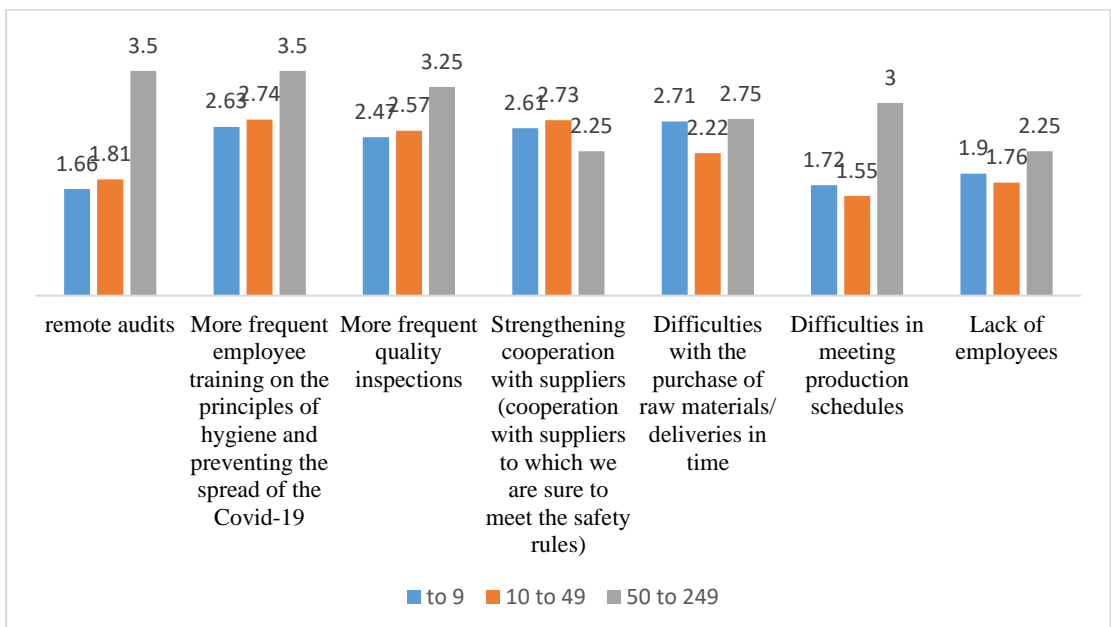


**Figure 3.** Changes in the functioning of food quality and safety assurance and business operations caused by the pandemic, on a 5-point scale. Source: own elaboration.

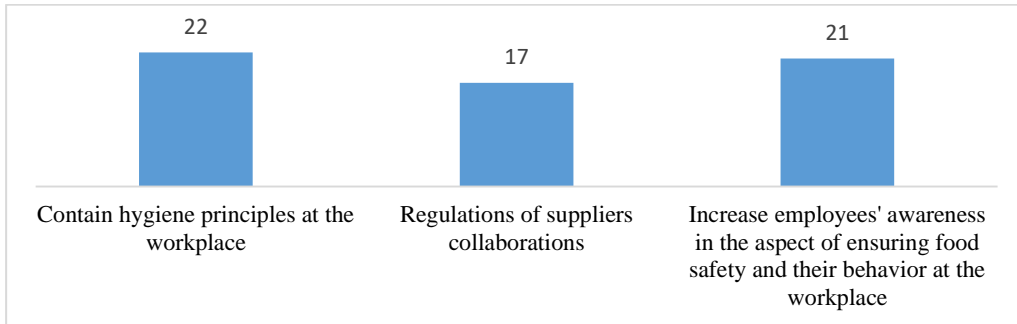


**Figure 4.** Changes in the functioning of food quality and safety assurance standards and business operations caused by the pandemic considering the number of experience (in years).

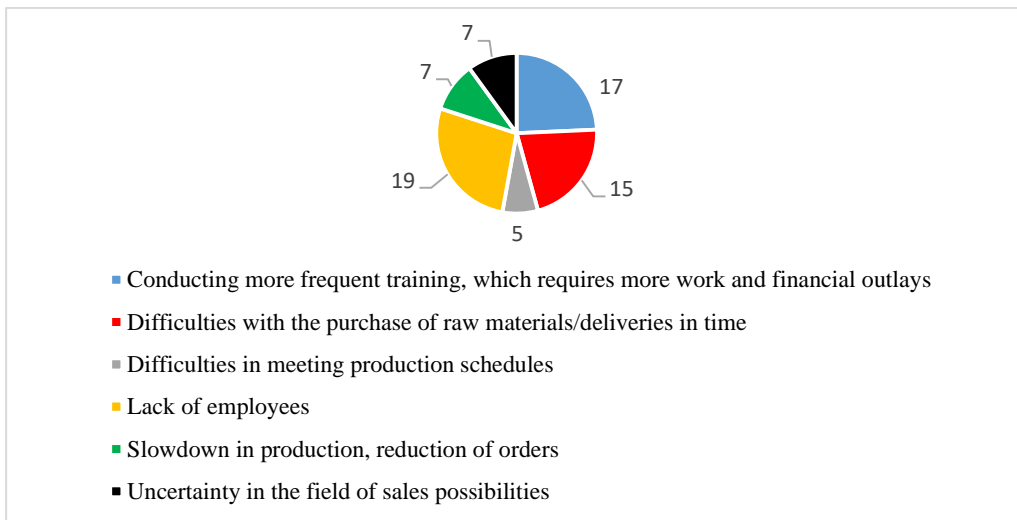
Source: own elaboration.



**Figure 5.** Changes in the functioning of food quality and safety assurance standards and business operations caused by the pandemic considering the number of employees. Source: own elaboration.



**Figure 6.** Reasons for food safety standards usefulness during the pandemic. Number of indications. Source: own elaboration.



**Figure 7.** Negative aspects of the pandemic. Number of indications. Source: own elaboration.

## 5. Changes in the functioning of food quality and safety assurance and business operations caused by the pandemic

The respondents were asked to indicate the changes the COVID-19 pandemic causes in the process of food quality and safety assurance and business operations (on the scale 1 to 5, where 1 is the lowest rank, 5 the

highest). On the basis of their average ranks it can be said that the most important changes were more frequent employee training on the principles of hygiene and preventing the spread of the COVID-19 and strengthening cooperation with suppliers (cooperation with suppliers to which we are sure to meet the food safety requirements) (Fig. 3).

Considering the number of years of the experience in business the answers were

varied (Fig. 4). For example, the companies operating in the food industry for 6 to 10 years indicated as the most important change the more frequent quality inspections as well as more frequent employee training on the principles of hygiene and preventing the spread of the COVID-19. Companies with less experience tended to downgrade changes caused by the pandemic. When we look at the answers on the basis of the number of employees of the companies we can see that the bigger companies usually gave higher ranks of changes caused by the pandemic (Fig. 5).

HACCP, GHP and GMP are to obligatory standards in the food industry. Companies operating in the food chain can also implement other standards such as ISO 22000 (Food safety management systems. Requirements for any organization in the food chain), IFS Food (International Featured Standard Food) or BRC Food (British Retail Consortium Food). Representatives of the companies taking participation in the survey were asked to decide if these standards were useful during the pandemic. 40.8% companies agreed that these standards were useful during the pandemic, however 25% of them didn't agree with this opinion and 34.2% were not able to evaluate the usefulness. The reasons why these standards were assessed as useful during the pandemic are presented in the figure 6.

The pandemic has generally drawn attention to the need for good hygiene and also the need for safety in various dimensions. Companies with 1-5 years of experience as well as companies with more than 20 years of experience more often than others indicated the answer about the usefulness of food safety standards during the pandemic. For companies with little experience food standards helped to organize their processes in the field of food safety assurance. For companies with bigger experience these standards showed the need and value of their implementation and continuous

development.

### **Negative and positive effect of the pandemic**

Companies were asked to indicate the positive and the negative effects of the pandemic. Among the positive effect they could choose: (1) the increase of the employees' awareness in the aspect of ensuring food safety and their behavior at the workplace and (2) reorganization of work, or indicate their own opinions. 40% of the respondents didn't notice the positive effects of the pandemic. The increase of the employees awareness was most often mentioned by the participants (40%). Among other positive aspects were in descending order of indications: the development of online sales, increased sales, increased number of food inspections, the possibility of obtaining funding. Apart from the positive aspects of the pandemic, survey participants also indicated negative ones from a closed list (conducting more frequent training, which requires more work and financial outlays; difficulties with the purchase of raw materials/deliveries in time; difficulties in meeting production schedule; lack of employees) and could propose their own answers (Fig. 7).

Companies having less experience (1 to 5 years) indicated the higher numbers of the negative aspects of the pandemic what may show that they were less prepared for the unpredicted situations and have less ability to cope with risks from the company external environment. As other authors showed staff awareness and hygiene are two of the most important attributes derived from the COVID-19 pandemic affecting food safety. Dudek & Spiewak (2022) on the basis of their analysis elaborated effective ways for the food system's actors to deal with the changing socio-economic situation (best practice) during the COVID-19 pandemic, these are: establishing, maintaining, developing and shortening direct relations with food consumer customers; increasing

the added value of offered products by increasing their health benefits, specifying production locations (local product), highlighting the products' flavour value, producing food in an environmentally friendly way (certified organic food); diversifying the channels and ways of selling products (middlemen, processing businesses, wholesalers and retailers, own sales outlets, including online shops); pursuing a pro-employee hiring policy (e.g., appropriate wages, good work conditions, maintaining long-term relationships with employees); launching food deliveries directly to customers (food boxes); following sanitary norms related to the pandemic during food production, such as social distancing, disinfection, wearing mouth and nose coverings, quarantine, extended work hours and shift work as well as increasing the emphasis on compliance with food safety and work safety rules.

Szczepaniak et al. (2020) concluded that food chains dealt well with the pandemic, there are no major difficulties in the functioning of food chains. There are segments in the food industry for which the COVID-19 pandemic created opportunities for an increase in production volume (e.g. products with a longer shelf life), as well as those whose sales collapsed partially or completely (e.g. products manufactured for the needs of the HoReCa sector). In a fast-growing period part of the spirits industry, namely alcohol producers, also benefited from the pandemic ethyl alcohol, as the demand - both domestic and foreign - for spirit as a disinfectant increased sharply.

## 6. Conclusions

The food sector turned out to be resilient to the external risk of the COVID-19 pandemic. Due to the provision of basic goods necessary for survival, food production could not be closed. For this reason, the food sector had to adapt to the new pandemic

reality and restrictions very quickly. To a large extent, food processing is manual work and limiting interpersonal contacts was also difficult. The food industry, as far as possible, introduced the recommendations of social distancing, wearing masks and disinfection, i.e. the 3 main recommendations of the government. In meeting these recommendations, the requirements of mandatory and optional food quality and safety assurance systems helped, i.e. disposable gloves, hygiene rules, protective clothing. Hygiene principles have always played a central role in food processing. Employees participated in training on maintaining hygiene at the workplace, in addition, the pandemic emphasized the importance of maintaining hygiene during food production. Business owners organized more frequent training in this area.

The COVID-19 pandemic as an external risk difficult to predict, has become an opportunity for some companies and a threat for others. It was, for example, an opportunity to increase production – for example food with a long shelf life, spirit. Other companies producing mainly for gastronomy or hotels had to limit their production due to smaller orders caused by the closure of gastronomy and hotels. For many companies, it was also an opportunity to start selling online. The implemented food standards helped to adapt to the pandemic situation due to the knowledge of the requirements of behavior at the workplace, the role of maintaining hygiene rules, quality and safety inspections, and generally standardization of processes. The pandemic has also shown the need for proper collaboration with suppliers and trust in the food chain. On the other hand, the only aspect in which the food standards did not help the functioning of the food industry during the pandemic was the lack of employees.

Summarizing, the food industry was the least affected by the negative effects of the pandemic among other industries, and the implemented food standards made it easier to adapt to the rapid changes in the external environment caused by the pandemic. However, as it was shown there are new challenges ahead in the food industry resulting from changes of consumers behavior and companies expectations caused by the COVID-19 pandemic. The food industry should collect the lessons learned from the pandemic and be well prepared for the future difficult to predict situations. The pandemic also showed that the trends in the market can change so it is important to monitor consumers requirements and answer them as much as it is possible. Another conclusion resulting from the pandemic is that it is worth strengthening what is good, for example to continue the high standards of food quality and safety, hygienic requirements, locally produced food with clean label. The pandemic also showed the need and possibilities of new technologies in the wide food sector, for example on line

selling, traceability systems, new technologies for food preservation.

One of the strategies in SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) in the strategy maxi-mini what means that companies should strengthen their advantages, skills and minimize the threats from the outside. This strategy would be very good for the food sector for the time of the pandemic or after the pandemic. Food standards help to increase the strengths (and are the strengths in themselves) so to be more resistant to external threats like the pandemic or any other crisis that could come.

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# **14. International Quality Conference**



**CONFERENCE MANUAL**

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**SCIENTIFIC FOCUS 5**

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## PAST AND FUTURE DECADES OF WOMEN'S QUALITY OF WORK LIFE ON THE AXIS OF SOCIAL SUSTAINABILITY: TURKEY-SERBIA COMPARISON WITH EVALUATIONS, EXPECTATIONS AND RECOMMENDATIONS

**Abstract:** *With the awareness of women's power in working life, women are now seen as the key to social sustainable development. The evaluations to be made with the problem how the quality of work life of working women (in the light of criteria such as participation in employment (labor force), starting and maintaining entrepreneurship, entrepreneurship incentives, success, happiness, education, family support, salary, job satisfaction, position, etc.) has been interpreted in the last ten years, the expectations for the next ten years and the rates that will change by means of the proposed recommendations are the main subjects of this study. Interpreting the antecedents, results and future expectations of women's employment and women's work life quality in the countries with a comparison between Serbia and Turkey among the developing countries will show the importance given by the relevant nations to women employees on the axis of social sustainability.*

**Keywords:** *Social Sustainability, Women's Employment, Sustainable Quality of Work Life, Turkey, Serbia*

### 1. Introduction

Women and girls, who make up half of the world's population, are not among the first issues that come to mind when it comes to sustainability. Topics such as the climate crisis, energy problem, and water shortage generally take priority as more preferred by institutions that want to do something in the field of sustainability. Some of the depressing data on women and girls, who have to face a series of inequalities that start at the time of birth, in different areas throughout their lives, are as follows (Kolbay Hülya, 2023): Globally, approximately 15 million girls under the age of 18 are married every year.

One third of the developing countries have not been able to achieve gender equality in schooling. Worldwide, 35% of women are exposed to physical and psychological violence by their spouses, lovers or acquaintances. Approximately 133 million girls in Africa and the Middle East have been subjected to female genital mutilation. 80% of the 1.3 billion poor people in the world are women. Women are paid 24% less than men compared to the world average. Women and children are 14 times more likely to die in natural disasters than men. In 8 out of 10 households where water resources and access to water are limited, women and girls are responsible for collecting water. Women and

children constitute the majority of those who have to migrate due to climate change in the world.

The fact that women cannot find the place they deserve in society because of their gender, that they cannot be a decisive actor in politics, and that they cannot gain equal rights with men in the axis of home-work-social life are among the factors that drag not only women but also societies backwards and directly affect the sustainability of the world. In this context, knowing the antecedents and results of women's work life quality, taking measures by institutions, determining the steps to be taken especially by business life and private enterprises, and increasing the power of women in society will have a great impact.

This study considers the gender variable as one of the indicators of quality of work life and argues that there is a significant relationship between gender and quality of work life. It has also been proven by various studies (for example, Torlak Evinc & Yavuzcehre, 2008: 34; Castillion et al., 2005: 1232) that the quality of life of women is significantly lower than that of men. As a matter of fact, there are great differences in terms of gender, primarily in the fields of employment and education in underdeveloped and developing countries. Unpaid family work (housewife) is common among women living and not working in these countries, who are not allowed to work, and who come from conservative, patriarchal and traditional family circles, and women's quality of life depends on their husbands' work and social security (Torlak Evinc & Yavuzcehre, 2008: 34; Aydiner Boylu & Pacacioglu, 2016: 139). In these countries, different expectations and responsibilities such as cooking, cleaning, taking care of children and other family members, which are defined as gender roles and imposed on women by societies (Sabbah et al., 2003: 11; Shaphiro, 1998: 276), significantly lower women's quality of life.

On the other hand, business life, which is an indivisible part of life (DeCoster, 2004), comes to the fore in the interpretation of quality of life with its aspects that deeply affect people, including sadness and joy, victory and defeat, socialization and exclusion. When the studies that relate work life and quality of life are examined, it is observed that evaluations are made with the dimension of "satisfaction" (Aydiner Boylu & Pacacioglu, 2016). However, in this study, in the context of work-life quality, not only the factors that affect the level of satisfaction of the person, but also the current causes and consequences that increase and decrease the quality of women's work life by making a distinction in the context of gender are focused. When the literature is examined, while there are studies specific to women's labor force in the evaluation of perceptions of working life quality (for example, Momčilović et al., 2017, Pasli Gurdogan & Cetinkaya Uslusoy, 2019), no studies were found for the interpretation and comparison of the statistical data announced by the countries. In this context, it is thought to fill an important gap. In the related study, firstly, a literature review on the concept of quality of working life will be included, and then the data of the last ten years in the female workforce in Turkey and Serbia, two developing countries, will be interpreted. There will be general conclusions and discussion sections after the section, which will include evaluations of the changes for the next ten years, accompanied by predictions. As a result, the evaluation of the current situation for both countries will benefit the competent authorities in taking lessons and determining policies.

## **2. Review on the Concept of "Quality of Work Life"**

Working life is not a process that starts with the desire to have a job, which is to work, but ends with the end of the period of being active

at work. Because the financial gain, values, attitudes and judgments related to working life continue to be effective later on (Ozmete, 2002).

The quality of work life is basically a subject that includes different perspectives such as job design, reorganization, meeting basic human needs, harmonizing with values, in order to improve the relationship between the individual and the job, in order to increase the satisfaction of the individual with the work and working conditions. Therefore, it is a broad concept that includes moral elements such as a good and sufficient income, a material and safe working environment, human rights, human development, promotion opportunities, balancing work and other areas of life (family, friends, etc.), participation in decisions. It also tends to expand day by day. The concept was first used by Irving Bluestone for program design in increasing employee productivity in the 1960s (Goode, 1989). Later, in an international conference held in New York in 1972, the democratization of workplaces approach was discussed (Yousuf, 1995).

At the core of the concept of quality of working life with its developing structure since the 1970s, there are the following basic concepts (Ozmete, 2002): adequate and fair wages, safe and healthy working conditions, available opportunities for the use and development of human capacity, continuity of development and safety, social integration in the organization, communication in the organization, interaction between work and other areas of life, social responsibility in working life. Since the 2000s, elements such as "entrepreneurship, innovation, incentives and supports, activity in policy making, green recovery, green practices" have been added to this structure. In determining the quality of an individual's working life, it is important to understand the development, performance, participation and motivation process in working life. The level of contribution to the knowledge-skill-ability triad, the motivation

for the satisfaction of needs and ultimately the level of participation in organizational decisions, which an individual reveals as a result of his work, has a great share in the interpretation of the quality of working life.

Work life quality is a qualitative concept that aims to capture the essence of one's work experience (Easton & Van Laar, 2012). The concept takes its power from both work-related and non-work-related elements and workplace elements that can be directly affected by management (Bilge & Bilge, 2022). Since it is a multidimensional concept, it is difficult to come across a researcher who has fully defined the concept. Some have associated the concept with personality, psychological well-being or happiness (Easton & Van Laar, 2012), while others have measured it with job satisfaction (Efraty & Sirgy, 1990). Carlson (1980), on the other hand, defines the concept as a continuous process in achieving the determined goal with the active participation of employees, apart from seeing the concept as a goal in the context of the willingness of the business to develop. Therefore, it would be an erroneous approach to evaluate and measure the quality of work life based on only a single feature of the job or personality traits. In essence, each individual is different from each other, so it is useful to use more than one premise to measure the concept.

When the literature is examined, the quality of work life has been examined with the following concepts in recent years: affective well-being (Duyan et al., 2013), happiness (Pasli Gurdogan & Cetinkaya Uslusoy 2019), burnout (Mercan et al., 2023), job motivation and life satisfaction (Santas et al., 2018), stress and health (Momčilović et al., 2017). As a sample, research was conducted with a large number of participants from various sectors (for example, health, heavy industry). However, no study has been found that includes proportional evaluations of the antecedents and outcomes of women's work life quality. In this study, the work life quality

of the female workforce will be evaluated by taking into account the official researches of the two countries that are the subject of the study and especially the data in recent years.

### **3. The Place of Women in Working Life in Turkey with Statistics: The Last Ten Years**

First, general information about the population of Turkey will be given, and then the situation of women will be evaluated with statistics. In this context, according to the address-based population registration system data of the Turkish Statistical Institute (TUIK), the population of Turkey in 2022 is approximately 85.3 million, of which 42.7 million are males and 42.6 million are females (TUIK, 2023). In other words, 50.1% of the total population is men and 49.9% is women. In the related bulletin, it is stated that the median age is 34.2 years and women live longer than men in general.

In February, there were two major earthquakes in Kahramanmaraş, called the "disaster of the century" in Turkey. Due to the disaster, 10 provinces (Adıyaman, Gaziantep, Hatay, Kahramanmaraş, Kilis, Malatya, Osmaniye, Diyarbakır, Adana, Şanlıurfa) suffered various damages and had to be excluded from some statistical examinations. According to the results of the Household Labor Force Survey, the number of unemployed persons aged 15 and over is 3 million 514 thousand. Unemployment rate stands at 10.0%. While the unemployment rate is 8.7% for men, it is estimated to be 12.6% for women. While the workforce is 34 million 975 thousand people, the labor force participation rate is 53.6%. While the labor force participation rate is 71.2% for men, it is 36.4% for women. The number of people who immigrated to Turkey from abroad is approximately 740 thousand people in the last year. 51.9% of the migrant population is men and 48.1% is women. In addition, 12.1% of

the foreign population coming to Turkey are Iraqi citizens. On the contrary, the number of people who migrated abroad from Turkey is approximately 288 thousand people in the same year. 55.7% of the migrant population is men and 44.3% is women. When the age groups of the population immigrating from Turkey are examined, it is seen that the most immigrants are in the 25-29 age group with 14.4%. This age group is followed by the 30-34 age group with 12.3% and the 20-24 age group with 11.6%.

In Turkey, 49.9% of the total population is women and 50.1% is men. This proportional balance between women and men has changed in favor of women from the age group of 60 and above, due to the fact that women live longer. While the proportion of the female population is 52.2% in the 60-74 age group, it is 72.4% in the 90 and over age group. According to the results of the National Education Statistics Database, the ratio of the population aged 25 and over who completed at least one level of education in the total population increased between 2008 and 2021. While the proportion of individuals aged 25 and over who completed at least one education level in the total population was 81.1% in 2008, it was 92.1% in 2021. When this rate is analyzed by gender, while the rate of women aged 25 and over who completed at least one level of education in 2008 was 72.6%, the rate of men was 89.8%, this rate was 87.3% for women and 97.1% for men in 2021.

While the ratio of the population aged 25 and over who graduated from college and faculties, master's and doctorate degrees, in the total population was 9.8% in 2008, it became 23% in 2021. When this rate is analyzed by gender, while the rate of women aged 25 and over who graduated from higher education in 2008 is 7.6% and the rate of men is 12.1%, this rate is 20.9% for women and 25.1% for men in 2021. According to the results of the household labor force survey, the labor force participation rate for those

aged 15 and over was 51.4% in 2021. This rate was 32.8% for women and 70.3% for men. When the labor force participation rate is analyzed by education level, it is understood that the higher the education level of women, the more they participate in the labor force. While the labor force participation rate of illiterate women is 12.8%, the labor force participation rate of women with less than high school education is 25.3%, the labor force participation rate of high school graduate women is 32.5%, the labor force participation rate of women with vocational or technical high school graduates is 38.5%. The labor force participation rate of graduate women is 67.6%.

According to the results of the household labor force survey, the rate of employed people aged 15 and over in 2021 was 45.2%. This rate was 28.0% for women and 62.8% for men. The highest employment rate was in TR21 (Tekirdağ, Edirne, Kırklareli) region with 52.0%, and the lowest employment rate was in TRC3 (Mardin, Batman, Şırnak, Siirt) region with 29.9%. The highest female employment rate was 36.8% in the TR90 (Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane) region. This region was followed by TR82 (Kastamonu, Çankırı, Sinop) with 35.6% and TR83 (Samsun, Tokat, Çorum, Amasya) with 33.8%. The lowest female employment rate was realized in TRC3 (Mardin, Batman, Şırnak, Siirt) region with 14.5%. This region was followed by TRC2 (Şanlıurfa, Diyarbakır) with 15.9% and TRB2 (Van, Muş, Bitlis, Hakkari) with 19.6%.

According to the results of the household labor force survey, the rate of part-time workers in employment was 9.9% in 2021. This rate was 16.4% for women and 7% for men. While the employment rate of individuals in the 25-49 age group with children under the age of 3 in their household was 59.8% in 2014, it is 58.9% in 2021. When this ratio is analyzed by gender, it is understood that the employment rate of

women in the 25-49 age group with children under the age of 3 in their household in 2021 is 26.1%, while the employment rate of men is 89.1%.

According to the results of the life satisfaction survey, it was observed that 63.2% of the employees in 2022 were satisfied with the time spent on commuting to work. It was observed that this rate was 67.5% for female employees and 61.5% for male employees. According to the data of the Ministry of Foreign Affairs, while the rate of female ambassadors was 11.9% in 2011, it became 27.2% in 2022. According to the data of the Grand National Assembly of Turkey, as of the end of 2022, the number of women deputies is 100 among 579 deputies. While the rate of female deputies entering the parliament was 9.1% in 2007, it became 17.3% in 2022. According to higher education statistics, the rate of female professors among professors working in higher education was 27.6% in the 2010-2011 academic year, while it was 33.2% in the 2021-2022 academic year. While the rate of women working in the associate professor staff was 40.2% in the 2021-2022 academic year, the rate of women working in the teaching staff was 50.8%. According to the results of the household workforce survey, the rate of women in senior and middle management positions in companies was 14.4% in 2012, while it was 20.7% in 2021. According to the results of the family structure survey, when the perceptions of individuals about women's work in 2021 are examined, the rate of those who think that women's work and their contribution to social life is valuable was 82.6%, while this rate was 85.6% for women and 79.5% for men. When the education gap between spouses in formal marriages is examined, it is seen that 39.4% of women are married to men with higher education than them in 2021. It was observed that the rate of women with higher education than their spouses was 15.9%, and the rate of spouses with the same education level was 42.8%. According to the divorce statistics, it

was seen that the custody of the children was mostly given to the mother as a result of the divorce cases that were finalized in 2022. While the rate of children given to the custody of the mother was 75.7%, the rate of children given to the custody of the father was 24.3%. According to the results of the family structure survey, when it is examined who does the housework in the household in 2021, it is seen that all the works are generally undertaken by a household member, except for the whitewashing/painting of the house. When the housework done by the household member is analyzed by gender, it is seen that women generally undertake the housework. Women were responsible for child care with 94.4%, laundry and dishwashing (even with a machine) with 85.6%, cooking with 85.4%, and daily tidying and cleaning of the house. The retirement age for women is 58.

According to the results of the household information technologies usage survey, the internet usage rate of individuals in the 16-74 age group in 2022 was 85.0%. While this rate was 80.9% for women, it was 89.1% for men. In addition, the rate of individuals in the 16-74 age group who ordered or purchased goods or services for personal use over the internet was 46.2% in the twelve-month period between April 2021 and March 2022. According to gender, the rate of ordering or purchasing goods or services over the internet was 42.7% for women and 49.7% for men.

According to the results of the life satisfaction survey, while the rate of those who felt insecure when walking alone at night in their neighborhood was 21.8% in 2022, this rate was 30.4% for women and 13.0% for men. 51.1% of women and 71.9% of men felt safe in their environment. While the rate of those who felt insecure while sitting alone at home was 5.0% in 2022, this rate was 6.8% for women and 3.2% for men. 80.5% of women and 88.2% of men felt safe while sitting alone at home.

The COVID-19 Pandemic has been a turning point in education, health and social fields for

many countries. As a matter of fact, this is also the case for Turkey. With the COVID-19 Pandemic in Turkey, the lives of some working women have become more difficult. In a study conducted by the Bread and Rose organization in 2021 with only women from various sectors, the measures taken in workplaces during the pandemic period were mostly found to be insufficient. It has been reported that the increasing need for cleaning in the workplace during the pandemic process is tried to be "solved" by sharing it among female workers working in production, not by employing new personnel for cleaning. The increase in the intensity of work in the relevant departments along with the increase in internet sales has led to the misinterpretation of flexible working and the uncertainty of working hours. The reason why women had to endure these conditions during this period when more work was started with fewer employees was the lack of job security and the fear of being fired. 95 percent of the women stated that they were more tired and exhausted than before the epidemic, 78 percent stated that they experienced "anxiety/anxiety", 53 percent "tension/irritability", and 51 percent "unhappiness".

Sustainable development in economy and social life is possible with the active participation of women, who make up half of the population, in all areas of life. Undoubtedly, the most important of these areas is participation in business life. Unfortunately, women's participation in business life in Turkey is still far behind what is desired. According to the Global Gender Gap Report published by the World Economic Forum in 2016, Turkey ranks 130th among 144 countries in eliminating gender inequalities in economy, education, health and politics. However, women's participation in the workforce presents significant opportunities for Turkey as well as for the rest of the world. According to the Women Matter report by McKinsey Turkey,

in the global economy, if equal participation of women in the workforce is ensured, a growth of between 12 and 28 trillion dollars in 2025 seems possible (Canakcı, 2018).

Along with all the depressing results, there are also pleasing developments. For example, a study titled "Women in Employment and Entrepreneurship" was conducted in 2022 with the cooperation of the Beko brand with Konda, and as a result of the interviews with 2789 people, the rate of continuing the business they established was 73 percent, while this rate was higher than that of men. The results of the research revealed that women are more successful in entrepreneurship than men. While the rate of women who said that they have successfully continued the initiative they started, was 31 percent, while this rate for men was 23 percent. While the women and men participating in the research expressed success in business life with the same words, these words stood out as: hard work, perseverance, struggle, courage, talent, intelligence and happiness. 47 percent of the participants measured the success of the woman by becoming a mother. 'Respectability' came first as a measure of success among working women with 36 percent. The propositions 'Women's work is not men's work' and 'It is not a problem for women to earn more' were also mostly supported by women. While 18 percent of the women participating in the study could not work on the grounds that they were dealing with child or patient care, 13 percent of the women came to the fore by being housewives. Among the participants, the rate of those who think that the society will become healthier with the increase of women's participation in business life is 76 percent. 90% of working women are of this opinion. In addition, 85 percent of women think that they should be encouraged to participate in business life. For working women, this rate rises to 94 percent. In Turkey, 85 percent of the respondents and 94 percent of working women argue that men

and women should receive equal wages (Seyda, 2022).

Finally, according to the latest data, the minimum wage in Turkey has been determined as 393.02 euros. The inflation rate is 12.09%. In addition, the gross domestic product per capita is calculated as approximately 8620 euros.

#### **4. The Place of Women in Working Life in Serbia with Statistics: The Last Ten Years**

First, general information about the Serbian population will be given, and then the situation of women will be evaluated with statistics. In this context, according to the Statistical Office of the Republic of Serbia address-based population registration system data, the population of Serbia in 2022 is approximately 6.6 million, with 3.2 million males and 3.4 million females (Statistical Office of the Republic of Serbia, 2023). In other words, 48.5% of the total population were men and 51.5% were women. In the related bulletin, it was stated that the total employment in the first quarter of 2023 was approximately 2.35 million people. Unemployment rate is around 9.4%. According to the latest data, female labour force participation was 46.62%. In other words, the percentage of the female population aged 15 and over with economic freedom is approximately 47% in Serbia (The Global Economy, 2023). Women's retirement age is 63.33 (Trading Economics, 2023).

In Serbia, women spend 2.2 times more time on unpaid household and care work than men. In recent years, women in Serbia have spent 19.2% of their day in unpaid work, while men 8.7%. According to the latest data taken in 2018, women in Serbia own more businesses than men (27%). In fact, with this ratio, the share of female business owners in Serbia falls into the fourth quintile among all countries for which data is available. The

percentage of respondents who reported having an account at a bank or other type of financial institution (on their own or with someone else) or using a mobile money service in person was 70.1% for women and 72.9% for men. In addition, women held 39.2% of the seats in the national parliament in Serbia in 2021. The proportion of women's seats in Serbia has increased since 2010. The current rate is above the average rate in upper-middle-income countries. Women represented 34.2% of those employed in senior and middle management in 2021. The share of female employment in senior and middle management in Serbia is in the third quintile among all countries for which data is available (The World Bank, 2022).

According to EuroFound's research, the frequency of work-life balance problems in Serbia is higher than the EU average. For example, in Serbia in 2016, 83% of respondents are too tired to do housework at least a few times a month. This also marked the highest share among all countries surveyed. Additionally, in Serbia, 66% of respondents had difficulty fulfilling their family responsibilities as they worked at least a few times a month in 2016, again a much larger proportion than the EU average of 38%. In addition, when the ratios by gender are examined, it is seen that the frequency of experiencing work-life balance problems in men and women is similar (EuroFound, 2016).

Finally, according to the latest data, the minimum wage in Serbia is set at 460.21 euros. Thus, in the January-February 2023 period, average net salaries and wages increased by 16.0 percent in nominal terms and by 0.1 percent in real terms compared to the same period of the previous year. It was observed that the inflation rate was declared as 16.2%. In addition, the gross domestic product per capita was calculated as approximately 6456 euros (Trading Economics, 2023).

In addition, although the exact rates could not

be reached, it was understood that female entrepreneurship in Serbia is less than male entrepreneurship, and that women's roles in the family – especially those who are entrepreneurs – are an obstacle to improving their quality of life (Momčilović et al., 2017).

## **5. The Place of Women in Working Life: Prospects for the Next Decade**

The portion of economic, environmental and social steps taken with a holistic approach on the protection of the future in the development of countries is undeniably high. With the main aim of finding solutions to the current and potential problems of our planet and leaving a more prosperous life to future generations, countries seek to be economically and socially prosperous, which can renew itself without harming the ecology, together with the decisions they take and the reports they publish. On the way to sustainable development, it is important to focus on the social dimension in terms of social benefit. In this context, businesses need to carry out their activities by taking into account the quality of life of the society and the next generations, to improve both the working and living conditions of their employees, and to ensure that they work more humanely and in prosperity. By making sustainability their policy, a total awareness is created in businesses. This change results in equal opportunity in all employee segments, transparency to all stakeholders, and sustainable value creation.

It has been observed that the business world has been reshaped and standards have changed after the COVID-19 Pandemic. The pattern of "working in the office" has been demolished, and the "remote working" system has been activated in most sectors. With the system change, there were serious decreases in costs, and changes in the demands and expectations of employers were observed. In the research conducted by many



institutions and organizations (for example, GOOINN), it has been pointed out that the business will grow in the fields of automation and research, development and supporting new technologies. It is also mentioned that with the emergence of new employment forms, it will be necessary to establish and regulate a universal protection and social protection system that will adapt to this, reduce inequality, and respond to new situations and needs. These things are expected from a society and a business in the axis of social sustainability.

There are also changes in the skills that will stand out in the future business world. The increase in communication possibilities, the digitization of the world and the rise of smart machines are transforming the sectors, and in this context, the expectations of the new generation employees are changing radically (Öndes, 2017). Ten skills that will be decisive in the business world in the next 10 years are discussed in the 'Skills for Future Professions 2020' report, recently published by the Future Institute, which is affiliated with the University of Phoenix. These skills are: intuition (seeing the deep meaning and significance behind what is being said), social intelligence (connecting with other people in a direct and deep way, understanding and adapting to their reactions), original and adaptive thinking (responding to an unexpected new situation), intercultural competence (language and keeping up with new conditions), numerical thinking (making a certain number of subjective data a summary content and making data-based reasoning), new user-added media literacy, interdisciplinary action (based on the understanding that some problems cannot be solved with a single discipline), cognitive load management (recognizing important information and learning how to improve cognitive function using various techniques), visual collaboration (being able to communicate with various parts of the world at the same time), and design mindset

(employee designing their own workspace). It is also expected that an ideal employee will be T-type in the next ten years. In other words, while the employees of the future specialize in at least one area, they should also have knowledge in other areas. Among the reasons that shape the skills in the business world of the future are the increase in life expectancy, the rise of smart machines and systems, the digital world, new media ecology, a constantly connected world and social technologies (WEF, 2020).

The future also requires change in managers and leaders. Now supports adaptive systems, has a flexible structure, inspires, cares about mental health and well-being, has the motivation and discipline to think critically, problem solving, active learning, self-control, resilience, stress tolerance, flexibility, positive thinking, empathy and action, There is a need for leaders who use digital tools and focus on quality (Yıldız, 2022). One thing we have learned with the COVID-19 Pandemic is that it will not be possible to meet today's needs for all stakeholders in working life with the current order and skills. Continuous renewal with multiple skills, strategic and future-oriented thinking and acting, and the role of facilitating leadership will become much more important.

## 6. Conclusion

There is no single agreed definition of the quality of work life. In addition, the reason for the quality of working life does not depend on a single factor. However, there is an understanding by most researchers that it is significant with job satisfaction. In any case, it seems essential for organizations that aim to increase the quality of work life, to see employees as valuable, to instill the feeling that they are the most valuable part of the organizational system. This approach also helps employees to work more motivated and willingly by meeting their socio-psychological needs (Momčilović et al.,

2017).

The concept of quality of working life seems to be meaningful together with the concept of "welfare". Because it is based on the subjective feelings of the employee in the organization and the main reason why different elements come to the fore when it is wanted to be defined by the person is that it is based on individual differences. While a person's well-being can only be measured with material elements such as "wage, salary", another person's initiation and maintenance of entrepreneurship can be mentioned together with spiritual factors such as community service level, job position, and happiness. As a result, the determinants of a working life quality are the high level of psychological well-being of the employee, being sure of the fair distribution of the wages, being seen as valuable in the organization, working in a job that matches his knowledge and skills and believing that he will develop, working in a safe and healthy environment, and having job security.

On the other hand, women are a catalyst for a fully socially sustainable life. It is obvious that they are able to do things beyond what they can do, at the point of balancing both their home and work lives. It is seen that societies add wealth with their productivity, success and perspectives at the point of sustainable development. In this article, some factors that increase the quality of women's work life are mentioned and socio-economic and socio-demographic structures of women are analysed in the light of the data obtained from the two nations. In this context, the relationship between the mentioned factors and the effects of women on the quality of working life has been tried to be revealed. The biggest limitation of the study is that the national language of the Serbian country to be researched is not known by the researcher, so only the texts written in English and because of the researches made by the official authorities are taken into account.

In summary, the basic statistical information on women in Turkey is as follows (TUIK, 2023);

- Women made up 49.9% of the population.
- Labour force participation rate of higher education graduate women is 67.6%.
- The employment rate of women is less than half of men.
- 67.5% of working women are satisfied with the time spent commuting to work.
- The rate of female deputies is 17.3%.
- The rate of women in managerial positions is 20.7%.
- Women are generally responsible for housework.
- 30.4% of women feel insecure when walking alone at night in their neighbourhood.
- Women's retirement age is 58.

In summary, the main statistical information for women in Serbia is (Statistical Office of the Republic of Serbia, 2023);

- 51.5% of the population consisted of women.
- Labour force participation was 46.62% among women.
- 27% of women are business owners.
- 70.1% of women have financial accounts.
- The proportion of seats reserved for women in the national parliament is 39.2%.
- Women represented 34.2% of those employed in the upper and middle management.
- Women's retirement age is 63.33.

When a short comparison is made in the light of the data obtained for both countries, it can be stated that the following factors are relatively more common in Serbia;

- Female population,
- Women's employment,
- The place of women at the top and middle management level,
- Number and proportion of female deputies in the parliament,
- Retirement age for women.

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# International Quality Conference

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**14<sup>th</sup> IQC**  
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## THE POTENTIAL OF QWL INVESTMENT IN THE LOW-INCOME SERVICE SECTOR

**Abstract:** *This paper explores the potential benefits of implementing Quality of Work Life (QWL) tools in the low-income service sector, with a particular focus on the academic industry. By investing in QWL tools, academic institutions can create a positive work environment that fosters employee well-being, engagement, and motivation, leading to improved service quality outcomes and an enhanced student experience. The paper highlights the importance of QWL indicators such as work-life balance, job security, and employee development opportunities in promoting creativity, innovation, and continuous improvement in service organizations with a focus on academia as a service provider. It argues that companies that prioritize QWL can differentiate themselves in the marketplace, achieve higher employee retention rates, and provide better service to their customers. The paper draws upon relevant research to support the positive relationship between QWL and service quality, emphasizing its significance in the low-income service sector, such as academia. Overall, this paper suggests that investing in QWL tools can be a valuable strategy for academic institutions to improve service quality outcomes and enhance the overall student experience.*

**Keywords:** *QWL investment, service sector, employee well-being, service quality, work-life balance, employee retention.*

### 1. Introduction

In this paper, we explore the importance of QWL for the low-income service sector, with a focus on the academic industry. We review the challenges faced by low-income service workers in this industry and discuss how QWL initiatives can help address these challenges and improve employee well-being and service quality. We also provide examples of QWL initiatives that are relevant to the academic industry and highlight the potential benefits of implementing similar programs in academic institutions.

#### 1.1 Definition of QWL

Quality of Work Life (QWL) refers to the overall well-being of employees in the workplace, encompassing various aspects of their work environment and job experiences.

QWL is an umbrella term that covers a wide range of factors that can impact an employee's job satisfaction and overall sense of well-being, including work-life balance, job security, workplace culture, employee development opportunities, and more.

The dimensions of QWL include:

**Work-life balance:** This refers to the extent to which employees are able to balance their work responsibilities with their personal and family obligations. Organizations can support work-life balance by offering flexible work arrangements, such as telecommuting or flexible schedules.

**Job security:** Employees who feel secure in their jobs are likely to be more engaged and productive (Saxena, V. & Srivastava, R. K., 2015). Organizations can support job security by offering stable employment opportunities

and providing clear paths for career advancement.

**Employee development:** Providing opportunities for employees to learn and grow in their roles can enhance their job satisfaction and engagement (Markos, S. & Sridevi, M. S., 2010). Organizations can offer training programs, mentorship opportunities, and other resources to support employee development.

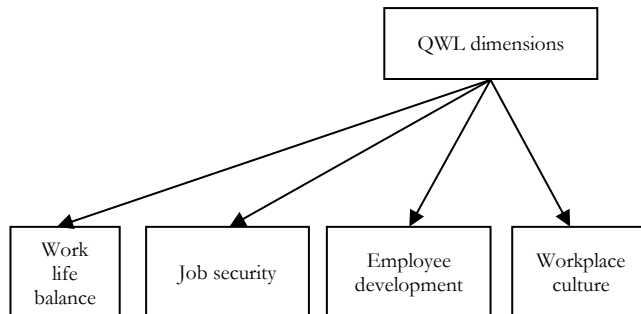
**Workplace culture:** A positive workplace culture can contribute to a sense of community and belonging among employees (Klein, K. J. & D'Aunno, T. A., 1986). Organizations can create a positive workplace culture by promoting open communication, recognizing employee contributions, and offering opportunities for employee feedback and input.

**1.2 The importance of QWL**

Quality of Work Life (QWL) is a crucial factor for organizations as it impacts various aspects of their functioning. By improving QWL indicators, organizations can create a positive work environment that fosters creativity, innovation, and continuous improvement (Li & Yeo, 2011). There are several mechanisms in which the implementation of QWL factors can contribute to organizations, as described below.

when employees feel satisfied and happy with their work environment, they tend to be more productive (Abou Elnaga, A., 2013), which ultimately benefits the organization. Higher productivity, in turn, can lead to better financial performance, employee retention, and reduced turnover rates. In addition, organizations that prioritize QWL and promote a positive work environment are more likely to attract and retain top talent. This is because employees are drawn to companies that prioritize their well-being and provide a positive work-life balance (Manning, A., 2016).

The most important argument relevant to this article is the fact that QWL has a direct impact on the quality of work that employees produce and the level of service that organizations can provide to their customers. It has been shown that companies that invest in QWL are more likely to achieve better service quality outcomes than companies that do not prioritize QWL (Mohamad, 2012). It has also been shown that QWL tools can also help service providers identify and address workplace issues that can impact service quality, such as employee turnover, absenteeism, and even burnout (Aarons 2006). When employees are motivated, engaged, and satisfied with their work environment, they are more likely to produce high-quality work and provide exceptional service to customers (Abou Elnaga, A., 2013).



**Figure 1. QWL dimensions**



### 1.3 definition and challenges of the low-income service sector

The low-income service sector is a broad term used to describe service jobs that typically pay lower wages and offer fewer benefits than jobs in other sectors. These jobs are often characterized by long hours, high levels of stress, and little job security (Borkakoty, A. et al., 2013). Examples of low-income service jobs include waiters, secretaries, security guards, and call center agents, among others.

Low-income service workers are faced with a multitude of challenges that impact their quality of life and job satisfaction. These challenges include low wages, irregular or unpredictable schedules, lack of job security, and limited opportunities for career advancement (Lambert, S. J., 1999). These workers may also be subject to poor working conditions, such as long working hours and limited break time (Lambert, S. J., 1999). These challenges can lead to high levels of stress and burnout, resulting in decreased job satisfaction and motivation, and ultimately, negatively impacting the service provided to customers (Lambert, S. J., 1999).

Moreover, the low-income service sector plays a critical role in the economy, providing essential services in industries such as healthcare, education, and hospitality (Francois, J., & Reinert, K., 1996). Despite their important contributions, low-income service workers often work in challenging conditions and earn wages that are insufficient to meet their needs.

In the context of the academic industry as a low-income service sector, it is important to consider the unique characteristics of this sector. One challenge is the limited funding and resources available for administrative support in academic institutions, leading to a heavy workload and the need to multitask (Casu, B., & Thanassoulis, E., 2006). Additionally, administrative roles in academia often require specialized knowledge and skills, which may not be

recognized or compensated appropriately. These employees also may face job insecurity and limited career advancement opportunities like in other low-income sectors. The characteristics of the work environment, such as a hierarchical structure and a culture of overwork, may further contribute to challenges for administrative employees (Sullivan, T. A., 2014). These challenges may contribute to inefficiencies and lower productivity within the administrative system, which can have a negative impact on the quality of education and research at the institution (Boštjančič, E., & Slana, Z., 2018).

### 2. the benefits of QWL in low-income service sector

The implementation of QWL factors can provide several benefits for low-income sector employees. Firstly, by improving the work environment, QWL can compensate for the low wages that these workers receive, leading to an overall improvement in their well-being, job satisfaction, and motivation (Gunawan, H., & Amalia, R., 2015). This can result in increased productivity and higher quality work, as well as reduced absenteeism and turnover rates (Aarons 2006). Secondly, QWL can provide opportunities for personal and professional development, which can lead to increased skills and knowledge, and ultimately, improved job prospects and wages. This can be particularly relevant for low-wage workers, who may have limited access to training and development opportunities.

Thirdly, by prioritizing QWL, organizations can create a positive image and reputation, which can attract more customers and ultimately lead to increased profits (Kulkarni, P. P., 2013). This can create a virtuous cycle, where higher profits can be used to provide better wages and benefits for workers, leading to further improvements in QWL and ultimately, better service quality outcomes.

By improving the work environment, providing opportunities for personal and professional development, and creating a positive image and reputation for the organization, QWL can compensate for the low wages that these workers may receive and provide them with meaningful and rewarding work experiences. Ultimately, this can lead to improved service quality outcomes and a more sustainable and equitable economy (Cavry, 1995).

### **2.1 the benefits of QWL in academia as a low-income sector**

Investing in QWL (Quality of Work Life) tools in the low-income secretarial sector of academia can have significant benefits for both the employees and the organization. As mentioned earlier, QWL tools can improve employee morale and job satisfaction, which in turn can lead to increased productivity, employee retention, and reduced turnover rates. In academia, this is especially important as the low-income secretarial sector plays a critical role in the student academic experience. These employees are often the first point of contact for students and are responsible for a wide range of tasks, such as handling inquiries, managing appointments, and processing administrative tasks.

By improving the QWL indicators in this sector, such as work-life balance, job security, and employee development opportunities, universities can create a positive work environment that fosters creativity, innovation, and continuous improvement (Li & Yeo, 2011). This can lead to employees who are better motivated, engaged, and committed to their work. As a result, they are more likely to provide high-quality service to students, which can improve the overall student experience and positively impact the reputation of the institution (Cavry, 1995).

Furthermore, investing in QWL tools in the low-income secretarial sector can also help universities to differentiate themselves from their competitors, attract top talent, and increase student enrollment (Zabadi, A. M. (2013). Students who have a positive experience with the university's administrative staff are more likely to recommend the institution to others, which can result in increased applications and ultimately increased revenue for the university (Meyer, C., & Schwager, A., 2007).

In summary, investing in QWL tools in the low-income secretarial sector of academia can have a range of benefits, including improving employee morale, increasing productivity, improving the quality of services provided to students, and attracting top talent and new students to the institution.

### **3. Conclusions & recommendations**

This article highlights the potential benefits of investing in Quality of Work Life (QWL) tools in the academic industry, which is a low-income service sector. By improving QWL indicators such as work-life balance, job security, and employee development opportunities, service organizations can create a positive work environment that promotes employee well-being, engagement, and motivation, leading to better service quality outcomes. Companies that prioritize QWL can differentiate themselves in the marketplace, achieve higher employee retention, and ultimately provide better service to their customers. QWL is an essential factor for organizations as it impacts various aspects of their functioning, and it has a direct impact on the quality of work that employees produce and the level of service that organizations can provide to their customers.

Based on the findings of this article, we recommend that academic institutions invest

in QWL tools to improve the well-being, engagement, and motivation of their secretary offering flexible work arrangements, stable employment opportunities, training programs, mentorship opportunities, and promoting open communication, recognizing employee contributions, and offering opportunities for employee feedback and input. It is also important to ensure that employees have a safe and healthy work environment, providing resources such as ergonomic workstations, health insurance, and mental health support to promote employee health and safety. By prioritizing QWL, academic institutions can attract and retain top talent, achieve higher employee retention, and ultimately provide better service to their students, enhancing the overall academic experience.

To be more concrete, here are a few recommendations of how to improve QWL in the secretary low-income sector of the

academia. First, improve working conditions; Secretarial service work can often involve long hours, repetitive tasks, and high stress. Providing ergonomic workstations, comfortable seating, and appropriate lighting can help improve the physical working conditions. Additionally, provide training and development opportunities: Offering professional development opportunities, such as training workshops, webinars, and conferences, can help employees enhance their skills and knowledge, which can lead to increased job satisfaction and motivation. Encouraging employees to pursue higher education or certifications can also be beneficial.

By implementing these recommendations, academic institutions can create a work environment that prioritizes employee well-being and ultimately leads to increased productivity, job satisfaction, and employee retention.

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## SOCIAL JUSTICE IN VIETNAM: REALITY AND SOLUTIONS

**Abstract:** *The issue of social justice is a fundamental issue of each era and has a great topical significance because it is posed together with human existence, associated with dreams and aspirations towards a nice and happy life. After all, the goal of economic growth is to serve people, the subject of development, fairly and progressively. Because, "Humans, ultimately mastering their social existence, are also thereby mastering nature, mastering themselves, and becoming a free man" (Marx & Engels, 1995, p.333). It is further confirmed in the United Nations Human Development Report (1995) when it says: "what does development mean without regard to human life?". The purpose of economic development, after all, is only a means to serve human development. It is people who create conditions, seize opportunities, and turn them into a driving force to realize their development goals, which in turn will promote socio-economic development. In the process of international integration, Vietnam has actively implemented policies to achieve social justice and has achieved certain results, contributing to improving the living standards of all people. There are certain limitations that need to be addressed to realize social justice in all of social life. The article analyzes the viewpoints and practices of implementing social justice in Vietnam, thereby proposing solutions to effectively implement social justice in Vietnam today.*

**Keywords:** *Social Justice; Social Development, Perspective; Practice, Vietnam*

### 1. Introduction

Social justice is a fundamental value that every society aspires to achieve. It has an essential role in creating stability and social development in each country. The history of human development shows that all social movements leading to uprisings of social classes originate from injustice in life and. Their goal is to overthrow the old regime to and create a new state that is more progressive, bringing justice and equality to every individual and society. On the contrary, in any community, when Social

Justice is well implemented in social relations, members of society feel that they are respected, and deservedly compensated. People will more voluntarily devote themselves to the common cause. Therefore, social justice is a basic value in life, it is also the goal, as well as the means and driving force of progress and social development in all countries.

Currently, countries around the world, including Vietnam, are strongly affected by the industrial revolution 4.0. In that context, the issue of implementing social justice becomes more urgent. Vietnam is a

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developing country, with a middle-income level, and people's living standards have improved markedly. However, the implementation of social justice still has limitations, such as low child income, an increasing gap between rich and poor, an upward rate of re-poor, and unsustainable implementation of social security, which harm negatively affected the goal of social justice socio-economic development goals. Therefore, raising awareness about social justice, so that "no one is left behind" is an urgent requirement for sustainable development in Vietnam today.

## **2. Research Questions**

The article focuses on clarifying the research questions, which is also the orientation in which the report conducts research:

- What are the results of implementing social justice in Vietnam?
- What is the well-implemented social justice solution in Vietnam?

## **3. Literature Review**

Regarding the topic of the article, there are significant works such as the Research Work on Economic Growth and Social Justice in Some Asian Countries and Vietnam which have confirmed that economic growth is a condition for reducing inequality, but the low level of inequality also encourages inequality and encourages growth. Therefore, the author analyzes the models as well as the lessons learned in some Asian countries, which are suggestive and referencing (Linh, 1998). Social progress - some urgent theoretical issues have been raised about the theory of movement, development, and progress, distinguishing the similarities and differences between these three concepts. In particular, the author has systematized typical views on social progress and standards of social progress in

the history of philosophy before Marx: from Heziot, Confucius, Plato, Aristotle, J.Vico, Henvetius, J. Russo, D. Didero, J. Condolences to G.V. Then Hegel went to Marx, Engels, Lenin, and Ho Chi Minh, combining them with some modern conceptions. At the same time, social progress is viewed from two angles: social and moral progress with socio-cultural progress (Chuan, 2000).

In the book On social progress in the market economy, the concept of social progress has been presented quite fully over the periods and some typical conceptions of the standards of social justice, the author also clarifies that the development of the market economy affects justice and social progress. (Vuong, 2004)

The concept and practice of fast-paced, high-quality sustainable economic and social development in Vietnam commented: "Economic theories have achieved only very limited success in describing the vivid and diverse real world of human development. No theory has yet been as successful as it promises to be. The repetition of general prescriptions (e.g., neoliberal structural reform programs) for the whole world, blindly adhering to a certain doctrine while ignoring individual objective realities of each country's social, political, and economic aspects, is an action that often has bad consequences. In each country, each person cannot blindly and mechanically follow any development theory but they must actively and flexibly decide and implement their development path according to the circumstances of the country, the historical tradition, and the identity of the nation, in line with the trend of the times. Only then can success" (An, 2005); "human is the central factor in realizing the combined goal" (Nga, 2007); Economic growth and social progress in the process of international integration in Vietnam. The author said: "Vietnam has made great achievements in realizing economic growth goes hand in

hand with social progress.” However, the contradiction between economic development and social progress is also very serious and harsh” (Tri &Hau, 2021).

In the article Development of social security in Vietnam: Current situation and solutions, the authors said that Development of the Social Security in Vietnam: Reality and Solutions, the authors argue that: “In the process of international integration, Vietnam has built a synchronous social security system, especially policies on job creation, minimum income guarantees for people; social insurance to compensate for the reduced income in case of illness, labor accident, old age; irregular and regular social assistance; providing basic social services in terms of health, education, preferential policies for people with meritorious services, etc. These are pioneering achievements in the implementation of Vietnam's Millennium Development Goals, which have been recognized and praised by the United Nations. However, the current social security system in Vietnam has not yet met the needs of society as policies have been promulgated a lot, but are not synchronized, and have not reached the hands of those who need support when implementing them declared in fact. The quality of public services is still low, and security measures to overcome difficulties in unusual conditions, such as the Covid-19 pandemic, are still delayed and have not yet ensured fairness, inclusiveness, and sustainability. The social security system in the new situation needs to clearly define development goals for the people, attach importance to social inclusion, and fundamentally change the perception of the position and role of communities, businesses, and regions' private sector in the pillars of well-being, reducing the burden of state subsidies and deepening international integration”(Tri, et al, 2022); "To maintain a stable macroeconomic environment on the basis of economic promotion restructuring associated with renewing the economic

growth model, improving productivity, quality and performance of the economy” (Tri, 2022).

In general, most of these works continue to clarify the roles, practices, and solutions for implementing social justice in countries around the world in general and Vietnam in particular, from which to conclude lessons learned.

#### 4. Method

Social justice is an early phrase appearing in political and social life. Historically, social justice has been mentioned since ancient times in different ideological forms: religious, cultural, and political. Interestingly, each form of ideology has a different conception of social justice. This demonstrates that the concept of social justice appeared quite early, in various form, and parallel with the development history of societies.

The issue of social justice has received more attention from the social sciences in recent centuries from the perspective of disciplines such as philosophy, politics, psychology, sociology, etc. each industry has a different interpretation of social justice. Within the framework of this article, we limit the issue of social justice from the perspective of Marxist philosophy.

In the Dictionary of Sociology of Nguyen KhacVien, two concepts are raised: Equity is the proportion between "dedication" and "enjoyment" in the condition that everyone has the same conditions and opportunities (this should remove inheritance privileges...). Another view holds that social wealth must be distributed according to the needs of each person so that all individuals are equal in material terms, etc (Vien, 1994, p. 43).

As for Marshal's Oxford Sociological Dictionary, social justice is expressed in many aspects. First, fairness is an exchange

that is equal in the rate of expenditure and income of all parties involved in the exchange. Second, distributive equity includes the unidirectional distribution of resources over rights, duties, or anything else among the entire recognized group of people. Third, procedural fairness, or procedures and mechanisms that are fair to all, also recognized that a due process that is fair and agreed upon by all can nevertheless lead to a distribution of results that some might consider unfair. Fourth, reward fairness involves fairness in specifying punishments, or levels of compensation, for being victimized. And finally, equity as equality can be equality of opportunity, equality of objective outcomes, subjective equality (equality of outcomes that takes into account public needs or values labour), positional equality (where rewards are distributed according to standard expectations to avoid feeling unjust), or parity (equality of individual contributions) (Marshal, 2010, p.108-109).

When referring to social justice, Ho Chi Minh wrote: "The people have obligations and rights at the same time" (Minh, 2011, vol.8, p.264). In the conditions after gaining independence, Ho Chi Minh always emphasized: "Our country is a democracy. How many benefits are for the people. How much power belongs to the people" (Minh, 2011, vol.6, p.232); "Our state today belongs to all workers. Therefore, workers, farmers, and revolutionary intellectuals need to realize that: Currently, our working people are the masters of our country, not employees of the exploiting class as in the old days. We have the right and enough conditions to build our own free and happy life. The working people are the collective owners of all material and cultural wealth and are equal in rights and obligations" (Minh, 2011, vol.13, p.66).

According to Ho Chi Minh, the purpose of building socialism is to constantly improve people's living standards and ensure fairness

and social progress. The goal of economic development is to raise people's living standards, to make people's lives more and more prosperous and happy. Material life, according to him, first deals with food, clothing, housing, and medical treatment. In other words, social progress is achieved when each person has more and more conditions for development; in which case, the prerequisite is to be the master of their destiny and that of their country, is to "make sure the people have enough to eat, enough clothing, more and more happiness, everyone can go to school, get sick but have medicine, if the elderly do not work, they can rest (...). In short, society is getting more and more advanced, the material is increasing, the spirit is getting better" (Minh, 2011, vol. 9, p.591). Such a society can only be socialist. He also affirmed that it is not only when economic conditions are improved that social progress can be realized, but it must be done when people's lives are still facing many difficulties.

Implementing social justice within the actual conditions of the country is always a pressing issue in social life. People will hardly satisfy all their needs as desired, especially when life is full of difficulties and deprivations people can readily accept it and try to find a way to overcome it, but they cannot accept social injustice caused by the unfair distribution situation.

By absorbing, inheriting, and developing theories on social justice along with summarizing practical experiences in our country and other countries in the world, Vietnam always asserts: "Associating economic growth with progress, social justice; promoting the human factor, taking people as the center; promoting the role of culture - the spiritual foundation of society, the goal and driving force of development" (Communist Party of Vietnam, 2021, p.99). To realize equality of development opportunities, our Party always emphasizes on the "dual" goal of social justice, both in



terms of economic efficiency and social efficiency, focusing on development goals. The XIII Congress of the Party not only emphasized the role of the State but also attached great importance to: "Promoting the role of social and socio-professional organizations participating in the formation and regulation of the public relations market economic system. Handle well the inadequacies of the market mechanism, ensure social welfare and security, national defense, security and protect the ecological environment" (Communist Party of Vietnam, 2021, p.133). This is also the basis for us to strive to soon complete the goals under the 2030 Agenda for Sustainable Development of the United Nations, emphasized by the 13th Party Congress: "Development for people, creating conditions for everyone, especially children, disadvantaged groups, ethnic minorities, and migrants to integrate, have equal access to resources, development opportunities and equitable enjoyment of social basic services. Continue to perfect and implement the policies of ethnic equality, solidarity, and mutual development" (Communist Party of Vietnam, 2021, p.150).

Along with a summary of the country's development process over more than 35 years of innovation in both theory and practice, the document of the 13th National Party Congress of our Party summarizes: "Associating economic growth with progressive implementation and social balance; promoting the human factor, taking the people as the center; promoting the role of culture - the spiritual foundation of society, the goal and driving force of development" (Communist Party of Vietnam, 2021, p.99). To realize equality of development opportunities, our Party always emphasizes on the "dual" goal of social justice, both in terms of economic efficiency and social efficiency, focusing on development goals. At the same time, Vietnam needs to strengthen social development management, ensure social

justice and sustainability in social development policies, especially social welfare, and social security; synchronously and comprehensively implement economic, progressive, social, and environmental justice goals, on that basis renew and rationally allocate resources to improve the efficiency of social development. Building and implementing institutions and policies for social development at the same time, as well as managing sustainable and harmonious social development. It is necessary to correctly forecast the trend of social restructuring in our country in the coming years to build social policies and manage social development according to the development conditions of the country; at the same time, harmoniously handle social relations, control social stratification, and promptly and effectively handle risks, conflicts, and social conflicts, ensure social order and safety, and protect the legitimate rights and interests of the people.

Thus, the essence of social justice is to liberate people and gradually realize people's lofty dreams and aspirations; bringing into play the dynamism and creativity of people in all areas of society, so that society is considered progressive and fair. In other words, social justice is both a standard of social progress and a condition for social progress to be realized. Social justice refers to the equality between people in a certain aspect, usually a matter of obligations and rights, between contributions and enjoyment. Social justice expresses human aspirations and is the goal and driving force of social development. Social justice is to be implemented in all fields (economic, social, cultural...) based on ensuring the equivalence between the creation and distribution of social benefits. Social justice is expressed in the following aspects: (i) in economic terms, social justice is considered as the ratio between the contributions of individuals and social groups to the production process and the contributions of social groups to the

production process. the enjoyment of production results - this is the most basic aspect of social justice; (ii) concerning the political and legal aspects of social justice, relating to and regulating issues of democracy, individual freedom, human rights, party leadership, and state management; (iii) regarding the socio-cultural aspect of social justice, relating to and stipulating issues of ethics, customs, practices, social stratification, and social security; the problem of opportunities for the creation and enjoyment of cultural and artistic achievements.

The article is made based on the worldview and methodology of Marxism, and the views of scientists and organizations in the world and Vietnam on social progress. The historical and logical method summarizes the fundamental problems, the dynamic trends of social progressive development, and the issues that need to be solved. At the same time, the article also uses a synthesis of specific research methods such as comparison, analysis, synthesis, induction and inference, data synthesis, etc. to serve the research and presentation of the article.

## **5. Results of implementing social justice in Vietnam**

Before innovate, the economy in Vietnam only existed in two forms of ownership by the entire people and by collective ownership; Private property must not exist. Since "Doimoi", Since "Doimoi", the fundamental change has been recognized in various forms of ownership, such as ownership by the entire people, collective ownership, individual ownership, smallholder ownership, and property ownership with private capital. Accordingly, the economy has many components with conditions for existence and development. The Party's great orientation on economic development sets forth the following

requirements: "Develop a socialist-oriented market economy with many forms of ownership, different economic sectors, forms of business organization, and forms of economic development distribution methods" (Communist Party of Vietnam, 2011, p. 73). In which, the subjects of all economic sectors are equal, cooperate and compete according to the law; the market plays a key role in effectively mobilizing and allocating development resources, which is the main driving force to release productive power; State resources are allocated according to strategies, master plans and plans in line with the market mechanism. The state's roles are orienting, building, and perfecting economic institutions, creating an equal, transparent, and healthy competitive environment; using tools, policies, and resources of the State to orient and regulate the economy, promoting production and business and protect the environment; and implementing social progress and justice in each step and development policy. The market economy has created equal opportunities for all members of society in accessing resources, actively choosing production, and choosing markets. Remove subsidies. All transactions related to resources and production results are subject to market laws; The State protects the property rights and legitimate interests of economic owners and ensures fair competition. Consumers are free to choose products. The relationship between producers and consumers is equal the price of goods is an agreement between the seller and the buyer. That is social justice in the market. As a result, the society's resources have been aroused and put into use, creating conditions to promote the growth of the economy by over 5.8%/year (period 2011 - 2015) and 6%/year (period 2016 - 2020) (Communist Party of Vietnam, 2021, p.8). It shows that Vietnam's economy has had outstanding development, openness, and high integration. That result has an important

contribution to Vietnam's extensive international economic integration and opening up. International integration is an important factor in promoting the development of Vietnam's economy.

The results of high and stable economic growth in Vietnam in recent years have created favorable conditions for the State to mobilize resources and solve social problems.

- About job settlement. Job creation is an important part of the socio-economic development strategy, contributing to the livelihoods of workers. With high economic growth, workers have more opportunities to create jobs and find jobs. The number of jobs increased from 29,412 million people in 1990 to 52.3 million people in 2012. In 5 years (2011-2015), the labor market has developed, creating jobs for about 7.8 million people, of which about 469 thousand people go to work abroad (Communist Party of Vietnam, 2016, p.238). Along with the process of creating jobs for workers, reducing the urban unemployment rate, and increasing the employment rate in rural areas. The unemployment rate in the age group in 1998 was 6.9%, decreased to 2.3% in 2015, and increased to 3.88% in 2020 (Communist Party of Vietnam, 2021, p.8) due to the impact of the pandemic. The Covid epidemic has seriously affected the production activities of many businesses, while according to the ILO in 2020, the number of people who lost their jobs increased to an unprecedented high (additional 33 million people lost their jobs) of the total number of people who lost their jobs. 220 million people and a global unemployment rate of 6.5% (Anh, 2020), making this the most severe crisis the global job market has experienced since the Great Depression recession occurred in the 1930s.

At the same time, awareness of vocational training, and the development of vocational education in the whole society and the people have had a dramatic change; the

position and role of the vocational education system in the national education system have been enhanced. Vocational education results have contributed to improving the quality of human resources. According to the latest report of UNDP (December 16, 2020), Vietnam is classified in the group of "high human development countries", ranked at 117 out of 189 countries; The human capital index (HCI) is second only to Singapore in Southeast Asia (World Bank Report, 2020).

Thus, Vietnam achieved the above results because the Party and State consider job creation as a priority direction in the realization of social progress, with the view that "Career is the root of people's livelihood".

- On hunger eradication and poverty reduction. Per capita income has increased continuously over the years, and people's living standards in regions, especially the poor have improved, so the poverty rate has decreased continuously at a high level in the whole country. Specifically, in 1993 the country had 58.1% poor households, by 2015 it was less than 4.5%, (particularly in extremely difficult areas, less than 30%) (Communist Party of Vietnam, 2016, p.110); the human development index (HDI) increased from 0.683 (in 2000) to 0.728 (in 2011), ranking 128/187 countries, in the upper middle group of the world; In 2011, our country completed 6/8 of the Millennium Development Goals (MDGs) which set by the United Nations for developing countries by 2015. Currently, Vietnam is implementing the Targeted Reduction Program. Sustainable poverty in the 2016-2020 period was strongly implemented, shifting from a single-dimensional approach to a multi-dimensional approach, focusing on the poorest groups and households. The rate of multidimensionally poor households in the whole country will decrease from 9.88% at the end of 2015 to less than 3% in 2020, on average in the period 2016 to 2020, it will decrease by more than 1.4%/year

(Communist Party of Vietnam, 2021, p. 43). The World Bank's Vietnam development report assessed: that Vietnam's achievements in hunger eradication and poverty reduction are among the most successful stories in the process of economic development.

- About social insurance. Vietnam considers social insurance work as one of the key tasks of the socio-economic development process, ensuring the rights and obligations of millions of workers. In recent years, based on stable economic growth, the number of participants in social insurance has increased rapidly, contributing to ensuring the safety of employees when facing risks in life. The rate of participation in compulsory social insurance, voluntary insurance, and unemployment insurance is increasing, contributing to ensuring safety when workers encounter risks in production. Currently, Vietnam continues to invest in building new and upgrading, expanding many hospitals, developing sea and island healthcare, and encouraging the development of non-public healthcare. People's types of insurance are increasingly expanding with diverse products. The subjects participating in social insurance, health insurance, and unemployment insurance are increasing day by day and enjoying the regimes and benefits by regulations. The number of people participating in social insurance reached more than 11.5 million. Health insurance coverage is over 90% of the population (Communist Party of Vietnam, 2021, p.65).

- Social assistance work has gradually shifted to a human rights-based, human-centered approach. The beneficiaries of social assistance were expanded, and the standard of social assistance was adjusted to increase, creating conditions and opportunities for the disadvantaged to stabilize their lives with the movements of "Muslim, Mutual Aid", "Fund for the poor", "Grateful return", "Drink water, remember the source" are held regularly and attract the response of many social forces, significantly

contributing to improving social security for all people, especially the poor and poor areas.

- On education and training. Developing education and training not only plays a role in promoting economic development but also affects people's basic development, ensuring equity and sustainable social progress. To create opportunities and conditions for children in poor households, ethnic minority children in disadvantaged areas, helpless children, etc. to access basic education, the Government has issued many policies on tuition waivers and reductions and other preferential policies. In recent years, education and training have grown in size, diversifying classes from preschool, and primary school to college and university. In 2000, the whole country reached the national standard on illiteracy eradication and primary school universalization by the end of 2010, and most of the provinces achieved lower secondary education standards. The rate of students graduating from high school in the 2016-2017 school year accounted for 97.94%; the national literacy rate of the population aged 15 and over is 95.1%; 100% of provinces and cities meet the standards of preschool education universalization (General Statistics Office, 2018, p.120). Thus, the implementation of social progress in education has been improved, especially in creating learning opportunities and conditions for ethnic minorities, remote and isolated areas, children of poor families, and children with disabilities, who have made remarkable progress. The education system has initially been diversified in terms of types, methods, and resources, gradually integrating with the general trend of world education. From an education system with only public schools and mainly of the formal type, there are now non-public schools, with many types of informality, open schools, and training methods from around the world distance, the method of training associated with foreign countries.

- The capacity of the system of medical facilities is consolidated and developed. As a result, people have easier access to medical services. In addition, medical facilities and equipment are also focused on investment, better meeting the people's medical examination and treatment needs... Vietnam is one of the few countries with a comprehensive health system that has been adjusted and organized widely to villages and hamlets; it has mastered many world-class high-tech techniques such as limb, heart, liver, and kidney transplants...; it controls many dangerous diseases, including Covid-19; and it proactively produces many types of preventive vaccines, most recently a vaccine against Covid-19...The average life expectancy of people increased from 62 years old in 1990 to 73.7 years old in 2020. In 2019, the development index Human development (HDI) of our country reached 0.704, belonging to the group with the highest HDI in the world, especially compared to other countries with the same level of development (Trong, 2021).

However, besides the above-mentioned outstanding results and achievements, "There are still signs of not paying due attention to ensuring socialist-oriented development; ... ensuring social welfare, implementing social progress and justice in the development of the market economy; the overall and synchronous development of regions, regions, and localities has not yet been ensured according to comparative advantages and to promote specific socio-economic conditions" (Communist Party of Vietnam, 2021, p. 108). Policies and laws are not synchronized; organization and management model; the effectiveness of social management still has many limitations and shortcomings. Poverty reduction is not sustainable; a part of the poor, poor communes have the ideology of dependence, looking forward to the support of the State. Education and health care in mountainous, highland, and ethnic minority areas are still

limited. Medicines, traffic, labor, and food are not safe. Crime and social evils are still hidden and complicated in many places. The principle of distribution by labor has not been thoroughly implemented; "Policies on salary, income, social insurance, health insurance, and social welfare are not effective; the benefits of the people from the country's development achievements have not been harmonized" (Communist Party of Vietnam, 2021, p.86). Although the unemployment rate in the working-age population decreased from 2.88% in 2010 to 2.5% in 2020, the professional and technical qualifications of Vietnamese workers are still weak in quality. There is a shortage in quantity, nearly 80% of employees are untrained (General Statistics Office, 2020, p.164), some part of laborers have been trained or are used in the wrong profession, they have to be trained to create new jobs that can work in enterprises, and there is a serious shortage of highly qualified technical workers and high-class service workers (finance, banking,...); the number of poor and unemployed is still high.

A selfish and self-interested lifestyle also began to form and has increasingly penetrated many strata of society. The lifestyle in favor of enjoyment, and living in a hurry is gradually destroying the personalities of many people, leading to many traditional values gradually becoming obsolete. Meanwhile, the crisis of trust is also a major obstacle to the establishment of social relations and the realization of economic and political goals. Along with that, sexual abuse, child abuse, and deviant behavior of students tend to increase; school violence is common among female students; a part of teachers and teachers have a decline in personality and morality, which adversely affects the image of the teaching profession... increasing the crisis of trust in society.

These limitations and inadequacies show that the implementation of social justice in

Vietnam is not synchronized, compatible, and in harmony with political and cultural development.

## **6. Solutions for social progress in Vietnam**

First of all, in macroeconomic policymaking, the relationship between economic growth and social justice must be harmoniously resolved, step by step, firmly and synchronously with both goals of economic and social justice. Continue to strongly affirm the need and importance of social justice implementation. From there, it serves as a solid basis for the formulation of the State's guidelines, policies, and laws on the implementation of social justice throughout the development process. Raising awareness among all levels, sectors, and the whole population about the relationship between economic growth and social security; especially in agencies that plan and implement socio-economic development policies. Do not let misconceptions in the planning and implementation of economic policies forget about the need to harmonize with policies to implement social justice.

Second, it is necessary to have a new mindset about progress and social justice in the new era. The implementation of policies to create equity in Vietnam in the past seems to be only on the "surface" and has not yet solved the root cause of poverty, the core of poverty is inequality of opportunities, thereby solving the problem. Necessary synchronous solutions have not been fully focused on and implemented. Therefore, in the coming time, besides continuing to implement subsidy programs and redistributing income, it is necessary to change the mindset in formulating measures to tackle the root of poverty to implement poverty reduction measures poverty reduction program progress, and social justice. To do this, the orientation in the coming time is: To promote comprehensive

development of human resources; improve the effectiveness and practicality of education and training; support the poor to participate in radiology services; labor market development.

Third, deal well with labor, employment, and income, ensuring the quality of people's lives. Job creation is one of the important policies of each country, especially for developing countries like Vietnam. Lack of work, no jobs, or jobs with low productivity and income will not be able to help people secure their lives and develop sustainably. Having a job and increasing income will help people be able to meet their legitimate material and spiritual needs, help them access good quality services, improve their status in society, and integrate with the surrounding environment. In that spirit, all levels and sectors need to promote social investment promotion, create more jobs, develop and perfect policies on wages and salaries, and fundamentally overcome irrationalities. In which, attaching importance to improving the quality of human resources; Vocational training and job creation for workers must be associated with socio-economic planning, economic development programs, occupations, and orientations for economic restructuring of each locality. Continuing to improve labor protection policies, and promoting labor export is an important solution in creating jobs, meeting practical needs, contributing to increasing incomes, and improving skills for workers' current motion.

Fourth, actively prepare necessary resources, which focus on mobilizing social resources in the implementation of social security to ensure social justice. When promulgating social policies, it is necessary to ensure material resources from the state budget and other sources for the implementation of such policies to create trust among people and all classes of society.

It should be clearly defined that the state still plays a leading role in organizing the implementation of social policies. It mainly focuses on building mechanisms and policies, to ensure minimum law enforcement and support. To maintain a good social safety net, the state must gradually reform the social security system toward socialization in order to reduce the burden on the budget and be suitable for socio-economic conditions. Mobilize humanitarian contributions of domestic and foreign organizations and individuals to participate in the implementation of social security programs.

Fifth, expand the scope and beneficiaries of social welfare in stages suitable to the level of socio-economic development. Vietnam is a developing country, the economy is not yet strong enough to deploy a comprehensive social welfare system, therefore, in the process of implementing the social welfare system, it is necessary to proceed step by step, prioritizing the implementation of the social welfare system for disadvantaged groups, the elderly, young children, the disabled..., then gradually expand the beneficiary group, accelerate and promote forms of socialization of social welfare activities. Experience in many countries with successful social welfare models shows that the private sector is a key force in creating social welfare funds while creating conditions for people to freely choose. Choose your form of protection.

Sixth, enlist international support. It is the material and spiritual help, the sharing of knowledge and experience to help countries facing difficulties in solving the relationship between economic growth and social security policies. To be able to enlist the help

of friends from international organizations. To do so, Vietnam needs to strengthen propaganda and promotion of foreign aid-seeking programs; use it for the right purpose as committed when receiving aid; publicity, and transparency in the use of international aid.

## 7. Conclusion

Implementing social justice is a correct and transparent policy of the Party in leading the country. The basic purpose of the social justice policy is to ensure people's living standards and socio-political stability. Implementing social justice is both a goal and a driving force for comprehensive human development, an important measure in realizing the country's sustainable development goals. In the process of international integration, Vietnam has achieved positive results in the implementation of socio-economic development policies to ensure social justice. However, Vietnam is still facing many difficulties in implementing social justice to reduce unsustainable poverty, the gap between rich and poor tends to widen; underemployment and unemployment are still increasing; The quality of social security services is still low and does not meet the needs of the people... With the proposed solutions, the author wishes to contribute to finding the right direction to well-implemented social justice in the community. In the coming time, towards the goal of "striving for the middle of the twenty-first century, our country becomes a socialist-oriented developed country" (Communist Party of Vietnam, 2021, p.112).

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## DATUK KALAMPAYAN POLITICAL COMMUNICATION APPROACH AND ITS RELEVANCE TODAY IN SOUTH KALIMANTAN

**Abstract:** *Datuk Kalampayan's political communication research began with his contributions to the government of the Banjar Sultanate, such as the establishment of an advisory body to the Sultan, the establishment of a juridical institution known as Karakatan Qadhi as the forerunner of today's religious courts, the writing of fiqh books of worship in Malay at the request of the Sultan known as Kitab Sabil Al-Muhtaddin, as well as the construction of waterways in the fields of cultivation and agriculture in the 18th century. This study aims to analyze the political communication approach of Datuk Kalampayan in the Banjar Sultanate and its relevance today in South Kalimantan. Researchers used qualitative methods in this study, by digging up data through interviews with informants, according to their capacity; zuriat, members of the legislature/author of the book Sheikh Muhammad Arsyad Al Banjari and other sources, as well as decommentation data. The results of the research include the approach to political communication that runs harmoniously and synergistically; argumentative rational dialogue; strengthened his theory of symbolic interactional Mean in 1934; The political communication model that was carried out was: the bilhikmah political communication model, with characteristic values, including; strengthening the firmness of faith as the foundation of social, national and state life. upgrading yourself (science and charity), consistent coexistence, harmonious synergy. Do not make frontal criticism of the government, and always pray for the good of the government for the benefit of masalah. Prioritizing argumentative rational dialogue in conveying opinions, ideas and thoughts. Prioritizing togetherness, advancing regional development, and interacting by displaying good manners.*

**Keywords:** *Datuk Kalampayan, political, communication model*

### 1. Introduction

Research on Sheikh Muhammad Arsyad Al Banjari such as Bambang Subiyakto, in the dissertation of the Doctoral Program (S3) of

the Graduate School of the Indonesian University of Education Bandung (2015) examined the character values of social studies education. Hasanah (2019) explained the focus of his research is on proving the role

of moderate- ready Arsyad Al Banjari and that Banjar is very pliable and very open to new elements without losing personality, not rejecting cultural and artistic aspects of religion.

Buseri (2017) explained educational and spiritual and cultural research on the role of Sheikh Arsyad Al Banjari, Abd. Rochim Al-Audah (2019) in his dissertation at the Postgraduate Doctoral Program at Universitas Islam Negeri (UIN) Sunan Gunung Djati Bandung, the focus of his research lies on the Political Thought of Sheikh Muhammad Arsyad Al Banjari, and its Relevance for Legal Political Development. Wafa (2018) explained FISIP, Islamic University of Kalimantan Muhammad Arsyad Al Banjari, the focus of his research lies on the Thoughts and Work of Sheikh Muhammad Arsyad Al Banjari in the Perspective of Religious Communication. Meanwhile, Purnomo, (2010) focused his research on stakeholders and elaborated Thaib communication model (2019), His research focused on political communication reviewed from the perspective of communication science, political science, and Islamic communication, as Umar (2020) explained in the postgraduate thesis of Universitas Islam Negeri Alauddin Makassar focused his research on Ulama and Politics (Study of the Role of Ulama in Political Contestation in Polewali Mandar Regency), so in the research researchers clearly have no similarities in studying the work of Sheikh Muhammad Arsyad Al Banjari, because researchers look more at the aspect of political communication of Sheikh Muhammad Arsyad Al Banjari, so this research is very clearly visible the difference. His closeness to the Sultanate made it easier for him to communicate. Seeing the phenomenon in Datuk Kalampayan's closeness to the Sultan in interacting and communicating, shows that there is harmonious political communication. Mulyana (2013) said that communication in politics is a linear implementation in the

system.

The linear approach has an influence on the information of the political field, while the system approach is integrated into the stability and harmony of the political system. Both of these approaches constitute the reality of political communication as an orderly reality and therefore so easily foreseen (Iyansyah et al., 2021).

When viewed in the context of the relationship of political communication there is a desire for a person to conform to a communicator or other form of communicator emotionally can be satisfactory; so the communicator will prevail in his communication if he is able to attract the attention of the communicator (Effendy, 1993). This means that as a communicator as well as a mediator, he gives a thoughtful attitude (Wijaya et al., 2021).

The relationship of political communication can be seen from the aspect of interpersonal communication/interpersonal communication expressed by Mulyana (2004) as communication between people who face-to-face, allow everyone to respond directly.

Interpersonal communication or interpersonal communication is the delivery and reception of messages between communicators and communicants with immediate feedback and effects. From that, there are several communication components, including the source, message, receiving channel, and return. Interpersonal communication affects communication and relationships with other people. The message that is communicated, begins with oneself (Muhammad, 1995).

Interpersonal communication allows dialogical communication to take place. Dialogue is a form of interpersonal communication that shows the occurrence of interaction and communication in the form of functions as communicators or communicants in turn. This process occurs with mutual respect as human beings (Hidayat et al., 2021).

On the other hand, it can be seen that interpersonal communication is sometimes used to facilitate persuasive communication, which is a human psychological communication technique that is polite, flexible, and civilized. Thus, each communication actor will perform four actions, namely forming, conveying, receiving, and processing messages, the four actions usually take place sequentially, and the form of a message is interpreted as creating an idea or idea with a certain purpose (Habibah et al., 2021).

In the process of interpersonal communication, of course, there is interaction in communicating and interaction in the dialogical, then in line with the Symbolic International theory of Goerge Heber Mead in 1934 by formulating through his book mind, self and society. This theory was later developed by Herber Blumer in three ways, namely, human behavior is influenced by the meaning they have about others, interactions are very important for the development and delivery of messages, and the meaning that a person has regarding various events or others can change over time (Arizal et al., 2021).

Datuk Kalampayan's persuasive communion with the Sultan can enable closeness and unite the Sultan with the people through communication-based on the ties of Islamic religious teachings/values, especially during the reign of Tahmidullah to Sultan Adam al-Wasikbillah, which has such a strong dimension. Religion and politics in their view are a unity of remembering (Shaddiq et al., 2021).

Then if we look at the context of the latest development in socio-political relations, political communication can also be seen from the theory of organizational/group communication, because it is related to the hierarchical line of political parties, so the management of political parties at the provincial or district/city levels that even the sub-district level cannot break away from the hierarchical line of the party, this is what

allows technical obstacles in the field why political parties at the provincial level and below it seems to have difficulty in conducting political communication, so often political parties cooperate with clerics in conducting their political communication (Kurniawan et al., 2021).

## 2. Research methods

The research was conducted with the focus of research researched with a qualitative type of research with a case study approach. Researchers will observe directly to the research resource persons how political communication in the Banjar Sultanate is carried out by Datuk Kalampayan so that they can better understand and get clear and accurate research information and data.

Qualitative research methods are based on postpositivism, where the researcher is a key instrument, data collection techniques are carried out triangulation, data analysis is qualitative, and qualitative research results emphasize meaning more than generalizations (Sugiyono, 2015).

In this study, researchers interviewed 14 informants, consisting of 4 people from the Datuk Kalampayan jury and 1 author of a book related to Datuk Kalampayan, and 7 people from political party administrators in South Kalimantan, and 2 academics. To choose the location where the existence of the information from the zuriat he is located in the city of Martapura, Banjar Regency. Meanwhile, the informant from the author of the book is located in Banjarmasin.

The data worked on from the object of this study is sourced from primary data; main data and literature relating to Datuk Kalampayan and some literature relating to political communication. In this study, the primary data source in the form of words was obtained from interviews with predetermined informants which included various matters related to the title of the study, namely the Political Communiqué of Sheikh Muhammad

Arsyad Al- Banjari (Datuk Kalampayan in the Banjar Sultanate in its application to Political Parties in South Kalimantan, which included the proximity of Datuk Kalampayan in the Banjar Sultanate, and Application of Datuk Kalampayan's Political Communication Model to Political Parties in South Kalimantan).

### 3. Results and discussion

There is nothing in the historical record that states that Datuk Kalmpayan ever made a criticism of the Sultanate government, let alone done it frontally, because he was of the view that while the government was running its system of government with the aim of achieving the benefits of mashlahah, it should be supported, and if it makes a mistake then give good advice and pray that the ruler is always in safety and wise in exercising his power (Shaddiq & Handayani, 2021).

According to informants from zuriat Datuk Kalampayan, namely Mr. Hatim, Mr. Fauzan, Mr. Zailani, and Mr. Defri, said that Datuk Kalampayan's closeness in the Banjar Sultanate was very clearly visible, especially since he was a child until adulthood lived in the Sultanate palace environment after being appointed as a child by Sultan Tahlilullah, even married by the Sultanate to Mr. Bajut, even studying at Haramain at the expense of the Sultanate, this made a deep impression on him (Joko et al., 2022).

Meanwhile, according to other informants both Suripno, Suwardi, Zulva, Hasanuddin, Firman, Lutfi, Irfan, Iqbal, Audah, and, Yuni also said that Datuk Kalampayan had a very remarkable affinity in the Banjar Sultanate, it was they asserted that it was life in the palace environment that was the important thing in the life journey of Datuk Kalampayan because it had been maintained by Sultan Tahlilullah from childhood to adulthood. which was then very harmonious and synergistic closeness with the Sultanate's government (Norrahmi et al., 2021).

Thus the life of Datuk Kalampayan in the palace environment became the main source of his closeness in the Sultanate of Banjar so that the interaction and communication of the Sultanate seemed so harmonious and synergistic with the Sultan's power and government so that it seemed easier and more comfortable in conveying his ideas and thoughts (Irpan et al., 2021).

It could be that when in the haramain he already had a grand design of thoughts with various ideas and ideas that would later be communicated to the Sultan after returning later, it was proven by various thoughts, ideas he communicated to the Sultan were always approved.

This is not only his brother as a Sultanate scholar, but he can position himself as a person who easily understands and understands the dynamics of life in the Sultanate, so he chose to live outside the Sultanate environment, and lived outside the palace, and the Sultan gave up and gave him up to live outside the palace by giving up a piece of land to be his residence which is now in the area within the fence Martapura.

His closeness in the Banjar Sultanate, not as a return for gratitude because he had been maintained by Sultan Tahlilullah from childhood to adulthood and married to a commensurate woman, was also given the scholarship to study haramain for 35 years, but his closeness in the Banjar Sultanate was based on faith and charity in the life of society, nation and state.

The closeness is based on the value of religion that binds the power of faith to unite in harmonious and synergistic relations in the life of the nation and state society, in line with the vision of Sultan Tahlilullah who agreed to him as a child, namely the application of Islamic law in the Banjar Sultanate.

That is, to unite life in society, nation, and state, it cannot only hold on to the strength of its humanitarian aspects which are based on the culture of the community but the continuity of life in society, nation, and state

is based on the solemnity displayed with the glory of morals, because the life of the nation and state is part of the ijtihadi shia in the fiqh of worship.

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As for bridging the implementation of fiqh

worship (ijtihadi syiasi) it is to display good morals, because politics as a shiasi ijtihadi is of course political interaction and communication prioritizing civilized politics, not making it difficult for others or causing trouble to others, but civilized politics, always contributes to its ideas, ideas, and thoughts in supporting government and praying for his government always in blessings and safety, so that it can carry out its programs well, that way prosperity will be felt by its people.

Then the closeness of communication Datuk Kelampayan was consulted by Banjar seen from the interaction and communication carried out by Datuk Kelampayan in the Sultanate of Banjar which was so visionary with what he conveyed to the Sultan, strongly supported and corroborated his theory of symbolic interactional communication of Mead in 1934 through his book entitled *Mind, Self, and Society*, for Datuk Kelampayan had already practiced it in the Sultanate, with his ideas and thoughts that were his contribution at the time From the information obtained by the researcher that the role/work of Datuk Kelampayan in the Banjar Sultanate is very clearly visible, and shows the relationship between Datuk Kelampayan and the Sultan living side by side in contributing, not criticizing each other, the Sultan needs a scholar who always gives his advice and thoughts, while Datuk Kelampayan as a scholar also prays for the course of the Sultan's government, also gave various thoughts in the continuity of government in the Sultanate.

Among the character values, he has, among them, commitment and consistency in conveying the truth in the good according to Islamic teachings, having criticized the government/Sultan, always praying for goodness in the continuity of the Sultanate, being moderate to the Sultanate/government system by giving thoughts to the Sultan according to his function and duties as a cleric, the principle that the ulama and the government (umara) are side by side by side

with each other to contribute to each other benefit.

The values of character Datuk Kelampayan in the Sultanate of Banjar set an example to us today and in the future that the character is very important in displaying attitudes and personalities to anyone by prioritizing and displaying customs and ethics in interacting and communicating with others, consistency and commitment in being in giving thoughts on the frame of truth and goodness for the benefit of the benefit.

When we look at the contribution of Datuk Kelampayan in Sultanate of Banjar which is extraordinary in his work and role, this shows his closeness in the Banjar Sultanate in interacting and communicating with the Sultan of Banjar which is very meaningful in the continuity of the Sultanship of the Sultanate. As a figure of a cleric in the Sultanate, of course, his work and role are very strategic in carrying out political communication in the environment of the Banjar Sultanate.

The interaction and political communication of Datuk Kelampayan in the Sultanate of Banjar are inseparable from the various things he got in the midst of community life, because Datuk Kelampayan chose his life outside the palace environment so that he was willing to see firsthand what was faced by the community, besides he was also a cleric who was asked for his opinion by the community. From that reality, there was a sensitivity and concern that he ultimately communicated with the Sultan, as a manifestation of the attitude of supporting the continuity of the Sultan's rule.

The attitude of supporting the continuity of the Sultan's rule was then manifested by him in some of his ideas and ideas and thoughts that were conveyed to the Sultan, where, the idea, the idea (encoding) was a process of changing thoughts into communication.

In conveying the message to the Sultan (communicant), the face-to-face takes place with an argumentative rational dialogue until

the Sultan gets the result of the conversation and makes the main point of mind Datuk Kelampayan as important points, which then, the Sultan makes the communication process (argumentative rational dialogue as a thought (decoding), which then becomes a reciprocal relationship in the Datuk Kelampayan as a communicator and the Sultan as a communicant (on the contrary) and reached an agreement so that it was always agreed upon and even condoned by the Sultan.

It was told by informants from his zuriat, both Guru Hatim, Fauzan, Zailani, Defri, which Datuk Kalampayan's contribution to the Banjar Sultanate was extraordinary with his ideas and thoughts in the continuity of the Banjar Sultanate, which of course cannot be separated from the values of Islamic teachings. In carrying out the mission of broadcasting Islamic teachings in the Banjar Sultanate, of course, Datuk Kalampayan hoped to get the blessing of the Sultan of Tamjidillah II, so he saw that previously the Banjar Sultanate did not have a Crown Council, then he initiated his idea to form a Crown council in the Banjar Sultanate. Another roles was also narrated by informants from his zuriat, where the most famous is the Sultan's request to Datuk Kalampayan to make a book of fiqh worship in Malay and the request of course cannot be refused by him, he also fulfilled the Sultan's request, which is now known as the book/kitab of Sabil Al Muhtaddin, and prayed eternally falaq daulahnya, and still learned until now, it is not only in the land of Banjar and archipelagos, even in Southeast Asia and Africa.

In the economic field he made an 8 km long waterway, for the plant and chain which is now the aqueduct called the lord's river, in the constitutional field he proposed the establishment of a mufti institution/Sharia court, he also initiated to form the Constitutional Institution of the judiciary, which we are called the one named karapatan qadhi as the forerunner of the current Religious court. The mufti institution was led



by his first grandson named Mufti H. Muhammad As'ad Samai Mufti. H. Jamaluddin Sungai Singgah and the first qadhi were also led by his grandson named H. Muhamad Thoha which was recorded in the state gazette no. 689 of 1937 which recognized the qadhi Institution or Karapatan qadhi Institution as a State Institution by the Dutch.

While information from other informants both Suripno, Suwardi, Zulva, Hasanuddin, Firman, Lutfi, Irfan, Iqbal, and Audah, that the work and role of Datuk Kalampayan in the Sultanate is very meaningful in the continuity of the Sultanate because it is his ideas and thoughts that are the most important thing for the Sultanate, he has multi-dimensional science, both religious knowledge and public knowledge, so many initiations came from him both the formation of crown council as an advisory institution of the Sultan, mufti institution and Qadhi Institution (Karapatan Qadhi) as a judicial institution, Construction of an 8 km long water/irrigation canal known as Sungi Tuan, the establishment of the first pesantren hut in the field of education, as well as the writing of books, one of which was at the request of the Sultan to make a fiqh book of Malay-language worship known as the book of Sabil al Muhtaddin which until now people have learned.

By means of the information obtained by the researcher that the role/work of Datuk Kalampayan in the Sultanate of Banjar is very clearly visible, and shows that Datuk Kalampayan's relationship with the Sultan lives side by side in contributing, not criticizing each other, the Sultan needs a scholar who always gives his advice and thoughts, while Datuk Kalampayan as a cleric also prayed for the course of the Sultan's rule, also gave various thoughts in the continuity of government in the Sultanate. As interview with one of the zuriat Datuk Kalampayan Guru Hatim.



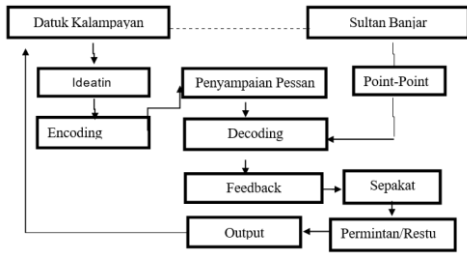
**Figure 1.** Interview of Researcher with Teacher KH. Hatim Salam/Zuriat 7th Datuk Kalampayan, taken on March 21, 2022 at 13.0-15.30 in his residence

The Sultan's blessing, as the political legitimacy of the Sultanate, is a form of the effectiveness of his political communication as a form of closeness Datuk Kelampayan in the Sultanate of Banjar, and as an output of this communication which is then returned to Datuk Kelampayan to follow up on the Sultan's blessing or request.

The Sultan's request for the grandfather of Kelampayan is a decree or a decision/order of the ruler of the Sultanate which is carried out as a duty given to the grandfather himself so that the blessing or request of the Sultan is a political decision of the Sultanate that can be a hold for the great-grandfather of the great-grandfather. It can be seen in the picture below.

The closeness of Datuk Kalampayan was the Sultanate of Banjar in conducting interaction and political communication to the Sultan, this happened according to interpersonal communication.

Interpersonal communication will run well if it is through the right approach. Interpersonal communication is the process of conveying messages between two people which is carried out face to face or face to face which allows direct feedback and the message is verbal or non-verbal.



**Figure 2.** Interpersonal communication model

Komunikasi Politik Datuk Kelampayan di kesultanan Banjar Gambar 1: diolah peneliti tahun 2022 Sumber : data Informan yang diolah.

Interpersonal communication is carried out in close proximity, communicators and communicants send messages directly and simultaneously.

Interpersonal communication is the interweaving of the process of conveying information, ideas, and feelings to others verbally or nonverbally in order to obtain meaningfulness so that others understand or change their attitudes, feelings and behaviors that occur in a society (Mulyana, 2005).

According to informants from the Datuk Kalampayan Zuriat, both Guru Hatim, Fauzan, Zailani, Defri, and Yuni said that Datuk Kalampayan's work in the Banjar Sultanate was very contributing, this certainly shows us that the relationship between beliu as a cleric and Sultan as a political power in the government is very harmonious and synergistic, although politically practically Datuk Kalampayan never involved and involved himself in the realm of political dynamics in the Sultanate, but he always gave his best in the continuity of the Banjar Sultanate also prayed for the eternal Sultanate of his rule.

Thenif we look at the current relationship between clerics and poltics, we know that together, it must be admitted that there is a part of the scholars who participate in politics practically, but not all scholars are that kind of. If we correlate it with the example of

Datuk kalampayan, then politics for the role of the cleric in the context of islamic proselytizing.

Politics as a means and medium of proselytizing towards the benefit of the good, so that the cleric in relation to politics can run harmoniously, the cleric in politics should not be in practical politics, but can give his thoughts as a contribution and pray that he can achieve the purpose of the mashlahah benefit.

Other informants Suripno, Suwardi, Zulva, Hasanuddin, Firman, Lutfi, Irfan, Iqbal, Audah and Yuni said that the cleric in relation to politics was not in the sense of having to enter practical politics, but for political parties it did not close the space for the cleric to enter the political party, in the context of being a party advisory panel to give its advice and thoughts to party cadres. Even political parties are currently always building relationships with clerics, so we hope that there will be synergy between political parties and ulama and harmonious relationships are established, and so far this is what has been done. If we terrorize Datuk Kalampayan's work in the Sultanate of Banjar, it is indeed as desired so that it can provide motivation in playing a role in politics, so that scholars are not dragged into practical politics.

Thus that the clergy and politics are important, but it does not mean that the cleric participates in politics, the cleric stays in his corridors by carrying out his duties and functions as the leader of the ummah, can give his political thoughts as a charge of proselytizing to political parties. Political parties also play a role in accordance with their vision and vision to achieve their goal that power is a way to achieve the benefits of benefit. As Suripno Sumas, legislative member of the PKB of the South Kalimantan provincial legislature, revealed in a research interview.



**Figure 3.** Researcher interview with Mr. H. Suripo Sumas, S.H., M.H., member of the South Kalimantan DPRD/PKB party, dated April 18, 2022 at 12.30-13.30 in commission room 4.

When we see Datuk Kalampayan's contribution to the Banjar Sultanate which is extraordinary in his work and role, this shows his closeness in the Banjar Sultanate in interacting and communicating with the Sultan of Banjar which is very meaningful in the continuation of the government in the Sultanate. As a figure of a cleric in the Sultanate, of course, his work and role are very strategic in carrying out political communication in the environment of the Banjar Sultanate.

Datuk Kalampayan's political interaction and communication in the Sultanate of Banjar cannot be separated from the various things he got in the midst of community life, because Datuk Kalampayan chose his life to be outside the palace environment, so he was willing to see firsthand what was faced by the community, besides he was also a cleric who was asked for his opinion by the community. From that reality, there was a sensitivity and concern that he ultimately communicated with the Sultan, as a manifestation of the attitude of supporting the continuity of the Sultan's rule.

The attitude of supporting the continuity of the Sultan's rule was then manifested by him in some of his ideas and ideas and thoughts that were conveyed to the Sultan, where, the idea, the idea (encoding) was as a process of changing thoughts into communication.

In conveying the message to the Sultan (communicant), with the face-to-face it takes place with argumentative rational dialogue until the Sultan gets the result of the conversation and makes the main point of mind of Datuk Kalampayan as an important point, which then, the Sultan makes the process of communication (argumentative rational dialogue is a thought (decoding), which further becomes a reciprocal relationship in the daktuk kelampayan as a communicator and the Sultan as a communicator and the Sultan as communicants (on the contrary) and reached an agreement so that it was always condoned and even condoned by the Sultan.

The Sultan's blessing, as *le gitimasi politik* Sultananan is an effective form of his political communication as a form of Closeness of Datuk Kalampayan in the Sultanate of Banjar, and As the output of this communication which is then returned to Datuk Kalampayan to follow up on the blessing or request of the Sultan.

The Sultan's request to Datuk Kalampayan is a decree or decision/order of the Sultanate ruler which is carried out as a duty given to Datuk Kalampayan himself, so that the blessing or request of the Sultan is a political decision of the Sultanate that can be a hold for Datuk Kalampayan.

According to Joseph A. Devito in the book *The Science, Theory and Philosophy of Communication* (Effendy: 59-60) that interpersonal communication is the process of sending and receiving messages between two people, or between a small group of people with instantaneous feedback.

Meanwhile, according to Weaver, interpersonal communication is defined as a dyadic or small group phenomenon which naturally entail communication about the self. Interpersonal communication as a phenomenon of interaction of two people or in small groups that shows communication in a natural and unpretentious way about oneself.

Effective communication is judged by the good delivery of messages from the communicator to the communicant. The characteristics of good communication according to Kumar in Wiryanto's book (2004:36) are; openness, empathy, supportiveness, positiveness, equality.

According to Suranto Rahmi; Interpersonal Communication Approach (2011: 114-118) there are four approaches in interpersonal communication. First, the informative approach is that the communicator only conveys information to the communicant with the aim that the communicant can obtain new information. Messages are conveyed repeatedly and are one-way in order to disseminate information. Second, the dialogical approach is a way of influencing and changing the views and attitudes of others openly. It is said to be open because both sides are equally willing to accept the views of both the communicator and the communicant. The characteristic of the dialogical approach is that there is a dialogue towards the process of sharing information, both parties are in an equal position. Third, a persuasive approach that aims to subtly change attitudes by means of persuading without force and without violence.

Persuasive is a complex communication process that individuals carry out using verbal and nonverbal messages in order to persuade or provide encouragement aimed at voluntarily changing one's attitudes and behavior. Fourth, the instructive approach is to emphasize the communicator's higher bargaining position where he gains legitimacy to govern, teach and even propose a kind of idea to the communicant. This approach is said to be coercive where communicators can coerce and sanction communicants. In general, a communication process is carried out in the hope of an impact or effect of the message conveyed by the communicator to the communicant.

In interpersonal communication, there are approaches that occur both verbally and non-verbally, these approaches, including:

## 1. Dialogical Approach.

Features of interpersonal communication with a dialogical approach are characterized by the presence of a conversation or dialogue. In this approach the communicator and the communicant are in the same position and on an equal footing, no one monopolizes the information. Dialogic demands the willingness of both parties to listen to the ideas or ideas of each.

Furthermore, in this approach, we seek and determine solutions from the right views and attitudes in understanding and responding to messages that are shared together. Communicators and communicants must have respect, trust each other and reward each other.

## 2. Persuasive Approach

The persuasive approach is a process of interpersonal communication in which the communicator conveys verbal and nonverbal messages to the communicant in order for the communicant to behave, acting as the communicator expects.

The persuasive approach is not difficult to apply well and can even bring the feeling of communicant into togetherness and family so that the communication process goes well and is effective. Among the Communicators and communicants have the same position and role so that the message/information conveyed is easy to understand and understand by both.

In interpersonal communication there is also a symbolic interactionism, in the theory of symbolic interaction seeks to describe how humans use language to form meaning, how humans create and present themselves, and how humans use symbols to create society by cooperating with others. This theory was then developed by Herbert Blumer by formulating 3 (three) premises, namely:

- Human behavior is influenced by the

meaning they have about others and various events;

- Interaction is essential for the development and delivery of messages;
- The meaning that a person has about various events or others can change over time.
- Symbolic intracensibility exists because the basic ideas in shaping the meaning that comes from the human mind (Mind) regarding the self (Self), and its relationships in the midst of social interaction, and aims to mediate, as well as interpret the meaning in the midst of the society (Society) in which the individual settles. A brief definition of the three basic ideas of symbolic interaction, including:

Mind is the ability to use symbols that have the same social meaning, where each individual must develop their mind through interaction with other individuals,

The Self is the ability to reflect on each individual from the assessment of the point of view or opinion of others, and the theory of symbolic interactionism is one of the branches in the theory of sociology that puts forward about the self (The-Self) and its outer world Society (Society) is a network of social relations created, built, and constructed by each individual in the middle of society, and each individual is actively and voluntarily involved in the behavior they choose, which ultimately leads humans to the process of taking a role in their society.

"Mind, Self and Society" is George Herbert Mead's most famous work (Mead, 1934 in West-Turner, 2008: 96), where the book focuses on three themes of concepts and assumptions that underlie symbolic interactions including: 1) The importance of meaning for human behavior. 2) The importance of self-concept 3) The relationship between the individual and society. First, on symbol interaction focuses

on the importance of forming meaning for human behavior, where in the theory of symbolic interaction can not be separated from the process of communication, because initially the meaning is meaningless, until finally it is constructed interpretively by the individual through the process of interaction, to create a meaning that can be mutually agreed upon.

Symbolic interaction is related to the relationship between individual freedom and society, where this assumption recognizes that social norms limit the behavior of each individual, but in the end it is each individual who determines the choices that exist in his social society.

In Datuk kelampayan's work in the Banjar Sultanate, it seems that when he was studying in Haramain at that time he had a mind that could contribute to the Banjar Sultanate in the continuity of the Sultan's government, because he always asked about the situation of the Sultanate and its people when there were Banjar people performing the Hajj. It could be that when in the haramain he already had a grand design of thoughts with various ideas and ideas that would later be communicated to the Sultan after returning later, it was proven by various thoughts, ideas he communicated to the Sultan were always approved.

The perspective of symbolic interaction in the political context (political symbolism) fundamentally departs from the assumptions about the two dimensions of human beings, namely humans as symbolists (man-the-symbolists) and humans as political people (man-the-political-being). The two are constant and interact inseparably.

In this context, politics is defined as the activity of distributing, maintaining, and exercising power within a social unit. Power itself, expressed in various relations characterized by domination and subordination, which occurs in all aspects in social relations. As a symbolic activity,

political activity begins when people interpret signs, gestures, and clues in meaningful ways. In Datuk kelampayan's work in the Banjar Sultanate, it seems that when he was studying in Haramain at that time he had a mind that could contribute to the Banjar Sultanate in the continuity of the Sultan's government, because he always asked about the situation of the Sultanate and its people when there were Banjar people performing the Hajj. It could be that when in Haramain he already had a grand design of thought with various ideas and ideas that would later be communicated to the Sultan after returning later, it was proven that various thoughts, ideas/ideas he communicated to the Sultan were always approved.

The Sultan's request to Datuk kelampayan to write a book of figh worship in Malay to be used as a religious guide in the territory of the Sultanate of Banjar, as a feedback from the intracampic intracampic in the process of political communication, which he inevitably fulfilled the Sultan's request by writing a book of worship figh for 2 (two) years, known as the Book of Sabil al-Muhtaddin.

In this context, the adab of intubating and communicating in society, nation and state by Datuk kelampayan emphasized the impression of language as part of the ethics of communication. The ethics of communication in poltics or in political communication is significant in equalizing thinking, so that communication becomes effective.

Datuk kelampayan, understanding this self-concept, it is not only understood that human beings are created not just individual beings and cultured social beings, but more than that the intended self-concept is to know oneself as a creation of God Almighty, so that by knowing oneself we will know the creator. Here he taught and practiced Tariqah Sammaniyah.

Obedience and submission to the Creator will demand oneself to noble morals, civility, by increasing faith and practicing it in all good

through positive works, then in political communication carried out in the dark and lateness in the Banjar dispute is based on Islamic values.

Faith and charity in the self-concept that is intended by the dark are the implimentation of morals as a bridge of life in inactivating and communicating with others, Faith as the foundation and charity is a real work as the implementation of the figh of worship, including political communication which is a shia ijthadi as part of worship.

Society or society is formed through coordinated interaction between individuals. According to Mead, the interactions that occur in humans occupy the highest level when compared to other creatures. This is due to the use of various kinds of significant symbols, namely language. Although sometimes humans respond automatically and without thinking to other human gestures, human interaction is transformed with its ability to form and interpret directly by using conventional symbol systems. Human communication has meaning in symbolic gestures and does not ask for an immediate response. Human beings must interpret each movement and determine their meaning. Since human communication involves the interpretation and assignment of meaning, it can happen when there is consensus in meaning. The meaning of symbols should be shared with other human beings.

Shared meaning always occurs through role-taking. To complete an action, the abuser must put himself in the shoes of others. Behavior is seen as social not only when responding to others but also when it has been incorporated into the behavior of others. Human beings respond to themselves as others respond to them and thus they share the behavior of others in an imaginer manner.

Society in the aspect of government power where Datuk Kelampayan views that the power of government in the Banjar Sultanate is based on the awareness to support the

government system of the Banjar Sultanate which has the style of an Islamic kingdom. Datuk kelampayan who has an understanding in the constitution does not question the form and system of his government, so the political communication he carries out is very strategic, this is in line with the thinking of Ibn Khaldun who offers a system of governance in government which is indeed very concerned about him.

Thus, Datuk is an expert in constitutional law seeing that the system of power in government cannot be seen by the state/kingdom, but the substance of his system of government that can achieve the benefits of mashlahah based on religious values embraced by its leader. The Sultan of Banjar at that time had a vision in the application of Islamic law, and his thoughts were also in harmony with the Sultan of Malay. So he wrote a book of fiqh worship in Malay and was later named the book of Sabil al-Muhtaddin, fiqh worship, at the request of the Sultan. The Sultan's request was stated in the introduction to the book of Sabil al-Muhtaddin, and at the end of the introduction to the book he prayed that the birth of banjar could be eternal.

In this study, the researcher found that his political communication model was Bilhikmah political communication, which emphasized the embodiment of the value of godliness which is practiced in the nobleness of behavior in deeds, whether acting, doing or acting which is summed up in noble morals.

With the determination of Datuk kelampayan on Islamic teachings, he practiced the political communication model he was consulted by the banjar Sultanate, namely the Bilhikmah political communication model, the bilqalam and bilkitabah communication model and the bilhal political communication model, which the political communication model as a manifestation of ijthadi shiasi, is part of the fiqh of worship.

The political communication model is based on the power of tawhid as its foundation in

managing the life of the nation and state, by prioritizing moral values in the implementation and management of the government, in line with the vision and mission of the Sultan by wanting the application of Islamic values in the life of the nation and state.

The continuity of the Sultan's rule was then understood that the manifestation of islamic teachings was the key to expediency in goodness, without which it was impossible for the benefits of mashlahah to be achieved by the government. Therefore, the intextuality of the Sultanate in interacting and communicating is always maintained in harmony and synergy between the two.

Bilhikmah's political communication, as a communication that prioritizes the ability of broad knowledge, and also respects and respects each other, by prioritizing nobleness and wisdom, full of wisdom, and fairness, in the process of communicating in the continuity of his interactions, both to the Sultan himself and the Sultanate community. Bilhikmah's political communication, which is full of Islamic values, cannot be separated from understanding the need to see the reality of society and the majority of the Sultanate of shafiiyah, the Bilhikmah he carried out has a strategic role in his political communication, so that the relationship between the dark and dark is so harmonious with the Sultanate, even maintaining the continuity of the Sultanate itself.

Bilhikmah's model of political communication puts things in place by thinking, trying to structure and organize in a way that is appropriate to the circumstances of the times by not being in agreement with God's laranagan. This foundation of al-hikmah is what Datuk kelampayan did in political communication in the Sultanate of Banjar, so that his ideas and thoughts and initiations can always be recognized and approved by the Sultan in the process of his political communication.

The Billikmah Political Communication Model is a political communication carried out by Datuk kelampayan in the Banjar Sultanate that refers to the verse of the Qur'an surah An- Nahl: 125 which means:

“Serullah (man) to the way of your Lord with wisdom (a true word that can distinguish between the truth and the bathil), and teach the good, and argue with them in a good way. In fact, your Lord, He knows better who is lost from His way, and He is the one who knows better who is guided (Hatta, 2009).”

The verse above explains that political communication is carried out in order to invite in truth and goodness based on the values of Islamic teachings with its fondassi is to strengthen aqidah (ketauhidan), with the abilities that must be possessed as a communicator, including;

First, the ability to upgrade oneself with disciplines, both religious science and general science, Second, Have superiority and toughness of attitudes and customs that do not harm others, Third, Ability to adapt in any situation and condition, Fourth, have visionary ideas and thoughts and fifth, Have a consistent commitment and ghirah/spirit in supporting the government in towards the benefits of mashlahah.

These five abilities as a self-concept that can be developed by always being in the understanding of the values of Islamic teachings, which make them besikap tawadhu, do not criticize the government (Sultan), but rather give his thoughts and always pray for the government (Sultan) in carrying out his government.

From some of the information obtained by researchers during the study, it was found that the political communication played by Datuk kelampayan had five roles that he carried out, including:

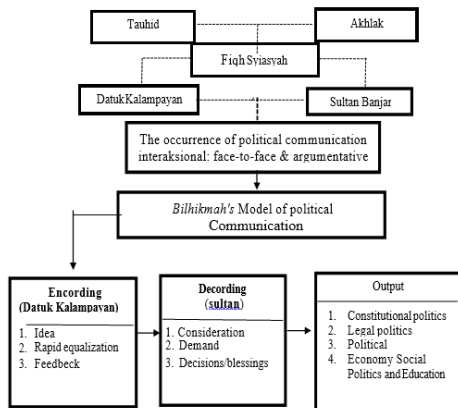
1. As an educator, namely establishing the first Islamic boarding school in the 18th century in carrying out educational functions. Through the bil qalam communication model, he

educated and taught the people and environment of the Sultanate to carry out the commands of Allah Swt. and stay away from His prohibitions. Therefore, the book of Sabil al-Muhtaddin was destroyed at the request of the Sultan keada he had to recite a book of figh worship in Malay, the statement of the Sultan's request was contained in the word of the author of the book of Sabil al-Muhtaddin. This aims to prevent people from deviant behavior from Islamic law in the Sultanate.

2. As an information straightener. There are three things that dai should straighten out through political communication bil qalam. First, information about the teachings of Datuk Kelampayan was in the Sultanate of Banjar. Secondly, information about his works or achievements who were a very productive person in those days and provided sprit of future generations. Third, as a writer, he was able to explore about the condition of society which is geographically very different from the geography in Haramain so that he adapted the teachings of Islam to the situation and conditions at that time, even what was very interesting about him was that information about Islam and its people was not manipulative and cornered Islam.
3. As a reformer, namely the dissemination of a renewal of the understanding and practice of Islamic teachings (Islamic reformism).
4. As a unifier, that is, to be a bridging that unites Muslims.
5. As a fighter, that is, a fighter, he preached the teachings of islam and tried to form a common opinion that encouraged the enforcement of islamic shia, rahmah li al- 'alamin.



In this context, the political communication model and darkness in the Banjar Sultanate, it can be seen in the picture below:



**Figure 5.** Political communication model and darkness in the Banjar Sultanate (source: Research Results made in 2022)

Political communication is based on faith and charity in order to strengthen the firmness of faith as the foundation of life in society, nation and state.

1. Upgrading oneself with knowledge and charity, by consistently coexisting in harmony.
2. Do not make a frontal criticism of the government, and always pray for the good of the government towards the benefits of mashlahah.
3. Promoting argumentative rational dialogue in conveying opinions, ideas and thoughts.
4. Promoting togetherness to advance regional development
5. Interact with a good adab display.

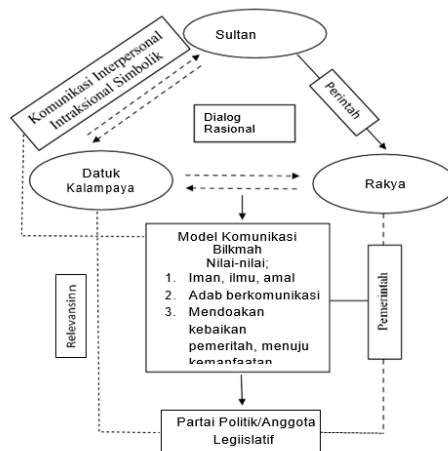
The value of the political communication model Datuk kelayaman in the banjar Sultanate can be seen in the figure below:

Datuk's model of political communication in the Banjar Sultanate The model of political communication in the Sultanate of Banjar at that time was very close to the value of Islamic teachings, this is due to the understanding and depth of knowledge that he

has both religious science and general science, so that his political communication model in the current context has characteristics and values that data are inherited and exemplified by us and the future. These values include:

The values of Datuk Kalampayan's Political communication model Bilikhmah's political communication, as a communication that prioritizes the ability of broad knowledge, and also respects and respects each other, by prioritizing nobleness and wisdom, full of wisdom, and fairness, in the process of communicating in the continuity of his interactions, both to the Sultan himself and the Sultanate community.

When there was a political dynamic within the Sultanate, indeed, Datuk kelayaman never involved himself in the matter, because he was very avoidant of practical politics, which of course would affect in carrying out the development of Islamic shia, so it was with this moderate attitude that he easily conveyed some of his thoughts as a contribution to the political communication he carried out.



**Figure 6.** Political communication model Datuk kelayaman in the Banjar Sultanate

Wisdom is practically meant to have something in its place. This wisdom is

divided into three types, namely: first, having a heart eye which includes, among others, the power of perception, intelligence, knowledge and wisdom. Second, knowing the justice of the threat of Allah Almighty, the certainty of His promises and the justice of the laws that are shari'a and the laws that apply to all His creatures. And thirdly, Giving rights to something in a sense: do not go beyond the limits, rush and delay time. Hikamh pays great attention to the three instructions above, namely by giving rights to every matter, namely the right of Allah Almighty with Shari'a and His destiny. If we go beyond the limit, procrastinating the time limit means that we are violating and violating wisdom. This is the so-called general decree on the law of cause and effect based on shari'a and destiny.

Al-Hikmah is an expression that contains truth and depth. Manaa in Indonesian is interpreted with the word wise, while the word wise in Indonesian contains the meaning of: Repair (make better) and avoid damage, Clever and strong in his memory, Always have a wise and sharp mind Wisdom is manifested into four things: manjerial prowess, discernment, clarity of mind, and sharpness of mind. Wisdom as a system that unites theoretical and practical abilities in political communication.

The political communication model of bill wisdom can be syar'i understood that what is done has validity in words and deeds, knows the right and practices it, wara' in dinullah, puts something in its place and answers firmly and appropriately, and can be an example to be imitated and exemplified by others, otherwise known as a role model.

With the demkian of Bilhikmah's model of political communication it puts something in

its place by thinking, trying to structure and organize in a way that is appropriate to the circumstances of the times by not being inconsistent with God's laranagan. This foundation of al-hikmah is what Datuk kelampayan did in political communication in the Sultanate of Banjar, so that his ideas and thoughts and initiations could always be and approved by the Sultan in the process of his political communication

#### 4. CONCLUSION

The proximity of political communication is crucial and strategic in the current regional development, so it is hoped that in carrying out the approach to political communication, it can certainly emulate what Datuk Kelampayan taught and practiced in the Banjar Sultanate, in order to achieve a harmonious and synergistic relationship between political parties-governments-communities. And it turns out that his approach to political Communication used his theory of symbolic intractional communication mean in 1934.

Bilhikmah's political communication model is expected to be a part that should be preserved as an asset of regional political communication that contributes to the government in achieving the goals of regional development.

The application of the values of political communication and darkness is expected to be carried out through government policies and political education to the community carried out by political parties by prioritizing political customs.

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## LEADERSHIP IN A YOUTH MOVEMENT AS A TRANSFORMATIVE EXPERIENCE

**Abstract:** *This study discusses the social leadership of counselors in youth movements in Israel and its contribution to social engagement, both for themselves and the members of the movements. The study method is qualitative, in which six senior counselors (branch managers) from two major youth movements in Israel participated: The Scouts and Bnei Akiva. The study provides a glimpse into the world of youth in Israel who participate in youth movements. The study shows how the quality of leadership of the counselors, empowers and advances social goals and contributes to community engagement from which everyone benefits. The study can contribute to the field of education by perceiving the leader as both a teacher and an educator.*

**Keywords:** *Transactional leadership, transformative leadership, youth movement, social engagement*

### 1. Introduction

Leaders have a significant role in creating the state of mind that is the society. They can serve as symbols of the moral unity of the society. They can express the values that hold the society together. Most important, they can conceive and articulate goals that lift people out of their petty preoccupations, carry them above the conflicts that tear a society apart, and unite them in the pursuit of objectives worthy of their best efforts. —

J. W. Gardner, 1965

Perhaps more than anything, Plato's Allegory of the Cave (2017), illustrates the various aspects of leadership. In this allegory, prisoners are bound together in an underground cave, they face the wall, and behind them there is fire or sun, but they cannot see it and in fact, they cannot see anything, but shadows cast by people and animals that are walking outside the cave. One of the prisoners is released and he likens the release to being cured of ignorance. The process of release is lengthy and painful and

is accompanied by anguish until he can gaze on the light. The whole process is made up of dilemmas - if he had to look to the light, would he not want to escape from the suffering and the darkness? Would he not want to return to the old world, beyond the cave, a world that does not hold such suffering? Perhaps he will stay in this place of happiness and transcendence and just pity those he left behind, in the dark cave. And in this free world, will he feel a social and class disconnect compared to those in the cave, who, though they are in the dark, have a social interaction? According to Plato, there is no dilemma at all. The released prisoner goes back to the cave; however, he returns a different person. The process of going back to the cave is described as suffering, because what he saw as true all his life, when he was dwelling in the cave, suddenly seems to him a lie, after he has seen the light. But upon returning and faces the risk that he will be ridiculed or even killed by his mates. The sun, the source of good, is the divine spark, and the moral of the allegory is that the sun, the light,

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is the education. A person goes through a process of transcendence that symbolizes degrees of truth. And the truth of the allegory is revealed. He who comes out into the light, he who discovers the truth, he who passes through education, must go back, and try to elevate the whole community. The leader is an educator. Everyone has a goal, to increase the benefit of the community, in order for the community and all its members to be happy. Thus, leaders must first of all, find their light, their knowledge, and only then, turn to leadership. That is, it is not a matter of persecuting the governing, but of a commitment to the community. Commitment to the society that took him through the education process, in which he found happiness. The leader rewards the community by returning to the cave and educating the people. Since according to Plato, the leader's goal is not to command people to follow him, but to persuade them to follow him (Plato, 2017).

Naturally, youth movements serve as a platform for leadership development (WHO, 2020). This conclusion arises after summarizing studies' findings and after reading the movement training programs. It can be said that, in the youth movements, every member in the senior class, experiences leadership education. Even if they are not counselors, they are partners in an increasing involvement in society and community, partners in contributing to society and helping others. Thus, it seems that education for engagement and caring, which forms the basis of every youth movement, provides an opportunity for leadership for every senior member in youth movements (Even et al., 2016).

Daudi (2013) contends, that the art of leading others comes through the art of leading oneself. Thus, leaders are an example of doing. The research question then is how the leadership experience in a youth movement can shape the world of values, personal identity, and the social engagement of the

counselors.

## 2. Leadership

Wherever there is a hierarchical community, such as a workplace, a youth movement, a state leadership, and more, the "boss" is always a different person from everyone else (Bennet et al, 2015). It is usually a person with great self-confidence who radiates power and has a presence that has "filled the room". Such person is not always pleasant or loveable, but in most cases, it is an inspiring person. Scouller (2011) contends that a leader is a person who leads a particular group at a particular time. But leadership is a rather broad and multidimensional term to be conceivable. It is a particularly complex system of influences that greatly affect the way a group of people are organized and how they act. The larger the community and situation, and the environment in which the group is involved, the more complex the leadership is as a system. When leadership is addressed as a process, it is more understandable that leadership and a leader are not the same thing. Although the phenomenon of leadership has existed for many years in human relations, the definition of leadership has occupied many academic researchers. Stogdill (1974) argues that the word "leader" was already in use in the early 14th century and the word "leadership" first appeared in the early 19th century (Fairholm, 2002). The concept of leadership is controversial. Rost (1991) argues that "these attempts to define leadership have been confusing, varied, disorganized, idiosyncratic, muddled, and, according to conventional wisdom, quite unrewarding" (p. 99). However, many other researchers, continue their work in learning, defining, identifying, and developing leadership (Fairholm, 2002).

As there is no one definition for a leader, there is no one leadership model agreed upon by all. In every department and at every stage, there

must be people who can take a leadership action to make their part in the system work. People who are willing to adjust a systemic policy to the reality at the field level. Men and women who are not afraid to sound an alarm to the higher echelons that the new policy should be corrected or reversed (Gardner, 1990). When we want to separate leadership and management, Fairholm (2002) argued that one is "performing leadership" and the other is "performing management" and these are two different tasks. Bennis and Nanus (1985) clarified that managers are "routine masters" and they achieve efficiency, whereas leaders are "masters of change." They are influential, they are effective, or in the authors' view: "The manager does things right; the leader does the right thing" (p. 21).

Gardner (1965) argued that leaders play a significant role in creating the mindset that is society as a whole. They can serve as symbols of the moral unity of society, they can express the values that hold society together and most importantly, they can think and express goals that will lift people out of their petty pursuits, carry them over the conflicts that separate members of society, and unite them in another striving goal, worthy of their efforts. This statement sums up the importance we assign to leadership, since in order for leaders to be able to draw from morality and use their influence, they need to wrap people around collective goals (Antonakis & Day, 2018). An interaction between the leaders and their followers is the foundation upon which leaders instill in their followers a motivation that leads them to pursue their goals (Shamir et al., 2018). As a result, these leaders become role models (Schweitzer, 1984; Willner, 1984; Bryman, 1992) and their followers internalize the values and ideals with a sense of motivation and enthusiasm (Shamir et al., 2018), when the ability to inspire trust, is what allows leaders to motivate others for the cause (Bennis, 2010).

Is a person born to be a leader? The theory of the Great Man known also as the theory of

traits, holds that there are people who are born to be leaders and there are people who simply "don't have it." The Great Man theory born in the 19th century, holds that history can be largely explained by the influence of great people, or heroes, who were influential and incredibly unique, and by virtue of their natural qualities, such as superior intellect, courage, heroism, or divine inspiration, they had a decisive historical impact. The father of the theory is the philosopher Thomas Carlyle who stated that the history of what man has achieved in this world is in fact the history of the great people who have acted over the years. They were great leaders, and created models of doing and achieving, that all human beings aspired to achieve and do (de Vries & Cheak-Baillargeon, 2001; Halaychik, 2016; Harrison, 2018). In their book, "Leading minds: An anatomy of leadership", Gardner and Laskin (1995) proposed a cognitive approach to leadership by which, a leader is a person who influences a large number of people and in a sense, such people inherit certain qualities that make them more suitable for leadership. For example, traits such as extroversion, self-confidence, and courage are all traits that can be associated with great leaders (Grant et al., 2011). Gardner and Laskin (1995) discussed leadership in the light of the stages of human development and researched Gandhi, Napoleon, Margaret Thatcher, Martin Luther King and more. They concluded that the leader has an influence on the emotions and behavior of masses of people. In contrast, the behavioral theory holds that great leaders are created and not born. This can be seen as a reversal of the Great Man theories. This leadership theory, which is rooted in behavior, focuses on the actions of leaders rather than mental traits or inner states. According to this theory, people can learn to be leaders through teaching and observation (Derue et al., 2011). Proponents of this theory argue that anyone can be a leader and that leaders can be developed, and leadership skills can be learned (Di Giulioi,

2014).

There are many models of leadership. Two major models that stand out in their importance are transactional leadership and transformational leadership. The concept of transformational leadership, first coined by Burns (1978), speaks of transformative leadership that enhances the motivation, morality, and performance of followers through a variety of mechanisms. These include connecting the sense of identity and sense of self of the followers to the task at hand, and to the collective identity of the organization; to be a role model who simulates the followers; challenge them to take more ownership of their work, and understand the strengths and weaknesses of followers, so that the leader can delegate tasks to his followers that will maximize their performance (Burns, 1978). Bass (1985) expanded Burns' idea by explaining the psychological mechanisms underlying business design and leadership. Bass added to Burnes' first concepts to explain how transformational leadership can be measured, as well as how it affects motivation and performance (Bass & Avolio, 1995). The degree to which the leader is transcendent is measured by the mirror of his influence on his followers. The followers of such a leader feel trust, admiration, loyalty, and respect for the leader, and due to the qualities of the transformational leader, they are willing to work harder than expected. These results occur because the transformational leader becomes for his followers something more than a work for self-gain. Such a leader gives his followers a sense of mission, an inspiring vision and identity. The transformational leader motivates his followers through the transmission of ideals, intellectual stimulation, and personal concern. In addition, such leaders encourage their followers to come up with new and unique ways to challenge the status quo and change the environment (Bass, 1985; Bass & Avolio, 1995; Burns, 1978; Yukl, 1999).

Burns (1978), coined another term, "transactional leadership" and argued that transformational leadership and transactional leadership are reciprocal styles. Transactional leaders do not usually strive for cultural change in the organization, but they operate in the existing culture, while transformational leaders can change the organizational culture (Burns, 1978). Under this leadership there is an exchange and reciprocal relationship between the leaders and their followers and transactional leaders can cultivate the commitment of their employees through appropriate rewards and by recognition that translates into compensations, new initiatives, and ideas (Breevaart et al., 2014). Bass (1985) argued that transformational leaders emphasize the development of higher motivation and evoke positive motivation and emotions by creating and presenting an inspiring vision of the future, while transactional leaders rely on a clear system of contracts and rewards. Unlike Burns, Bass (1985) argued that leadership can be both transformational and transactional.

As such, Avolio and Bass (1994) introduced the full-range leadership - a concept that consists of transactional leadership, transformational leadership and a leadership style known as *laissez-faire* ("let do"). The novelty of this model compared to the other models, is that each leader has characteristics of different styles where the combination of these characteristics, the characteristics of the leaders and the dominance of a particular characteristic or trait, determine the effectiveness of the leader as well as the leadership style as perceived by his or her followers (Bass & Avolio, 1994). Today's leaders integrate the entire sequence, and they reap tremendous success in situations where others have failed (Stafford, 2010). A full-range leadership model operates on several principles. The first is an idealistic influence, referring to the charisma of a leader or the ability of a leader to be a role model for his followers. This is the emotional component of

leadership. The second component is leadership behavior. In general, the components determine whether the leader is perceived as trustworthy and respectful by his followers and whether they tend to try to emulate his behaviors and pursue common goals (Kirkbride, 2006). Another principle of a full-term leader is to inspire motivation among the followers as well as the question of whether the leader evokes an intellectual stimulus in his followers. They encourage their followers to be creative and innovative in solving organizational problems. These leaders do not criticize people who "come out of the box" and deviate from traditional organizational practices. Another factor is individual attention. That is, a leader who is attentive to the individual follower, gives advice and support and addresses the personal needs of each one of his followers, and thus, enables them to develop and realize themselves. This individual attention is typically translating into positive organizational outcomes based on the collective efforts of significant individual performance (Antonakis & House, 2013). Salter et al. (2014) found a significant association between moral maturity and inspirational and rewards leadership qualities, suggesting that leaders' communicative behaviors include both transformational behavior and transactional behavior and that both styles are needed to create effective leadership. We found an example of effective leadership in non-formal education as this study will show.

## 2.1 Youth Movements

Youth movements constitute a non-formal education framework in which an organized and systematic activity operates outside the formal education system in order to receive defined educational goals such as the acquisition of knowledge and skills, leisure education and recreational activities or ideological education. The activity provides

unique patterns of education for different groups in the population. This pattern is characterized by a unique code whose main characteristics include free choice regarding participation or leaving an activity, interaction based on equality, and peer supervision, i.e., supervision through advocacy and persuasion instead of prohibition. This unique education method operates on the basis of adaptation to participants and courses of action that are appropriate to the goals (Mendel-Levy and Artzi, 2016). One of the major contributions in the field of non-formal education is voluntary activity. Volunteering experiences in general are defined as perceptions that are characterized by a sense of personal well-being that results in satisfaction and a sense of empowerment. Studies conducted in the field indicate that when volunteering is interesting and challenging, require responsibility and characterized by accomplishments, the volunteers will be satisfied. A study by Magen (1997) found that adolescents who were engaged in volunteering, described experiences of intensified happiness and a high sense of coherence as well as their aspirations for life indicated a stronger desire for personal commitment, compared to adolescents who did not engage in volunteering. Thus, the engagement of adolescents in social activities is of great importance. The sense of being able to help others, be effective in states of distress and serve as a source of support and hope with the ability to devote time and internal resources to realizing worthy social values, act as empowering factors for adolescent and their personal identity, sense of meaning in life, personal discovery, and ability to be more open and capture moments of true happiness (Gross & Goldart, 2017; Magen, 1997).

Into this niche, youth movements enter. According to the Israeli Ministry of Education, youth movements have an important place in the establishment of the

State of Israel and continue to contribute to youth and society in a wide range of issues including strengthening love for the country, self-fulfillment, encouraging coexistence, tolerance, reducing social disparities, fostering leadership, democracy, responsibility, and social engagement. In 2015, there were 13 youth movements in all sectors of the population in the Israel (Even, 2014; Ministry of Education, 2016). Youth movements emerged in the early 20th century and are a tool for instilling ideologies for youth (Minkov, 2010) which holds a built-in worldview. The youth who participate in such activities, come by choice and according to their ideological perception. One of the important aspects in youth movements is the principle of "youth educating youth." The training programs train the youth to be young counselors (Ministry of Education, 2009). Generations of active leaders and citizens are being trained in youth movements. The movements, thanks to the structure and the connection between counselors and groups, constitute a fertile paradigm for the experience and practice of the youth in tasks that require responsibility, initiative, and leadership (Even et al., 2016).

## **2.2 Youth Movements and Social Engagement**

In the delicate seamline between childhood and adulthood, youth movements play an important role in the maturation process of youth into adults with values and a sense of social engagement; In our time, dominated by technological innovations and online communication, youth movements offer another alternative - a human encounter "as before" and joint and empowering group action. The youth movements in Israel transmit and educate the values, each in accordance with its ideology. All this, with practical experience: the youth themselves lead the various activities in the youth movements - activities that invite members in

movements with diverse experiences, as well as an opportunity for personal development and expression of personal skills (Shemer, 2013).

Studies on youth volunteering around the world, found that volunteering is a beneficial experience and has significant developmental implications for adolescents. According to studies, adolescents who volunteer and are socially involved in settings such as youth movements, feel happier and more optimistic and also have greater self-confidence than their peers who are not active in the youth movements (O'Connor, 2011; Smith et al., 2010; UN Volunteers, 2017 ). A comprehensive study found that volunteer youth were better integrated into society, had higher self-control, and had a significantly lower tendency to engage in activities of a criminal nature (Shemer, 2013).

## **3 Method**

The research method in this study is the qualitative research method. This method is based on the assumption that the best way to show human experience is by a narrative. The qualitative paradigm is appropriate for the current research since it seeks the essence of the human experience and the central meaning that underlies it. This approach focuses on understanding the meaning of the experience for the people who participate in it. The experience of the study participants is the subject of this research, and therefore, the author explores them in the framework of these concepts. In other words, in terms of the meaning that ideas and actions have for the study sample during their period as senior counselors (branch managers) (Shkedi, 2007). This research does not attempt to give key answers to "what", "where", "when", but addresses the "how" and "why", which helps understand the internal leadership processes of the former counselors who participated in the study (Denzin & Lincoln, 2011).

### 3.1. Sample

The study population includes six participants who were formerly branch managers from two major youth movements. Three were former branch managers of the Scouts in Haifa and three were branch managers of Bnei Akiva in Jerusalem. All currently between the ages of 25-30 and were senior counselors between the ages of 21-25.

### 3.2. Research Instrument

The research tool is a semi-structured in-depth interview consisted of 8 questions.

### 3.3. Research Design

The study was conducted via Zoom. The author reached out to the participants through mutual friends and relatives. Before conducting the interview, the author had a "small talk" with the participants, explained to them the meaning of the research and its contribution and emphasized that the research was conducted in the mirror of leadership while paying attention to the value structure of their experience as youth counselors. The reliability of the study was maintained by condensing the study in quotations (Shaked, 2007).

The analysis of the data is done by coding the findings, sorting, and filtering out unnecessary or similar findings. The data were then collected and divided according to key themes (Shaked, 2007).

## 4 Results

### 4.1. Coping with organizing and organization

The experience provides an opportunity to discover the assertiveness inherent in the participants and their ability to build an organization while tackling challenges and identifying problems.

S.:

"When I first came to run the branch, I realized that the current staff of counselors was not active and did not contribute to the members. Therefore, I fired all of them and mobilized all the resources to recruit a new team of counselors."

During the challenging role, the participants often worked under conditions that were far from optimal. This can be seen from S. experience when he encountered a difficulty that every organization goes through and that is high employee turnover. S. solved the problem in a creative way and with the help of organizational and leadership ability.

The counseling experience is mainly a personal connection for the senior counselors themselves. The personal connection is significant to the success of the goals.

A.:

"You feel that you are a meaningful person and have a built-in desire that the youth will love you and make you feel a part of them."

It seems that the participants perceive the personal connection as important.

One of the important principles of leadership is to be attentive to the followers. It was evident that the participants showed great deal of consideration.

M.:

"On Tuesdays I would arrive at the place, relatively early, and organize it to create a good atmosphere for the members."

### 4.2. Personal Engagement

One of the components of a leader is the ability to set a personal example. The counselors acted to engage and set a personal example.

R.:

"I would greet everyone and make sure that each one of the members is with their counselors and they are collaborating as well."

Part of setting an example is not demanding from others what you are not willing to demand from yourself. From S., we can learn how he implemented that theme.

S.

"I decided to take on all the tasks associated with the group, and entrust counselors, to cope solely with recruiting members since it was important for us to get as many youths as possible to actively participate in the movement's programs. Therefore, I performed many tasks which are ordinarily under the responsibility of my team, to make sure that they would be free to concentrate on the young members."

#### **4.3. Leadership**

It is evident that one of the things that guided the participants is the desire to lead also out of a personal sense of mission.

Y.:

"I felt that I would and could continue with this line, out of a sense of mission and efficiency."

It is clear from D. that he sees himself as a leader and his role as a senior counselor enabled it.

D.

"I have something in me that really likes to take part and be responsible, lead, be the one who drives processes and things."

The senior counselors organized the members for social activities in the community.

Y.:

"On one occasion I initiated a task that involved all of the members and the junior counselors and that is garbage collection from all over the city. We received large garbage bags from the municipality. All the members participated and wore the movement uniforms holding big, orange bags. They managed to sweep to the task, passers-by and after a while it was no longer possible to differentiate between members and local

residents. They all worked together to clear the streets from garbage. In the meeting that followed, all the members wanted to talk about was how much they felt empowered by the garbage collection initiative.

It is evident that this framework, of education for values in after school hours, contributes to the empowerment of the youth. The study participants talked about values of community and giving as their values shared between unity and society, in which they see supreme and inclusive values.

A.:

"The value of unity is a value without which, no group can exist. There must be brotherhood among the members of the movement in order for us to move forward and act."

An important value that constitutes one of the goals of the youth movements is community. Participants internalized this value, which gave them social tools of containing and observation.

Y.:

"In terms of values, it is the ability to be a part of a community, a population that is diverse, to rejoice in it, to love it, to move forward together with it."

In addition, the participants also expressed social values of giving.

G.:

"Starting with the junior counselors and the senior counselors, where they don't give, there is nothing there."

And they also received social values of action.

D.:

"We performed all kinds of volunteer activities and created initiatives that their essence is act for the sake of the other, especially to show the children (members) that they don't live only for themselves."

These values of volunteering and giving to others, contribute to the empowerment of the



contributors themselves.

## 5 Discussion

When we refer to the counselor as a leader, as we do in this study, we can see how the quality of the leaders is reflected in their role. Bennis and Nanus (1985) argue that a leader is a "master of change" and indeed, the research participants appear to have been agents of change during their counseling experience in youth movements. This experience allowed them to discover the assertiveness inherent in them and their ability to build an organization when faced with challenges they had not been prepared for before. Gardner (1990) argued that a leader is a person who adjusts systemic policy to the field and that he or she, warns of flawed policies and solves problems. The participants encountered situations in which they were required to make organizational changes, such as replacing the entire counseling team.

Gardner (1990) also argued that the leader has a role to play in creating a mindset in society as a whole. The counselors were able to increase their population through unification and formation. They managed to sweep the junior counselors after them, as Antonakis and Day (2018) argued, that one of the important things a leader needs is to involve people around collective goals. It is evident that this is reflected in the behavior of the participants. One of the important things that defines a leader according to Bass (1985), is the ability to set a personal example. In doing so, the leaders empower their followers, in this case, both the junior counselors and the members, while setting a personal example. One of the participants said he arrived earlier, taking on a load of chores and tasks to make it easier for the junior counselors. This serves as a personal example and as asserted (Bass, 1985; Bass & Avolio, 1995), such behavior inspires and invokes action among the followers. According to the study

participants, one of the things that came up was their personal engagement with the members of the movement. A transformational leader is a leader who communicates personally with his or her followers. It is also evident from the participants' words that they aspired to be loved by their followers. Not only did they inspired the junior counselors to do what they wanted them to do, but they wanted these actions to be conducted out of will and warmth. These are basically the principles of transformational leadership (Bass & Avolio, 1995). When the leader instills motivation and enthusiasm in his and her followers, the followers emulate their leader's values and ideals (House, 1988). The study participants empowered the junior counselors and members and instilled in them a trust that they followed them and their tasks, all of which are the marks of transformational leadership (Erkutlu, 2008), and by doing so, they were able to bring their followers to success.

In terms of value, we can see how the experience empowered the participants. They felt that they had been given a lesson for life, which added to their personal identity. Gross and Goldart (2017), contended that when volunteering is interesting and challenging, the volunteers act out of a sense of worth and giving. This value can be seen in the narrative of the participants who described the variety of values they received from the movement, the value of giving was one of them and they instilled this value in their followers as well. By doing so, a sense of ability and competence was created in them (Gross and Goldart, 2017).

In terms of social action, Magen (1997) found that involvement in volunteering indicates a stronger desire for personal commitment. It is evident that the research participants have a deep commitment. Gross and Goldart (2017), argue that adolescents' involvement in social activity is of high importance because the sense of helping others and the sense of self-benefit, act as empowering factors and the

consciousness of personal identity. Magen et al. (1992) found among young people from low socioeconomic neighborhoods, that when they were motivated by the desire to contribute and help others and when they were actually involved in doing so, their sense of self-worth increased and their sense of coherence was strengthened and with it, the ability to experience life to a more fulfilling and happier levels.

More recent studies also demonstrate the contribution of civic engagement among adolescents. Callina et al. (2014) researched the term Hope among adolescents in various contexts. Adolescents' sense of hope was found to be woven from all sets of life, including their contribution to the community and society. McBride et al. (2011) researched youth volunteer programs in Latin America and the Caribbean and concluded that volunteering enables youth to take on significant roles that contribute to their development.

It can be concluded that the study participants, in retrospect, were aware of their power and strengths and the fact that they can attest to themselves today that they have moved things, led and driven processes, indicates high awareness and growth as a

result of the process.

### 5.1. Limitations of the Study

Since this is a qualitative study that was conducted on a small sample, it is naturally not inclusive. In contrast to quantitative research, none of the answers to the interview questions were identical to each other. Because this is a completely subjective view of the participants, each question had answers as the number of participants, which sometimes made it difficult to find a connecting line in some of the questions, and sometimes required deepening the meaning in order to make the analysis continuous and non-schematic. To overcome this problem the author focused on analyzing findings that directly relate to the research question.

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## **CREATED AND REALIZATION OF A DEMOGRAPHIC POPULATION MODEL FOR A SMALL CITY**

**Abstract:** *Using a mathematical model of the system dynamics of the demographic process in the work, an assessment of the impact of the housing construction industry on the future population was obtained it was revealed that the share of occupied plots for housing construction is a leading indicator in ensuring stable reproduction of the demographic process both in urban agglomerations and small towns countries, for example, the city of Kossy, Akmola region of the Republic of Kazakhstan.*

**Keywords:** *Mathematical model; System dynamics; Demographic process; Population; Housing construction industry*

### **1. Introduction**

It is known that work (Balabanova et al., 2021; Gnap et al., 2018; Low et al., 2020; Sterman, 2000) is devoted to comprehensive studies of obtaining systemic solutions to the problems of the demographic situation of the city's population, but today many authors conducts comprehensive and in-depth analyzes of the issue methodology and use more modern technologies, in particular, among them, we note that the work (Avdeev & Troitskaya, 2021) revealed features and factors of demographic dynamics in the Kyrgyz Republic. Meanwhile, the current socio-demographic situation in the Kyrgyz Republic is analyzed as a research complex of the article, in particular, the problems of natural population growth, internal mobility and international migration are analyzed as the main components of population dynamics. The authors of the article, on the basis of demographic trends in the republic, in particular, judging by census data and current statistics and based on the study of the situation of the population, estimate the features of the age-sex structure of the

Kyrgyz population and the increase in the rate of aging, as well as the population's settlement in cities and its urban centers justified the opinion of the concentration and evaluated the impact, in particular, justified the need to regulate the process of urbanization and the measures to attract internal migrants. Indeed, an analysis of the demographic dynamics in the Kyrgyz Republic has shown several interrelated problems and challenges arising from the rapid growth of the population and changes in its age structure and requiring urgent social and economic policy measures. As a result, the analysis of the dynamics of demographic growth in the Kyrgyz Republic revealed that a number of problems and difficulties are occurring that require urgent state regulatory measures from the society within the socio-economic situation caused by the rapid growth of the population and the change in the proportion of its age structure. As a result, on the example of the two largest urban agglomerations of the Republic, the cities of Bishkek and Osh, the massive departure of working-age residents, especially young people (labor migration),

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the growth of the retirement-age population, and the uneven distribution of residents around the city are the tasks of today's activities.

Further, in the article (Conti et al., 2021) validation studies were conducted for residents of nursing homes in England. The aim of this work is to explore a new methodology based on the association of unique identifiers of the home address of the elderly with the registration data of patients in primary health care, allowing to routinely identify residents of nursing homes in health care data. And the obtained estimates of diagnostic efficiency, although showing a slight false-negative rate (21.98%), emphasize a significant true negative rate (99.69%) and positive predictive value (99.35%), as well as a satisfactory negative predictive value (88.25%). This leads to the conclusion that validation gives confidence in the reliability of the new address matching method as a viable and general alternative to manual address matching.

In conclusion, we note that in (van Dalen & Henkens, 2021) received a consensus and disagreement were found among demographers on population problems and climate change. As a result, climate change was found to be at the top of the list of demographic concerns, but that their sense of urgency to act against global warming was not consistent with their belief that population policy could be crucial in reducing CO<sub>2</sub> emissions.

## **2. Literature review**

The positions of researchers on the problem of assessing the financial and economic ties of the industry's impact on the demographic process are diverse the article (Nwogu & Okoro, 2021) assesses mortality in lived person-years and the remaining life expectancy of adults in developing countries.

In the work (Arpino & Tavares, 2013), using the data obtained from the Eurostat Database and European Value Surveys of the last period, the estimations of birth trends for the population of Europe with or without changes in latent dependency values were given. As a result of their special focus on Spain, Italy and Southern European countries, in particular, they are treated as a homogeneous group with the same "traditional" values and demographic behaviors than the Scandinavian countries, which are considered to be typical and similar. However, it is shown that the latent dependency values for the countries of Italy and Spain are not very similar. It was also shown that similar values at the country level with respect to TFR (Total Fertility Rate) vary significantly at the regional level. Of course, it is clear that the demographic analysis carried out at the regional level will play a very important role in order to better understand the changes in the birth rate of latent dependency values. Within the framework of demographic analyses, it is proved that the latent dependence occurring in the recent trend of childbearing is related to value dynamics, in particular, the highest growth rate of TFR (Total Fertility Rate) is related to individualism relationship and personal autonomy and children, as well as simultaneous growth in regions phenomenon occurs. The article also substantiates the McDonald's theory with empirical evidence of the increase in the demographic trend of child birth and the occurrence of gender balance in market and family-oriented public institutions.

An article (Vanella et al., 2022) concludes that the low birth rate in industrialized economic countries leads to a decrease in the death rate of the population in the country, and it is true that this, in turn, puts the country's social security system under severe pressure. The aging of the population depends mainly on the long term of



retirement requirements and the conditions of entry of pensioners into the labor market. It is clear that the problem of forming adequate forecasts of the future structure of the population by age category poses a threat to the stability of the social security system, which is paid for the introduction of reform measures or further improvement. The article presents a probabilistic approach to forecasting the number of pensions in Germany until 2040. The model considers trends in population development, labor force participation and early retirement, as well as the implications of pension reforms. Principal component analysis is used to manage the high degree of complexity in forecasting trends in old age and disability pension claims arising from age and disability pension benefit rates, the overlap between different age groups and gender. For example, time series methods allow adding autocorrelation of time series of pension rates to the model. Monte Carlo simulation is used to determine future risk. This is an important feature of the model, because the future development of the population and, ultimately, the pension requirements and the resulting financial burden are highly stochastic. As a result, in the median trajectory between 2017 and 2036, the number of old-age pensions is projected to increase by about 5 million, and the number of disability pensions will also increase by 2036. These projections take into account the increase in the legal retirement age. As part of the 2007 pension reform. However, a moderate decline can be expected after the mid-2030s. Especially in the medium-term perspective, it clearly shows the need for further reforms.

The dynamics of population growth is usually autocorrelated: the amount of population growth is positively or negatively correlated with the amount of previous growth. This (Pilowsky & Dahlgren, 2020) study found that autocorrelation increases

the risk of extinction due to "inertia" that prolongs the deviation of positive populations toward decreasing growth rates. However, the level of life-cycle autocorrelation transition has not yet been fully analyzed. At the same time, a stochastic matrix with known autocorrelation values for each matrix element was developed with the colored noise R program to generate population growth projections. At the same time, long-term demographic data on the number of 25 inhabitants in the COMADRE and COMPADRE databases were used to analyze and model their stochastic dynamics. These results revealed a wide range of autocorrelation relationships across species, populations, and life cycle stages. It was found that the interclass number of period residents in the matrix strongly affects the autocorrelation of the growth rate. In addition, reproductive transitions in population growth have negative autocorrelation than survival transitions, and in matrices dominated by positive autocorrelation, there is a higher risk of extinction, and it was argued that the type of transition in population growth is not related to the color of the noise. In conclusion, the results of the study show that population growth is autocorrelated with life cycle exchanges, even population growth of the same species varies. Also, the R program for colored noise is recommended for autocorrelation analyzes of structural demographic indicators of population growth.

This article (Mulder et al., 2022) explores the existing associations between migration and labor market rates in the widely studied countries of Northern and Western Europe and the United States. To do this, the researchers used a sample of labor market participants from the Attitudes and Expectations Regarding Mobility survey conducted in Spain in 2019. As a result, it was found that, firstly, the probability of

becoming a professional is higher for women who have migrated than for those who have not migrated. Second, women who live close to family are less likely to be unemployed or find temporary work than those who do not, but none of these associations were found in men. Third, that living close to the family is consistent with the notion that the close family can protect women, from precarious positions in the labor market. Fourth, that migration differs from previous results for Northern and Western Europe and the US, which indicate that migration benefits men.

This article (Mulder et al., 2022) discusses migration as a way to enhance professional careers. However, especially in Mediterranean countries, labor market outcomes may also depend on local family resources. For example, it examines how labor market outcomes for men and women differ between (1) migrants and non-migrants and (2) those living close to and far from family. With the help of an in-depth study of migration trends and the labor market in Northern and Western Europe and the United States, he emphasized the important role of living in the environment of close people within the family, more than in other contexts. Indeed, a sample of labor market participants was described by analyzing the results of the survey "Attitudes and Expectations About Mobility" conducted in Spain in 2019. In particular, among the immigrant women group, it was shown that immigrant women are more likely to be professionals. However, the odds of being unemployed or in temporary employment were lower for women living close to family, but no association was found for men. The finding of living close to family is consistent with the notion that close family may protect women in particular from precarious positions in the labor market. The finding on migration differs from earlier findings for Northern and Western Europe and the United States, suggesting that migration is

particularly beneficial for men. It is also possible that this difference is specific to a low-migration context, but data limitations clearly prevent firm conclusions.

This article (Paquet et al., 2021) emphasizes the importance of assessing the contribution of demographic parameters in population growth to changes in population growth in order to understand why populations change. Integrated population models (IPMs) offer the possibility to estimate the contribution of demographic parameters to population growth for which no data are clearly collected – usually immigration. Such demographic parameters are often cited as important drivers of subsequent population growth. However, the accuracy of the assessment of their change over time, and therefore their contribution to the change in the population growth rate, is not fully studied today. Indeed, when estimating the contribution of immigration in the process of demography with the help of IPM, it is necessary to determine the potential biases and their dependence on the IPM parameter, the formulation of subjects, the level of temporal change of immigration, the sample and the demographic size, in order to determine the magnitude and quantitative cause of possible biases. Empirical data on populations with known immigration rates were also used, for example: the soya sheep *Ovis aries* and the Mauritian kestrel *Falco punctatus* with zero immigration and the Scandinavian gray wolf *Canis lupus* with near-zero immigration. In immigration scenarios with zero variation (proportion of variance attributable to immigration = 63% for the restricted formulation and real sample size) and wild populations, the IPM greatly overestimated the contribution of immigration to changes in population growth. true numbers of immigrants were zero or close to zero (eg, kestrel 19.1%-98.2%, sheep 4.2%-36.1%, and wolf 84.0%-99.2%). Although estimates of the

immigration share in the Immigration Survey became more accurate with increasing temporal variation and sample size, it was often not possible to distinguish accurate estimates from data with high temporal variance and overestimates from data with low temporal variance. A good estimate of the contribution of immigration may require larger imprecise sample sizes. To reduce the risk of overestimating the contribution of immigration (or any additional parameter) to the IPM, the following are recommended: (a) look for evidence of changes in the contribution of immigration to population growth before examining it, (b) model the data for comparison and compare the simulations to real data, and (c) Where possible, accurate immigration data should be used.

The aim of this work (Tiwari et al., 2020) is to forecast India's population by the end of the current century, and also to study the year when the number of young people per capita in India's population is structurally the highest. The authors compared the age structure of the population in 2001 with the structure of 2096, for example, based on the model of distribution of the population according to age characteristics. Also, the most popular method of population projection, known as cohort component method, was used in this study to estimate the population of India. For this purpose, the population at every five-year interval is used with valid forecasts of a certain level of birth and death, so this method is called a dynamic demographic projection model in the scientific literature. Meanwhile, Age Specific Fertility Rate (ASFR) for different years was derived from NFHS-3 and 4 to predict new arrivals. According to the study, India's population will begin to decline by the middle of the present century. However, it can be seen that the total population in 2021 is almost the same as the total population in 2001, but one interesting thing is that the age structure of the two

populations is opposite. According to the research, in the future, the number of women of old age (70+) will be more than the number of men of old age (70+).

### 3. Methods and main results

To construct a mathematical model of the demographic development of the population of a small town, the mathematical theory of differential-difference equations (Kerimkhulle & Aitkozha, 2017) and models of the system dynamics of complex objects (Sterman, 2000) are used. And for the implementation of which algorithms, program codes in the AnyLogic software (AnyLogic, 2022) were developed and result-oriented computer experiments were carried out to reveal the hidden relationships between the values of the input indicators: initial population size, immigration and emigration rates, average life expectancy, household size, fertility rate reproductive women and outputs: population, newborns, deaths, emigration and immigration.

In this regard, in this paper, a demographic model of the systemic dynamics of the population is considered in order to reveal the hidden dependencies between the input parameters and the result-oriented output data of the demographic situation of the inflows and outflows of the population of the small town of Kosshy, Akmola region of the Republic of Kazakhstan.

#### 3.1. Mathematical model of the population

Let  $t = 1, 2, \dots$ , – forecasting time periods, year, then to construct a mathematical model of the population in the demographic process of a small town, the following are used:

– first-order difference scheme equations to ensure balanced population growth –  $Population_t$ , and stability between inflows:  $Immigration_t$  – immigration numbers,  $Births_t$  – births number and population

outflows: Emigration<sub>t</sub> – emigration numbers, Deaths<sub>t</sub> – deaths numbers:

$$= \text{Immigration}_t + \text{Births}_t - \text{Emigration}_t - \text{Deaths}_t;$$

$$\frac{d(\text{Population}_t)}{dt} = \text{Immigration}_t + \text{Births}_t - \text{Emigration}_t - \text{Deaths}_t; \quad (1)$$

– initial population, – PopulationInitial:

$$\text{Population}_t|_{t=0} = \text{PopulationInitial}; \quad (2)$$

– immigration numbers, – Immigration<sub>t</sub>, which is determined through the population, – Population<sub>t-1</sub> and the number of attracting population inflows due to housing of the previous period, – AttractionDueToHousing<sub>t-1</sub> with the immigration rate, – ImmigrationNormal:

$$\begin{aligned} \text{Immigration}_t &= \text{Population}_{t-1} \\ &* \text{ImmigrationNormal} \\ &* \text{AttractionDueToHousing}_{t-1}; \end{aligned} \quad (3)$$

– births number, – Births<sub>t</sub>, which is directly proportional to the population of the previous period, – Population<sub>t-1</sub> with proportional coefficient, Fertility – fertility of reproductive women:

$$\text{Births}_t = \text{Fertility} * \text{Population}_{t-1}; \quad (4)$$

– emigration numbers, – Emigration<sub>t</sub>, which is determined through the population of the previous period, – Population<sub>t-1</sub> with the immigration rate, – ImmigrationNormal:

$$\begin{aligned} \text{Emigration}_t &= \text{EmigrationNormal} \\ &* \text{Population}_{t-1}; \end{aligned} \quad (5)$$

– deaths numbers, – Deaths<sub>t</sub>, which is directly proportional to the population of the previous period, – Population<sub>t-1</sub> with proportional coefficient, 1/AverageLifetime – inverse of the average life expectancy of the population:

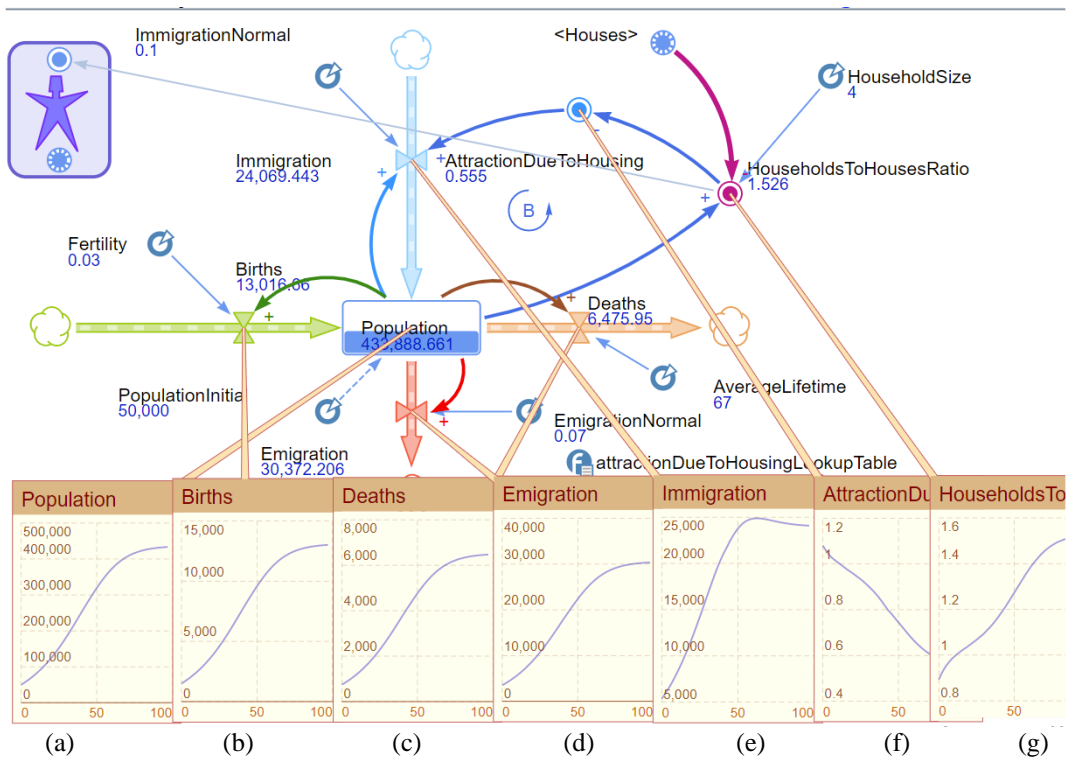
$$\text{Deaths}_t = \frac{\text{Population}_{t-1}}{\text{AverageLifetime}}; \quad (6)$$

– attraction function value attractionDueToHousingLookupTable population inflows due to housing, – AttractionDueToHousing<sub>t</sub> from the ratio of households to the number of houses, – HouseholdsToHousesRatio<sub>t</sub> according to the given lookup table:

$$\begin{aligned} \text{AttractionDueToHousing}_t &= \text{attractionDueToHousingLookupTable} \\ &(\text{HouseholdsToHousesRatio}_t); \end{aligned} \quad (7)$$

– the value of the ratio of households to the number of houses, – HouseholdsToHousesRatio<sub>t</sub>, which is directly proportional to the population, – Population<sub>t</sub> and is inversely proportional to the number of houses, – Houses<sub>t</sub> with proportional coefficient, 1/HouseholdSize – inverse of the household size of the population:

$$\begin{aligned} \text{HouseholdsToHousesRatio}_t &= \frac{\text{Population}_t}{\text{Houses}_t * \text{HouseholdSize}}. \end{aligned} \quad (8)$$



**Figure 1.** Input parameters, output data and computer implementation of a mathematical model of the demographic situation for a small town in the AnyLogic software [12]

### 3.2. Computer implementation of the population model

Let the input data of the parameters be given:

- PopulationInitial, – the initial value of the population size of a small town with an interval of acceptable values [30 000; 100 000] people, in particular PopulationInitial = 10 000 people;
- AverageLifetime, – average life expectancy with an interval of acceptable values [50; 80] years, in particular AverageLifetime = 67 years;
- Fertility, – fertility rate of reproductive women with an interval of acceptable values [0.01; 0.1] or from 1 % till 10 %, in particular Fertility = 0.03 or 3 %;

- EmigrationNormal, – the rate of normal emigration of the population with an interval of permissible values [0.05; 0.15] or from 5 % till 15 %, in particular EmigrationNormal = 0.07 or 7 %;

- ImmigrationNormal, – the rate of normal immigration of the population with an interval of acceptable values [0.05; 0.15] or from 5 % till 15 %, in particular ImmigrationNormal = 0.1 or 10 %;

- HouseholdSize, – average number of people in a household with an interval of acceptable values [2; 8] people, in particular HouseholdSize = 4 people.

Then the computer implementation of the mathematical model of the population (1)-(8) makes it possible to obtain the following results

of the output data – values, simulation, and visualization of the results of computer experiments:

- Population<sub>t</sub>, – population growth with 50 thousand by 434 thousand 510 people (see Fig. 1, «S» shaped curve (a)),
- Births<sub>t</sub>, – increase in births number with 1 thousand 500 by 13 thousand 35 people (see Fig. 1, «S» shaped curve (b)),
- Deaths<sub>t</sub>, – increase deaths numbers with 746 by 6 thousand 485 people (see Fig. 1, «S» shaped curve (c)),
- Emigration<sub>t</sub>, – increase in the number of emigrants with 3 thousand 500 by 30 thousand 415 people (see Fig. 1, (d) – «S» shaped curve),
- Immigration<sub>t</sub>, – increase immigration numbers with 5 thousand 401 by 24 thousand 68 people (see Fig. 1, curve (e)),
- AttractionDueToHousing<sub>t</sub>, – decrease in the coefficient of attracting population inflow due to housing with 1.073 or 107.3 % by 0.554 or 55.4 % (see Fig. 1, curve (f)),
- HouseholdsToHousesRatio<sub>t</sub>, – increase in the ratio of households to the number of houses with 0.897 or 89.7 % by 1.528 or 152.8 % (see Fig. 1, curve (g)).

#### 4. Discussion

Finding an effective solution to alleviate the burden faced by mental health services is critical today. In this regard, the work (Makanjuola et al., 2022) proposes an evaluation the Emotion Mind Dynamic (EMD) service. SROI analysis is theory of change at the program level to establish how inputs (e.g., costs, staff) translate into outcomes (e.g., number of clients) and then into outcomes that matter to clients affected by the EMD service (for example, improved mental well-being). The Welfare Assessment will quantify and evaluate outcomes using two sets of values. The mixed-method approach SROI collects quantitative and qualitative data from questionnaires and interviews with former EMD clients as well as new clients, executing a blended online learning program. A study result

was obtained to analyze the SROI of a socially prescribed lifestyle coaching program aimed at improving mental well-being and resilience. It is shown that the EMD lifestyle education program can create positive coefficients of social value. It also provides an EMD online blended learning program that compares: personal and blended online for improving mental well-being and self-efficacy through participation in this innovative lifestyle coaching program.

A study (Tiwari et al., 2022) examines of seasonal cycles and permanent migration on inequality in rural India. The authors apply a counterfactual method to estimate income, and the results show that seasonal migration is a strategy of the poor, as opposed to permanent migration, which involves more affluent migrants. Further, using Gini decomposition and aggregate regression, it is found that seasonal and permanent intra-group migration reduces intra-group migration and inter-group inequality, while seasonal cycle migration increases the number of poor and improves the situation of the poorest relatively. It was also noted that the impact of the migration process is consistent with the U-shaped pattern of migration in the permanent category and further downward trend of migration in the seasonal category.

The article (Agadjanian & Nedoluzhko, 2022) investigates the feature in fertility between minorities and majorities in Western countries with low fertility, usually a common issue on the cultural characteristics of minority groups and on the socioeconomic disadvantages associated with minority status. However, the establishment and operation of ethnic complexes outside the Western world are often at odds with the standard Western model, and therefore can influence fertility preferences, behaviors, and outcomes. As a result, the authors, analyzing the ethnic variability of completed and desired fertility in the multi-ethnic transitional environment of Kyrgyzstan, where ethnic groups and their ethno-linguistic parts are characterized both by different stages of the demographic trend, and by different positioning in socio-economic and political terms.

Based on data analysis, the work (Chen, 2022) made a few attempts to assessment of the level of education of women on fertility in China, indeed, author noted that more educated women have higher fertility, but it remains unclear whether education obviously affects female fertility. Here, the time and various aspirations of women for higher education are seen as exogenous sources of increasing the level of education of women in China. Thus to a study based on the data value of China (2010-2012), an increase in the amount of women with higher education adds 10% to the amount of newborns. Also, for each additional year of women's education, the amount newborn children is added with a probability of 0.14%, and to having one child by 3% and to having two or more children by 4% increase. The positive effect of education is due to the causes of occurrence: first, education does not lead to middle age at an early age; second, among ever-married women, education increases their need for children.

The article (Diter et al., 2021) aims to highlight school-related determinants on children's life satisfaction and its variation across social classes. Indeed, in fifty years, the topic of child has attracted attention in political and academic debates. These multiple determinants of children's life satisfaction, their relative importance cultural context, include consideration of the school environment for children's subjective well-being and the achievement of a positive education. It was also noted that the well-being influenced by the school environment, the quality of children's relationships with peers and teachers at school, participation them of children. Thus, based on

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the French part of the Program for International Student Assessment (PISA) 2015 (n = 4804), the authors defined a two-stage inequality expression. It is first shown that class differences influence of children will have both a school environment and relationships with peers and parents that increase their levels of life satisfaction. Further, it is noted that social inequality also manifests itself when studying of school-related factors on life satisfaction of children. School bullying, anxiety, and parental involvement in school seem to affect children differently depending on their social background.

## 5. Conclusion

Thus, studying the demographic model of the systemic dynamics of the population of the small town of Kosshy, Akmola region of the Republic of Kazakhstan, a latent relationship was revealed between the input parameters and the output data of the indicators of inflows and outflows of the population as the share of occupied lands for housing construction, which is a leading indicator in ensuring stable reproduction of the demographic process.

Based on the results of the study, an assessment was made of the impact of the housing construction industry on the future population of such outputs as population, newborns, deaths, emigrants and immigrants.

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## LIFE SAFETY IN THE HOUSEHOLD AND SOCIAL SPHERES

***Abstract:** The issue of ensuring the safety of life is becoming more and more urgent. Society is beginning to understand that the further development of mankind and technological progress require that everyone has the highest level of knowledge and culture in this field. The purpose of the presented research is to study the safety of life and to consider the safety of life in the household and social spheres. The methodological basis of the research is based on a combination of various general scientific methods of scientific cognition. This study used methods of information analysis and synthesis, the comparative method, and the method of induction and deduction. At the final stage of the study, the method of analysing scientific literature relevant to the subject of the study was used. Life safety (LS) can be characterised as a science that studies hazards and ways to protect against them. It is an integral part of the system of state, social and defense measures taken to protect the population and economy of the country from the consequences of accidents, disasters, natural disasters and weapons of destruction of the enemy. In the course of the study, it was determined that social practice indicates that a person violates the rules of safe behavior for several reasons. First of all, this is explained by ignorance of the object of influence, the rules of safe behavior and ways of their application, the discrepancy between the physical and mental capabilities of a person to the requirements of public practice. The practical value of the presented research lies in the fact that it can be used by both theorists and practitioners in the process of studying the safety of human life in the household and social spheres.*

***Keywords:** Hazard Identification; Anthropogenic Factors; Habitat; Emergencies*

### 1. Introduction

The issue of ensuring the safety of life is becoming more and more urgent. Society is beginning to understand that the further development of mankind and scientific and technological progress presuppose that everyone has the highest level of knowledge and culture in this area. Gradually, there is a need to organise targeted continuous training

of citizens on the basics of safe behavior to reduce the negative impact of the so-called human factor in all spheres of life (Akhmadieva and Minnikhanov, 2015).

Currently, society is in the process of forming a culture of safety in life. Today, this field of activity covers a wide range of people and different sectors of the economy. The practice of analysing and statistical data of operational reports of the Ministry of

Emergency Situations and other ministries shows that the number of people killed as a result of fires, material damage and, in general, human and natural emergencies is decreasing (Sexton et al., 2016). However, from time to time there are discrepancies between the production potential and the constant growth of social needs, which become more complicated from year to year. For example, the planning of large cities leads to the destruction and degradation of natural ecosystems. The creation of new sectors, intensive technological renewal of the basic sectors of the economy, and an increase in the number of enterprises require an adequate system of protection against man-made disasters of any origin (Syropoulos, 2020). Life safety (LS) can be characterised as a science that studies hazards and ways to protect against them. It is an integral part of the system of state, social and defense measures taken to protect the population and economy of the country from the consequences of accidents, disasters, natural disasters and weapons of destruction of the enemy. The main goal of the Belarusian Railways as a science is to protect people in the technosphere from negative dangers (impacts) of anthropogenic and natural origin, achieving comfortable or safe living conditions (Shershneva et al., 2019).

The impact of man-made risks disrupts people's daily lives, causes accidents leading to emergencies and catastrophes, including environmental ones. Currently, there is an alarming trend of increasing the destructive impact of natural hazards and processes. Despite all the specifics of situations in specific countries and regions, they are determined by population growth, the concentration of population and material values in relatively limited territories, and the changing nature of the genesis of natural disasters (Zagrebin, 2017). By invading nature and creating ever stronger engineering complexes, humanity is creating a new,

extremely complex system, including the technosphere, the patterns of development of which are still unknown. This leads to increased uncertainty in the functioning of the technosphere, the entropy of its processes, the danger of man-made disasters, large-scale accidents in industry, energy, transport, pollution of the biosphere with highly toxic and radioactive waste, which threatens human health (Kristowski et al., 2018). The tasks of the LS as a science include: identification of hazards, recognition and quantification of negative impacts on the environment; prevention of human exposure to certain negative factors; protection from danger; elimination of negative consequences of exposure to dangerous and harmful factors; creation of a normal, that is, a comfortable state of the human environment. Human security in a broader sense is a state of complete physical, social and spiritual well-being determined by internal (heredity, physical and mental health) and external (natural, anthropogenic, technogenic, social environment) factors (Sexton et al., 2016).

It is almost impossible to avoid most natural situations. However, there are a number of dangerous natural phenomena and processes that can prevent negative development. This can be achieved by taking measures to prevent hail, premature avalanches and spills of mud lakes formed by blockages of mountain rivers. Measures to prevent such situations may also include localisation or suppression of natural sites of infection, vaccination of the population and livestock (Kristowski et al., 2018). The organisation of security in various spheres of socio-economic development of the state needs qualitative development of aspects of pedagogical activity. This work will create such a concept as the "paradigm of life safety". Only in this way, or even better, a step forward, can the safe life of the country's citizens be ensured (Sexton et al., 2016).

The purpose of the presented research is to study the safety of life and to consider the safety of life in the household and social spheres.

## 2. Materials and Methods

The methodological basis of the research is based on a combination of various general scientific methods of scientific cognition. This study used methods of information analysis and synthesis, the comparative method, and the method of induction and deduction. At the final stage of the study, the method of analysing scientific literature relevant to the subject of the study was used. The method of information synthesis was used in the study. Synthesis is the process of joining or combining previously disparate things or concepts into one whole or set. Synthesis is also a method of combining the whole from functional parts, unlike the analytical method, this method involves dividing the whole into functional parts. The study also used the method of information analysis. Analysis is the process of dividing a complex topic or object into smaller parts to gain a broader understanding of the presented topic or object. Using the methods of analysis and synthesis of information, it was considered what the social sphere includes. It was determined that the social sphere includes: educational and educational institutions, medical institutions, cultural institutions, sports institutions, institutions that provide social services, catering establishments, organisations that provide utilities, passenger transport, and institutions that provide communication services.

Comparison can be characterised as a logical technique necessary in any cognitive activity: at different stages and at different levels, regardless of the subject. Comparison can be used as a special research method only if the comparison procedure requires special training and special organisation. Such a need usually arises when comparing

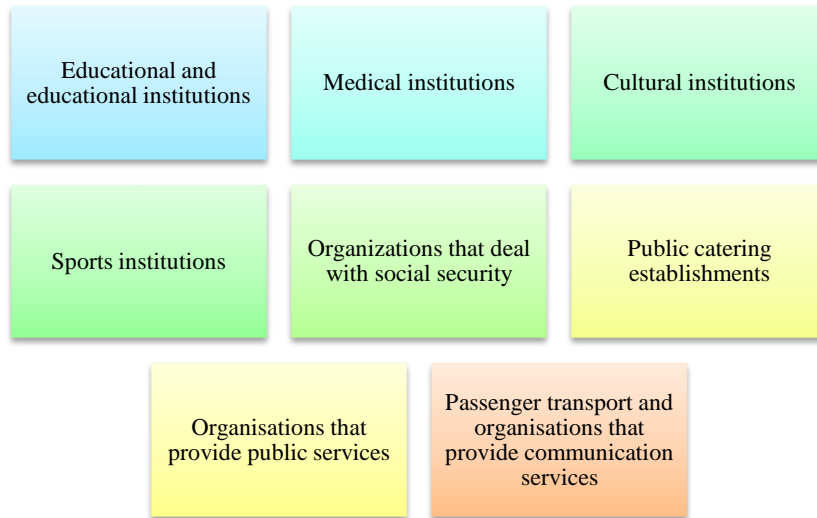
complex objects and phenomena that are characterised by a large set of very different characteristics. The experience of comparative law shows that based on the comparative method, it is possible to solve not only scientific and educational, but also important applied tasks. The methods of induction and deduction were also used in the study. The inductive method is a method of research and presentation in which there is a transition from the observed concrete facts to the allocation of principles, general provisions of the theory and the definition of patterns. Deduction is a method of thinking, the result of which is a logical conclusion, the truth of which is guaranteed by the truth of the assumption. With the help of induction and deduction methods, it was determined that the impact of man-made risks disrupts people's daily lives, causes accidents leading to emergencies and catastrophes, including environmental ones. At the final stage, an analysis of the scientific literature was carried out. The analysis of scientific literature is an accessible research method, but also the most demanding. This method requires certain skills of working with literature: the ability to take notes, group material in accordance with the work plan. The main purpose of analysing literary sources is to collect scientific data on the topic under study, consider the prospects of research and formulate a working hypothesis. When analysing literary sources, various works of researchers were considered. In the process of analysing literary sources, the studies of scientists from different countries were considered. All the studies considered were aimed at studying the problem of human life safety.

## 3. Results

In the course of his life, a person constantly faces dangers and extraordinary events, very diverse and related to natural, man-made,

environmental, social and other phenomena and processes. The social sphere is a set of industries, enterprises, organisations that are directly related and determine the way and standard of living of people, their well-being. The social sphere covers the entire

sphere of human life, from the conditions of his work and life, health and recreation to social, class and national relations (Kristowskiet al., 2018). Figure 1 shows what the social sphere includes.



**Figure 1.** Social sphere of life

Thanks to numerous organisations, the social sphere of public life thus provides people with working and leisure conditions, takes care of physical development, health and education. Everyday life is an unproductive, unprofessional sphere of human activity. This can also be called a way of life. The process of satisfying a person's material and spiritual needs characterises the way of life, satisfaction of needs leads to new needs, thereby outlining the development of the next human life, and consequently, the way of life (Skripnuket al., 2019). The household sphere prepares a person for social activity. This creates a special type of social relationship. Social and household relations create relations between people for the production and consumption of public goods. For society, the household sphere is the definition of the level and properties of the life of individuals. This also determines

the social stratification in society, so the household sphere of life is closely related to the property stratification of society. The practice of dangerous and emerging emergencies shows that up to 85% of all cases of their occurrence are related to human activity and arise for social reasons (Kristowskiet al., 2018).

Dangers, extreme and emergency situations are very diverse. They can be caused by natural disasters that cause natural disasters; environmental, related to imbalances in human activity and the environment; man-made accidents resulting from accidents and catastrophes in the industrial sector, transport, communication systems; social, related to public disputes and others. These extremely dangerous phenomena and processes are directed at society, that is, at specific people, public and state structures

and the environment (natural, industrial, social, etc.), outside of which society simply cannot exist. Conditioned upon this, they need not only to know, be able to identify, anticipate, but also to protect themselves from them, that is, to prevent, localise, neutralise, stop and, if necessary, eliminate (Skripnuket al., 2019).

In the social sphere, a dangerous situation, as in other spheres of life, a real event, a process that can harm people, society and the state is possible, including their well-being, destroy natural, material and spiritual things. A social threat is always meaningful, filled with specific content, and in the case of a clearly formulated dangerous situation, it often acquires a certain legal characteristic, which is often fixed in regulatory legal acts (Bolbocean and Tylavsky, 2021). Protection from social threats is the most important function of state and public structures. It consists primarily of preventive measures aimed at eliminating these dangers. In addition, it is necessary to properly train a person who can adequately act in dangerous situations: psychological, informational, legal, security, etc. In the process of training, it is necessary to adopt behavioral models that consider specific situations (Sokolovet al., 2018). Social emergencies can be characterised as limited situations in a confined space, which are the result of dangerous conflicts and conflicts in social relations, which may or may not lead to human casualties, harm to human health or the environment, significant material losses or destruction (Akhmadieva, 2015).

The basis for the emergence and development of social emergencies is the violation for various reasons of the balance of social relations, for example, economic, political, interethnic, as well as religious. These circumstances can be provoked by various factors causing social tension. Such factors include unemployment, corruption, crime, riots, terrorist acts, government crises, inflation, food problems, social unrest,

domestic nationalism, locality and others. The long-term influence of these factors on chronic physiological and mental fatigue of people, severe extreme conditions such as depression, suicide, etc. (Kristowskiet al., 2018).

There are a lot of social dangers. These include various forms of violence, including legalised (wars, armed conflicts, terrorist acts, riots, repression), crimes (banditry, theft, fraud), substance abuse (alcohol, drugs, medicines, cigarettes), suicide and much more that can harm human health and life (Akhmadieva, 2015). A special place in human security is occupied by such social factors as the level of well-being, general culture, service culture, living conditions, habits, moral and emotional characteristics. The socio-political environment is of great importance for its security, namely, the state and its institutions (legislative, executive and judicial authorities, self-government bodies, public administration bodies, ministries), public structures (political parties and organisations), trade unions, public organisations, family, citizens. All their actions must comply with the current legislation and be based on a balance of interests of the individual, society and the state, and their mutual responsibility for security (Sokolovet al., 2018).

One of the most important aspects is ensuring the safety of people from crimes (premeditated murder, violence, interference with the health and dignity of the individual, robbery and theft of personal property and documents, physical and psychological terror) related to threats, intimidation, extortion and other forms of human exploitation, influence, including informational and psychological (use of mass media) and psychophysiological (hypnosis, psychotropic drugs) (Skripnuket al., 2019). Social practice shows that a person violates the rules of safe behavior for several reasons. This is explained by the ignorance of the object of influence, the

rules of safe behavior and ways of their application, the discrepancy between the physical and mental capabilities of a person to the requirements of public practice. Such disorders can also be permanent (lack of coordination, insufficient concentration of attention, non-compliance with social requirements) and temporary (fatigue, deterioration of health, disability, depression, stress, intoxication) (Akhmadiyeva, 2015).

These causes cause danger and threats. Preventive measures in the first case include advertising (propaganda) of safety rules and training people based on them; in the second, training and practicing safe behavior skills; in the third, social control, professional selection, medical examination. Experience shows that a person and a social environment is a complex interaction of a person with different components of his social environment. To ensure their mutual security, it is necessary to prevent hazards and threats and prepare all elements of the system for action in dangerous situations (Kristowskiet al., 2018).

#### 4. Discussion

For a more extensive consideration of the concept of "life safety" and the study of life safety in the household and social spheres, it is necessary to consider the research of other authors. The article of S.N. Krivorotenko (2019) is devoted to the theoretical and organisational and managerial aspects of human interaction with the environment, protection of the environment and society from the negative effects of various hazards (natural, man-made and social origin), which allows developing effective measures to eliminate their causes, creating living conditions in the "Human Environment" system. The concept presented in Krivorotenko's research is intended to generalise and use various methods and tools to ensure the safety of life and environmental protection necessary for human functioning

in various environments: domestic, industrial and non-industrial, living and inanimate nature, emergency situations and other environments, and contributes to the development of the idea of the inseparable unity of effective professional activity, social interaction, harmonious spiritual and physical development.

The article of D.V. Smirnov (2017) presents the results of a study of didactic support for the development of functional literacy of schoolchildren in modern conditions on the thematic component of safe life. Analysis of contradictions in the development of functional literacy in the field of safe living and health in modern conditions: family and social institutions. The author identified the essence of the formation of functional literacy as the corresponding minimum content of education, its core in the field of a safe and healthy lifestyle. The procedural specificity of the leading type of activity is shown, the content and form of which depends on the specific historical conditions of the child's development. Based on the results of research and experimental activities, the author considers a typical situation when the knowledge and skills of safe behaviour of students and adults violate the basic rules of safety and health. The possibilities of creating behavioural models that ensure unconditional compliance with safety in the social and natural environment when implementing a system-activity approach are presented. The necessity of creating an informal socio-cultural environment for teaching and educating the younger generation based on the method of trial and error in various types of activities, obtaining social experience in socio-professional exams is substantiated.

The article of E.I. Zagrebina (2017) examines the relevance of the problem of complex security in the context of the combined action of various types of threats and dangers, including one of its components, namely, the security culture.



The author considered the organisation of the discipline "Safety of life" and its content, considering the complexity of the presentation. An example of a practical task in which it is necessary to apply knowledge to ensure comprehensive human security. The author has formed a unified competence for bachelor's degree programs as a result of mastering this discipline.

N.V. Grizodub (2021) notes that the discipline "Life safety" is mandatory for university students. Considering the security situation in the world and in some countries and regions, an increase in injuries and a decrease in the general health of the population. The author substantiates the role and importance of the discipline "Life safety" in universities by the example of studying the topic "Health and biological foundations of safety". Since it is the biological hazards that arise in the modern world under the influence of environmental factors that require careful consideration to ensure a safe human life in various fields: educational, social, professional and others. the health of students as the most mobile stratum of society conditioned upon the development of a safe culture of life, a model of safe behaviour in society and in future professional activity.

Whether it is a separate building or a campus in a university, corporation or medical complex, there is a general requirement when it comes to shock absorbers that ensure the safety of life. This general requirement is proper installation, operation and maintenance, which is confirmed by the necessary checks and tests from the beginning to the end of the service life of the safety valve. When it comes to life safety dampers, the responsibility for installation, operation and maintenance is a reality that should be discussed in detail. Besides the fact that proper installation, inspection, testing and maintenance of dampers to ensure the safety of life is mandatory, this is a good business opportunity for many

engineering firms or service contractors (Liescheidt, 2018).

The article by M.H. Faber, J.D. Sorensen, T.A.C.W.M. Vrouwenvelder (2015) considers the question of choosing the right metric of risks related to life safety and health in the context of regulation, considering the effects of temporal and spatial scales for their consistent quantification and comparison between social sectors, industries and areas of application. The starting point is a summary of what is considered to be the basis for modern best practices in regulating life safety and health risks. After that, based on selected main examples from various fields of application, inconsistencies in the existing quantitative risk assessment of best practices in the context of regulation are identified and discussed. It is identified and explained that the principle of optimising solutions and the joint implementation of the principle of ultimate life saving does not make it relevant to assess individual life safety risks for specific people. The obtained absolute level of individual risk to the safety of life is also not subject to an assessment of acceptability. The authors emphasise that the main reason for the inconsistency of quantitative assessments and comparisons of risks stems from the fact that the current regulations partly relate to public activities, and partly to applied technologies; in some cases they consider the standpoint of individuals, and in others the effectiveness of the technologies used. In addition, the authors have shown that the commonly used averaging of individual risks over time and space can lead to unintentional masking of ineffective actions and applied technologies. Finally, the authors propose how it is possible to consistently and uniformly assess and compare the individual risk to life safety for different types of activities and technologies used.

R.S. Akhmadieva, R.N. Minnikhanov (2016) note that the study of the problem of life safety is important because it is necessary to develop each person's ability to identify and prevent hazards, and to ensure personal safety on the road. Thus, this article is devoted to the disclosure of the structural and substantive components of the management of the life safety system on the roads. The main approach in the study of R.S. Akhmadieva, R.N. Minnikhanov (2016) has become an integrated approach that allows us considering the safety of personal life on the road as a purposeful system capable of self-organisation and self-management for the safe behavior of participants in road transport relations. The article covers the essence of life safety on the road, the authors presented their components as an integrative system. The authors have identified subjective factors affecting the safety of life on the road (the duration and periods of change of road signals; the expected time of passage of a certain section of the path), mental states and individual characteristics of a person (health and mood); age characteristics; the level of theoretical and practical skills of a road user. The article also identified the structure of the educational road environment for children. The authors identified the peculiarities of their upbringing (Akhmadieva and Minnikhanov, 2016).

N. Uchida et al. (2018) notes that although life safety information systems on smartphones are widely used for disaster emergencies, there have been some problems with their use by people who do not know how to work or are injured. Thus, the study of N. Uchida et al.(2018) offers methods for detecting static bodily objects using a delay-resistant network for a life safety information system. In the system, sensors on smartphones automatically detect abnormal static situations based on the difference in time and position based on Monte Carlo methods with a Markov chain,

and emerging messages are automatically transmitted with message priorities. Moreover, these messages are transmitted to servers with a network resistant to delays. Then a prototype of the system is introduced and experiments on evaluating the effectiveness of the proposed systems are discussed.

M.-O. Chae's research (2014) is a study of the ways in which the key conditions of anxiety, impulsivity, scholarship of life safety practices, attitudes to life safety practices, interpersonal assistance and self-efficacy from the modification of maintaining Pender's health affect the practice of behaviour that ensures life safety in school-age children. The author notes that the sample included 489 pupils of grades 5 and 6 from five elementary schools in Seoul and four provinces of South Korea. The materials were analysed using schematic statistics, correlations, factor analysis and modeling of structural equations. The attitude to the practice of providing life security, interpersonal support, self-efficacy and impulsivity directly affected the practice of behavior providing life security. M.-O. Chae (2014) notes that anxiety did not have a direct impact on the practice of safe behaviour, but indirectly affected it. In this modified model, 52.0% of the practice of safe behavior was explained by the main factors. In conclusion, the author noted that it is necessary to simplify the practice of behaviour related to the safety of life in late childhood. The author notes that it is necessary to develop a positive attitude to the safety of life, and to reduce impulsivity and increase self-efficacy (Chae, 2014).

O.A. Leshchynska, V.M. Firman, V.M. Marych, Y.V. Ilchynshyn, Y.B. Velykyi (2021) note that one of the most important aspects of life safety is the use of appropriate means and measures to create and maintain healthy and safe living conditions and human activities both in everyday life and during emergencies. The human factor as a

factor of life safety can be the main source of danger. A person's readiness for responsible constructive behavior is formed conditioned upon the influence of the organisational culture of the enterprise, and the information space. The authors sought to explore the role of moral attitudes of young people and their readiness for constructive social interaction. Research by O.A. Research Leshchynska, V.M. Firman, V.M. Marych, Y.V. Ilchyshyn, Y.B. Velykyi (2021) was held in the 2019-2020 academic year on the basis of Lviv Polytechnic National University. A total of 570 respondents took part in the survey. The survey was conducted. Factor analysis revealed six factors. The authors found that the majority of students have consumer, authoritarian and destructive ideas, so their reactions to the actions of life safety specialists on the introduction of occupational safety technologies are reduced to formal observation (Leshchynska et al., 2021).

R.Sh. Akhmadieva et al. (2019) substantiated a noxological approach to determining mechanisms to counteract the risks of modern hazards. The key ideas of the noxological approach in the framework of their research are environmental protection and human life safety. Their research is based on methodological principles and leading ideas of environmental protection and human life safety, presented in the context of social ecology, the concept of sustainable development of environmental safety, in the ecological paradigm, in the coevolutionary paradigm, in environmental ethics. The authors have attempted to create a theoretical model of a noxological approach to countering the risks of modern hazards in the field of environmental protection and human life safety. The systematisation of the basic concepts of the noxological approach as an independent scientific direction is carried out; the regularities and sources of hazards are established; the taxonomy of hazards is

determined; the prototype of the hazard passport is substantiated. The authors note that their research can be used for universities, teachers and students. The study comprehensively and fully presents a model of the noxological approach to environmental protection and human life safety: the risks of modern hazards (Akhmadieva et al., 2019). Therefore, the safety of life has a social orientation, since it is connected with ensuring the protection of society from dangers, including from itself. At the same time, it has a social aspect associated with the danger that spreads in society and threatens people's lives and health.

## 5. Conclusions

It was determined that the society is currently in the process of forming a culture of safety in life. It is important to note that today this field of activity covers a wide range of people and different sectors of the economy. Life safety can be characterised as a science that studies hazards and ways to protect against them. It is an integral part of the system of state, social and defense measures taken to protect the population and economy of the country from the consequences of accidents, disasters, natural disasters and weapons of destruction of the enemy.

The impact of man-made risks disrupts people's daily lives, causes accidents leading to emergencies and catastrophes, including environmental ones. Currently, there is an alarming trend of increasing the destructive impact of natural hazards and processes. In the course of the study, it was determined that social practice indicates that a person violates the rules of safe behavior for several reasons. This is explained by the ignorance of the object of influence, the rules of safe behavior and ways of their application, the discrepancy between the physical and mental capabilities of a person to the requirements

of public practice. The basis for the emergence and development of social emergencies is the violation for various reasons of the balance of social relations, for example, economic, political, interethnic, as well as religious. These circumstances can be provoked by various factors causing social tension. It was determined that the tasks of the Belarusian Railways as a science include: identification of hazards, recognition and quantification of negative impacts on the environment; prevention of human exposure to certain negative factors; protection from danger; elimination of negative consequences of exposure to

dangerous and harmful factors; creation of a normal, that is, a comfortable state of the human environment.

It is important to summarise that the safety of life is one of the most important aspects of human life. A large number of researchers from different countries of the world are engaged in the study of LS. In the course of the presented study, the safety of life in the social and household spheres was considered. However, it is important to note that there is still a need to consider and study LS in other areas of human life.

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## **CASE STUDY: REDUCING THE WASTE RATE BY USING PDCA**

**Abstract:** *Customer satisfaction is the key to success in all organizations, the global competition within the various manufacturing companies has led organizations to consider higher standards of competitiveness and develop advanced improvement strategies to satisfy the customer. Lean Manufacturing has proven to be relevant to improve performance in the process, it is considered one of the most recognized and effective tools for reducing costs and waste in order to improve customer satisfaction and implement continuous process improvement. This article describes the use of the PDCA approach (Plan, Do, Check, Act) in an automotive company whose objective is to reduce the waste rate in order to improve product quality. After defining the current state, measuring the rate of defects and setting the objectives to be reached, an analysis was made to detect the root causes, then actions were put in place to reduce the rate of waste and verify if the established objectives were reached. The use of the PDCA method plays a key role in improving product quality in order to achieve continuous improvement in the process.*

**Keywords:** *Lean Manufacturing, Quality, PDCA Cycle, Performance Improvement*

### **1. Introduction**

Continuous improvement is a fundamental culture to improve performance in all processes of the organization as well as for companies to remain competitive [1], [2]. In recent decades, companies seek to compete globally by improving quality, productivity and customer satisfaction [3]. The competition forces the different organizations to obtain relevant strategies in order to produce their goods in high quality, make the company more productive with less resources, there are different methodologies and approaches used to improve the quality in the company. Lean Manufacturing has proven to be relevant for the resolution of problems in the process and the continuous improvement of different companies [4],[5].

This article describes the concept of Lean Manufacturing and the PDCA cycle (Plan, Do, Check and Act). The Lean Manufacturing methodology is one of the most recognized and effective approaches worldwide to improve product quality and reduce various types of waste [6]. There are different tools and techniques of Lean Manufacturing [7] but this article focuses on the PDCA method in a cabling company to improve the productivity of the cutting process.

#### **1.1. Lean Manufacturing**

The concept of Lean Manufacturing was first implemented by Toyota Motor Corporation in the late 1950's named Toyota Production System [8]. It is used to eliminate waste to

improve the productivity of the organization [9]. The main objective of Lean Manufacturing is the continuous improvement and the elimination of non-value added actions and unnecessary steps in a process [10],[11]. This methodology can be applied in any industry and in all sectors of activity that are concerned with the search for financial performance [12] and it has become a dominant production strategy and a successful paradigm for manufacturing companies [13]. The main objective of Lean Manufacturing is to satisfy customers' needs and improve the organization's performance by identifying and eliminating different types of waste in the process. OHNO, the founder of the Toyota Production System, is recognized as the father of Lean Manufacturing, illustrated the categories of non-value added waste (also called Muda in Japanese) in companies [14], [15] represented as follows: Waiting, Overproduction of products, Inappropriate or unnecessary processing, Excess movement, Defective products, Excessive stock, Unnecessary transportation and Unused creativity [16]. Lean Manufacturing is based on principles for the proper implementation in the organization because it has become a priority for different organizations. These principles are: Value, Value Stream Mapping, Flow, Pull and Perfection [17]. Studies show that the Lean Manufacturing approach positively affects operational, economic and environmental performance [18],[19]. This concept gathers a set of tools and techniques to facilitate the detection of problems and their resolution in order to improve the quality, productivity and performance of the organization [20],[7], among these tools, we cite the PDCA approach [16].

### 1.2. The PDCA approach

PDCA is considered as a basic tool of Kaizen or continuous improvement, it has proven to be relevant in different industrial

processes[16]. At the beginning, this tool was implemented in Japanese companies and later on it was used by different companies [21]. The PDCA cycle is the acronym of Plan, Do, Check and Act [22], It is usually repeated monthly or weekly in industry, it is also called the Deming cycle which was developed from the cycle Shewhart [23],[24]. It is a method for developing improvements in the process [25]. The PDCA cycle is divided into four phases [26], [27]:

- Plan: Define and set the objectives to be reached, define the current situation of the process, propose corrective actions [23]. Each action can be supported by tools such as the Pareto chart, the Ishikawa diagram and Brainstorming.
- Do: To implement the action plan defined in the "Plan" step [28], tools can be used such as the action plan, benchmarking and the flow chart.
- Check: Check and test whether the established objectives have been achieved, Analyze the results of the actions implemented in the previous step [29]. Control charts and checklists can be used in this phase.
- Act: Develop methods to standardize improvements and return to the first "Plan" phase [30].

## 2. Case study

Plan:

The study was made in an automotive company and especially in the cutting area. This is the first step in the production process, the cutting area is equipped with automatic machines that serve to cut electrical wires according to the required lengths, strip them and then crimp them. The quality measurement factor in this process is the FTQ (First Time Quality), it is calculated by the following relationship:



$$FTQ = \frac{\text{Number of defects} * 1000000}{\text{Number of pieces produced}}$$

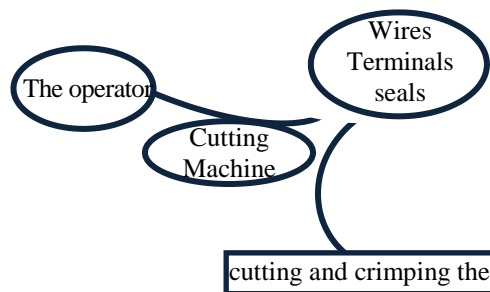
To fully understand the problem, the QOQCP method (Table 1) was used to

detail the project as well as a horned beast diagram (Figure 1) to illustrate the importance of the product and how this product meets the needs of its users.

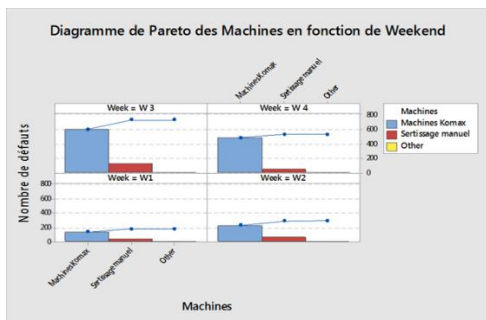
**Table 1.** Defining the Project

- Who is concerned by the project?
- What is the project?
- Where?
- When ?
- How ?
- Why ?

- Cutting Departement
- The number of anomalies is high
- The cutting process
- During the cutting process
- Using the PDCA approach
- To decrease the FTQ+ Customer Satisfaction



**Figure 1.** Horned beast diagram of the cutting machine



**Figure 2.** Pareto chart of cutting machines

After identifying the problem, we tracked the FTQ for 4 weeks, according to Figure 2 and by the Pareto chart, we notice that the KOMAX machines have the highest FTQ rate, KOMAX is designed for cutting, stripping and crimping of small and medium section wires. Then a thorough analysis is made by the FMEA method (Failure Mode, Effects and Criticality Analysis) to identify all possible failures.

**Table 2.** FMEA of the KOMAX machine

Machine equipments	Function	Mode of failure	Causes	Effects	Actions
Straightening unit	Straighten the wires	Wheel malfunctions	Lack of lubrication of the wheels	Wire skating	Ensure compliance of parameters with the standard Lubricate the wheels
Cutting station	Cut the wires to the desired length	Badly cut wire	Problem with the cutting blades	Bad cut	Check and adjust the cutting blades and clean them Check the movement

					of the cutting arm
Seals station	Insertion of seals	Blocking	Lubrication of the seals Problem with the kit	Stopping the machine Having problems without a seal	Check that the seals are not oiled Adjustment of the Kit
Press station	Crimping wires with terminals	Variation of the cable position in relation to the terminal Locking of tools	Adjustement	Refusal of the machine: Absence of visual defect, Deformed terminals	Adjustment of the rectifiers Change of applicators Changing the tool
Control Unit	Top WIN	Blocking the PC	Error Manipulation	PC shutdown	Restarting the PC Reinstalling Top WIN

**Do:**

This phase consists in implementing the action plan detailed in the previous step associated with the elimination of the causes of the problems detected in the cutting area and especially the KOMAX machine. After the action plan was developed, the team assigned each person their task to ensure the successful execution of the proposed plan.

**Check:**

After determining the failure modes of the KOMAX cutting machines and implementing an action plan, it was verified whether the applied actions were able to decrease the defect rate. It is also necessary to check the different units by a preventive maintenance evaluation grid of the KOMAX machine to avoid anomalies.

**Table 3.** Preventive maintenance of the KOMAX machine

	Actions	M	S	N
Presse Station	Clean the blades of the tool			
	Check the fit of the tool blades and other tool components			
	Attach the terminal guide			
	Cleaning the crimping press			
Cutting Station	Check the movement of the cutting arm			
	Grease the cutting head and arm			
	Check and clean the cutting blades			
Seals Station	Cleaning the seal station			
	Adjusting the Kit			
	Before starting the seals, check that the seals are not oiled (lubricated)			
Rectification station	Checking the condition of the bearings (Wheels)			
	Checking the operation of the wheels			

	Wheel cleaning			
	Wheel adjustment			

Act:

We must act on the actions that are not achieved and that have not generated relevant improvements, so we must repeat the cycle to re-evaluate the intervention and obtain a continuous improvement in the process.

### 3. Conclusion

PDCA (Plan, Do, Check and Act) is a never-ending cyclical process and a powerful method for continuous improvement. This article presents a case study of the PDCA

method in an automotive company. The company was able to reduce the defect rate but this should not lead to stop the improvement of the cutting process. The next step should be the development of a new PDCA circle to improve the quality of the product. The PDCA cycle is considered a simple approach but it is effective in solving problems and achieving continuous improvement in the process. This tool is part of the Lean Manufacturing methodology which is a highly recognized approach to eliminating waste and improving the performance of organizations.

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## SMART CLOUD BASED ECOLOGICAL SYSTEM FOR CONTACTLESS VEHICLE CLEANING

**Abstract:** *The rise in the overall standard of living leads to an increase in the number of used cars. As the number of cars increases, so do the maintenance requirements. As a result, the growth of vehicle washes is increasing. However, the issue of their economy comes up. The current literature sources present the following ecological and technical issue: how to determine and apply the best use of water and detergent on automated car washing systems while minimizing vehicle washing time. Thus, this paper tries to propose a ecological contactless vehicle washing smart system based on the application of cameras, programable logic units and cloud databses for high-quality vehicle washing, monitoring and optimal resources usage. Specifically, the proposed smart system for automatic contactless vehicle washing could be used for water flow regulation, detergent concentration regulation and for managing the process of determining the overall dimensions of the vehicle.*

**Keywords:** *vehicle washing system, Internet of Things, cloud computing, databases, automation*

### 1. Introduction

The majority of vehicle washing systems currently available rely on human labor. This type of car wash has a variety of flaws, including poor washing, lengthy wait times, and excessive water and cleaning product usage (Lalluwadia et al., 2017). To solve these challenges, a number of automatic car-washing systems have been created in recent times, based on the use of RFID-GSM (Vidyasagar et al., 2015), programmable logic controller (PLC) and SCADA ((Alphonsus et al., 2016; Lalluwadia et al., 2017), proximity sensors (Gaikwad et al., 2017).

However, in most cases the in process of car washing, systems used a fixed amount of water and detergent, regardless of the level of dirtiness of the car, which leads to an

ecological unoptimised waste of resources and larger costs. For vehicles with a low degree of soiling, the fixed amount of water and detergent used may be too high, which leads to their wastage and more difficult washing. On the other hand, for vehicles with a high level of dirt, it can be low, which leads to poor cleaning results.

In addition, in automated car washes that use the movement of the mechanical arm assembly and the jet or spray of water and detergent for cleaning and washing the vehicle, it is very important to correctly determine the overall dimensions of the vehicle being cleaned. It is a procedure that requires a significant amount of time spent in the vehicle washing process. An ultrasonic sensor is used to determine the length of the vehicle in automated car washes every time they enter, the application of which requires a

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certain amount of time. The ultrasonic sensor is located on the assembly of the mechanical arm, which, after the vehicle takes the washing position, determines its dimensions in the first pass around the vehicle. The ultrasonic sensor is connected to a PLC and transmits the dimensions of the vehicle to it. Based on the passed dimensions, the PLC device determines the further position of the mechanical arm assembly and defines the further movement around the vehicle being washed. The procedure is repeated every time the vehicle enters the car wash, requiring a considerable amount of time for each wash.

The aforementioned problems are the reason for the development of a system based on the application of cameras and a PLC with a hardware accessory for high-quality vehicle washing, and the desired characteristics with a number of additional advantages.

The proposed smart system for automatic contactless vehicle washing could be used for water flow regulation, detergent concentration regulation and for managing the process of determining the overall dimensions of the vehicle.

## **2. Literature review**

There are currently two basic types of car cleaning techniques in use. Car washing is a viable solution. The alternative is a mobile car wash service (Zhong et al., 2017). The first service is customer-driven, in which the consumer brings their vehicle to the store to be washed. Typically, a water line, a high-pressure spray pistol, and towels are all that is required to clean a vehicle. Hybrid design that combines automatic and manual car washers are used for a more complex, semi-automatic approach of cleaning automobiles. Time is the most major disadvantage of hand car cleaning. This is especially true during traffic congestion.

With the advent of Internet of Things (IoT) and car-to-car communication came the

"internet of vehicles" (Gerla et al., 2014), ushering in the age of the autonomous automobile. Elevator internet (Yang et al., 2016) is the result of the interconnection of elevators with the IoT, allowing for the first time to perform intellectualized elevator maintenance. The car wash sector is leveraging technologies from the IoT and big data to build a car wash cloud and terminal interface that connects cloud operators with car-wash shops, and car-wash manufacturer representatives with customers. The driver can take use of the automatic car-washing service at any time and from any location by visiting the nearest car-washing store. To put it simply, cloud operators are the ones in charge of building and maintaining the system. Manufacturers in response to various models will make functionality enhancements (Gerla et al., 2014). Safe, quick, convenient, and environmentally friendly automatic car washing service is provided by the shops, all of which have well-maintained car wash equipment.

The IoT as an emerging paradigm in ubiquitous computing built from the ground up on the internet (Wu, 2015), uses both wired and wireless networks to connect to the Internet. It achieves real-time, everywhere connectivity between things, objects, and people by employing synthetic mass sensors, an intelligent processing terminal, and global positioning system technology. When all is said and done, it achieves smart management and command. There is the widespread implementation of IoT applications like internet of vehicles, unmanned aircraft, automatic car washer (Gaikwad et al., 2017) and etc. Thus, has caused some to refer to it as the "third wave" in the global information business, following the computer and the internet (Zhong et al., 2017). This style of automatic car washing has a variety of specific uses, including a mass automatic car washer, video security cameras, access through mobile devices, and vehicle identification.



Therefore, in this age of the IoT, automatic car washing mode is not only an unavoidable consequence of technical progress but also a selling point. Thanks to the unified cloud platform, mobile terminals, video security cameras, and mass-produced automatic vehicle washers may all connect with one another. Meanwhile, transaction and client information is recorded. As a group, the merchants maintain their individual customers. Customers can have their vehicles cleaned at the most convenient location, regardless of where they are parked. This procedure ensures quality and lowers vehicle washing time. There will be fewer individuals hand-washing automobiles and more customers at car wash services. Different consumers can choose to retain the original, exquisite cleaning or inspection procedure.

In the paper by Vidyasagaret al. 2015, authors discussed the usage of a microprocessor to manage the automatic car washing process. They explained how to employ a wide range of IR sensors, RFID equipment, and GSM networks. A conveyer mechanism is used to move the car from the garage door to the garage worker's station. A sensor that can detect dust particles can pinpoint the area of the car where dirt has settled. A sprinkler and drying system are utilized to clean the car. In order to prevent unintentional car detection, RFID could be utilized in conjunction with GSM technology. Meanwhile, GSM could be used to keep customers updated on the cleaning status of their vehicles.

The electro-mechanical method for operating an automatic car washing was presented by Tejas et al. 2017. Automatic car washers use a device that raises parallel cars and moves forward to wash them. The vehicles are then washed in a sequence of foam water, soap water, and clean water. The vehicles are raised once more and positioned parallel to the ground. Mechanical assembly and electrical control make up the bulk of the system. The importance of PLC in operating vehicle washers is emphasized.

The paper by Sorkhabi et al., 2014 explains how a PLC is used in an automatic smart car washing. The smart car washing can automatically adjust its size to accommodate any vehicle. The dimensions of the vehicle are significant in adjusting various elements such as the position of the cleaning brush and the time duration. This automation improves speed, accuracy, productivity, and safety while decreasing washing time and cost.

### 3. System description

In view of the above, this paper tries to present a system for automatic car washing that can, by applying modern technologies, determine the optimal amount of water and concentration of detergent according to the degree of soiling of the vehicle body, while reducing the washing time. The mentioned issues were eliminated by the use of industrial cameras, ultrasonic sensors, a mechanical arm mechanism, a nozzle, a water tank, a detergent tank, a hose for water flow, a hose for detergent flow, a control valve for regulating the water flow and a control valve for regulating the flow of detergent that serve to inflow of water and detergent at the location where the vehicle is washed, and a programmable logic unit with a hardware accessory (Figure 1).

One of the cameras are used for vehicle identification through license plates. If the vehicle entered the car wash for the first time, the ultrasonic sensor is activated to determine the length of the vehicle. The information about the specific length of the vehicle is stored in the database, so that this information is automatically available every time the vehicle enters the car wash and its license plate is detected. The vehicle length information obtained from the database affects the control of the mechanical vehicle wash arm assembly, reducing the time required to determine the length using the sensor. Another camera records the dirty surface of the car and is used to determine the

level of dirtiness of the vehicle body. The information system is used to control the water and detergent flow valves based on the images formed by the cameras according to the degree of soiling of the vehicle body, so that the optimal amount of water and detergent mixture is sent to the mechanical arm assembly for washing the vehicle. Based on the level of contamination, it is possible to define the flow rate, the length of the open time or the number of active high-pressure nozzles. Therefore, the level of detergent and water usage is matched to the vehicle's soiling.

The cameras work via the GSM network, i.e. a sim card goes into it like a cell phone. Every SIM card has its own IP address, just like every computer. Through that IP address, you can see what is happening in the area where the camera is installed at any time from any computer that has access to the Internet.

When you connect to the camera, the camera sends a frame to your computer every 5 seconds. In addition, the camera has the possibility of connecting a motion sensor or a door opening sensor, whereby if someone enters the space where the camera is installed, it records a video length as long as it is set on the camera itself and sends it to you by e-mail or saves it on the memory card in the camera (Micro SD card is an accessory), and by connecting it to the camera, you can view the data stored on it. The camera has the ability to record on call, that is. by dialing the phone number that is in the camera, the camera records a video that is also saved on the memory card or sent to e-mail. This function is used if you do not have motion sensors and you suspect that something is happening in the area where the camera is placed and you do not currently have a computer near you.

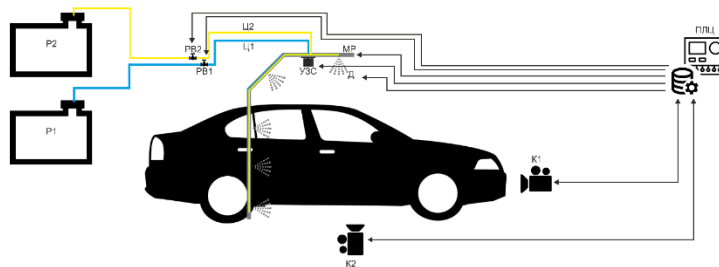


Figure 1. Solution proposal for a smart car wash system

The software for monitoring and managing Smart automatic car washes was created using JavaScript and PHP scripting languages and the Arduino library for C and C# programming languages (Figure 2). The software consists of three main components. The first component is used to collect data from Smart automatic laundries and was implemented using the PHP scripting language and the Arduino library for programming languages C and C#. The second component is a database component in

which data is stored in the form of an object-oriented database, that is, in the form of JSON documents. The third main component is the user interface, which is implemented using the JavaScript open source library. The data is collected from the automated laundries using the first component and forwarded to the second component via the GSM module. The data is then stored within another component and can be used as a control trigger through the GSM module for sensors that will reduce the water flow through the

electric valve or reduce the flow time or reduce the number of active nozzles of the automated laundry. Finally, data on resource consumption can be displayed to users with

different privilege levels within the third component of the realized software solution, that is, the Corinthian interface.



Figure 2. Information system concept

It was established that after logging in the user via the login screen, which is a navigation screen in the background, based on privileges (limited number of functionalities), laundries that need to be monitored can be selected in the user part of the application.

The application allows the user to get a graphic display of the values of the following parameters for a time interval:

- 1- Number of washes
- 2- Water consumption (Parameter 1)
- 3- Consumption of shampoo or detergent (shampooing) (Parameter 2)
- 4- Wax consumption (waxing) (Parameter 3)

The selection screen for the level with administrator privileges provides additional features and functionality. The administrator

has privileges over the data of all users and the laundries available to them. At the prototype level, the functionalities that are available are related to the basic data of customers of laundromats, users of the system, laundromats with their location, car brands and models, color catalogs, etc.

The details of the physical scheme of the part of the database related to data storage of measured values of parameters such as used chemicals, used water, number of washed vehicles, temperature and pressure of automated car washes were defined. Tables of physical schemes contain basic data on the current values of the observed parameters, the time when the parameters were registered and the time of data entry into the database. Picture is attached for temperature and pressure Figure 3.

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	id	int(11)			No	None		AUTO_INCREMENT	Change Drop More
2	valueTemp	float			No	None			Change Drop More
3	fileTime	datetime			No	None			Change Drop More
4	timeTemp	timestamp			No	current_timestamp()		ON UPDATE CURRENT_TIMESTAMP()	Change Drop More
5	user_id	int(11)			No	None			Change Drop More

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	id	int(11)			No	None		AUTO_INCREMENT	Change Drop More
2	valuePress	float			No	None			Change Drop More
3	fileTime	datetime			No	None			Change Drop More
4	timePress	timestamp			No	current_timestamp()			Change Drop More
5	user_id	int(11)			No	None			Change Drop More

Figure 3. Information system database concept

Realization of the software component of automation of communication using the selected Arduino GSM between the Information System and the main PLC device at the location of the laundry was applied. The basic requirements related to monitoring the temperature using the GSM module and sending SMS messages with information about the temperature to the IS database at certain time intervals were determined.

A sensor is used to measure temperature, pressure, consumption of chemicals, etc. The functionality of the module is shown on the example of temperature. Example: If the measured temperature is higher than 50 ° C, an SMS message is sent to the specified number with the appropriate values depending on the location of the washing station. The values are translated into information that is comprehensible to the IS user (washing station owner) and the IS administrator, on the basis of which further decisions will be made.

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## 4. Conclusion

The innovative part of the invention includes the installation of two cameras and a programmable logic unit with a hardware accessory: first camera, which is used to create photos for vehicle identification, and second camera, which is used to record photos with data on the dirtiness of the vehicle body, and a programmable logic unit PLC with a hardware accessory, which is used for storage of data on vehicle dimensions, vehicle identification based on license plates and to determine the level of vehicle dirtiness based on photos recorded by the second camera.

In view of the above, this paper presents an invention that was made as a system for automatic car washing that can, using modern technologies, determine the optimal amount of water and detergent concentration according to the level of soiling of the vehicle body, while shortening the washing time.

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## THE ROLE OF INDUSTRIAL DESIGNER IN ACHIEVING THE GREEN ECONOMY THROUGH RECYCLING

**Abstract:** *The carrying capacity of the earth is in danger due to recent rates of consumption. Our environment is changing drastically because of the large rise in the trash production. As a result, waste management programs now heavily emphasize recycling positive environmental effects. The green economy offers a compelling paradigm for creating societies that are more socially inclusive, resource-efficient, low-carbon, and less harmful to the environment. Industrial design practice and research have spent a lot of time recently focusing on ways to maximize output and consumption to reduce harmful environmental effects. The green economy concept has lately gained favor as a means of achieving both environmental advantages and economic growth. Industrial design can promote the green economy by promoting resource recycling. Design from recycling must be considered to completely establish a green economy. The paper provides a list of considerations to take into account while designing products made of recycled materials.*

**Keywords:** *green economy; recycling; waste management; industrial designer*

### 1. Introduction

One of the major problems that nations struggle with while attempting to combat pollution is waste. All processes including the collection, handling, transportation, recycling, and storage of garbage are referred to as "waste management." Recycling salvageable materials aims to reduce the negative impact of rubbish on both human and environmental health as well as to protect natural resources. (Mihai, et al. 2021).

The pollution that emerges from the manufacture and use of products and services, particularly those that are mass-produced, is to blame for many environmental issues. Natural resources, many of which are irreplaceable, are used in the majority of products and services. The process used to

harvest raw materials from the soil might have an adverse effect on the environment around it. Energy is used during the manufacturing process, which also produces waste and is sometimes dangerous for products. Many products have a negative impact on the environment while they are used, and when they are eventually disposed of, they may lead to additional issues (Deniz, 2002).

In a green economy, investments from different sectors that lessen pollution and carbon emissions, boost resources efficiency and energy and halt the loss of biodiversity and ecosystem services are what essentially drive income and employment growth. This will call for a sharp rise in different sectors' investment that either improve and add to the planet's natural capital or lower

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environmental shortage and threats. These industries contain renewable energy, low-carbon transportation, energy-efficient buildings, clean technologies, better waste management, improved freshwater supply, sustainable agriculture, and forestry, all of which are backed by changes to national policy, as well as improvements to global policy and the growth of market infrastructure (Ahmed, 2013).

One may argue that the green economy is a helpful tool for focusing sustainable development on its main drivers and the links between them in nature. Because it exists between public objectives and results, the green economy can be considered an "enabler" for sustainable growth. Sustainable development might arise from social objectives being met. There are connections among the "enablers" that have been highlighted, which represent just a few of the numerous elements needed to achieve sustainable development (for instance, the green economy needs sustainable urbanism as a basis and a partner process and depends on the value of natural capital). (Georgeson, et al. 2017)

The majority of people concur that a "green economy" entails safeguarding the environment by utilizing organic farming practices, renewable energy sources, and lowering hydrocarbon usage. For there to be a harmonious cohabitation between humans and the environment and to meet both groups' needs, the majority of green economy proponents concur. They also believe there is a connection between the economy and the environment (Mihai, et al. 2021).

Kim Ragaert 2020 applied a strategy of design from Recycling to develop successfully new products with a complex mixed plastic, called the Greentile (Ragaert, et al. 2020). According to Lucien Georgeson's 2017 research, in order to properly quantify the green economy and effectively track the "transformational green economy," it is necessary to move beyond

using GDP as the primary indicator of development (Georgeson, et al. 2017).

To carry out various circular economy strategies, such as waste reduction, recycling, remanufacturing, and reusing, Christian Spreafico and Daniele Landi 2022 investigate and analyze which product design methodologies—from routine design, industrial design, structural optimization, and systematic innovation—are most frequently used by experts designers and students. (Spreafico and Landi, 2022). According to Horodytska Oksana 2021, new recycling technologies are gladly being developed, researchers and stakeholders are aiming to maximize the circularity of plastics and lessen their environmental impact. High-quality applications must use recycled plastics to guarantee the greatest number of material life cycles possible. This helps the market expand and drives up request for recycled plastics (Oksana et al. 2021).

The objective of Lore Veelaert 2017 is to discover a methodological and practical foundation for creating recycled plastic waste streams that may be utilized in the next Design from Recycling project instances. By employing mixed recycled plastics as a starting point, this study sought to clarify the construction of a methodical approach that would hasten the design process (Lore et al. 2017). Mark Richardson 2011 set out to create a set of stronger upcycling rules that would work with the present primary design and fabrication (Richardson, 2011).

For Malaysia-specific important materials data, Al Amin Mohamed Sultan 2022 has successfully discovered 89 materials. Local governments, businesses, or other relevant stakeholders could utilize the knowledge to choose significant materials. Malaysia might use these findings as one of its strategic decision-making tools for determining which products to recycle first. (Sultan et al. 2022).

This paper aims to define the green economy's significance and the contribution



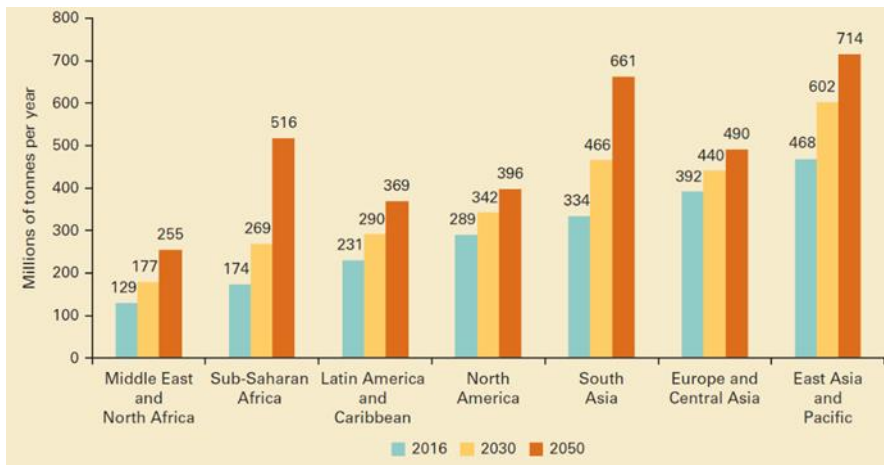
of recycling to it. The function of industrial designers in implementing green economy concepts is also important. This is done by recycling garbage and creating products out of leftover parts. This paper offers several factors that can help designers create designs made from recycled materials.

## 2. Waste over the world

2.01 billion tonnes of solid trash are produced globally annually, and, to be polite, at least 33% of that amount is not handled in an environmentally friendly manner. The average daily trash produced by an individual is 0.74 kilograms, however, this can range from 0.11 to 4.54 kg daily. Despite only making up 16% of the world's total population, rich countries produce around 34% of their rubbish or 683 million tonnes.

[World Bank].

By 2050, it is anticipated that there will be 3.40 billion tonnes of waste produced worldwide, more than tripling the rate of people growth. In general, there is a positive connection between waste generation and income level. In contrast to low- and middle-income countries, where it is anticipated to rise by 40% or more, the amount of rubbish produced daily per person in high-income countries would increase by 19% by 2050. By 2050, the amount of rubbish created is predicted to increase by 70% or 3.40 billion tonnes, more than twice as quickly as the rate of people's growth. This is caused by a number of variables, including people growth, the spread of urbanization, economic expansion, and consumer lifestyles and shopping habits. [World Bank].



**Figure 1.** Expected generation of waste, by region (tonnes in millions /year) [world bank]

Every year, humans produce millions of tonnes of waste, which is quickly becoming a major global issue. The need for governments to provide appropriate waste treatment and disposal services has never been stronger due to the enormous amounts of rubbish that are produced. Only 20% of waste is actually recycled annually, with the majority of it ending up in landfills. Particularly in

developing nations, waste is typically disposed of at hazardous open dump sites. Richer countries generate more rubbish than other countries, but they have better system for waste management to solve these issues (Tiseo 2022). About 30% of the world's waste products are to blame for the planet's continuous ecological problems and rapid climate change (Nandy et al. 2022).

As wealth rises, the mix of garbage changes, exposing various consumption patterns. High-income nations generate less dry trash that may be recycled, such as paper, cardboard, plastic, glass, and metal, which together account for 51% of total waste, as well as less food waste and organic waste, which together account for 32% of total waste. In low- and middle-income countries, respectively, 53 and 57 percent of the garbage produced is made up of food, and as economic development levels fall, the amount of organic waste rises. Less than 20% of the trash stream in low-income nations is recyclable. The waste streams are largely consistent throughout locations, except those that are correlated with income. All regions produce at least 50% of their waste as organic, except North America, Europe, and Central Asia, which produce more dry waste. [world bank]

### **3. Green Economy**

The global financial crisis of 2008–2009 acted as an ideal storm for the global rise of the green economy. The green economy seeks to make the world a better place. Reducing and preventing environmental risks can be achieved by lowering pollution and carbon emissions, improving energy and resources efficiency, protecting biodiversity and ecosystem services, remaining within the ecological boundaries of the planet, practicing environmental responsibility, and having a finite carrying capacity (UNDESA, 2012). Changing specific items to have a smaller environmental impact (Ceschin and Gaziulusoy, 2016).

In light of the repercussions of climate change, the world has been forced to take into account environmental standards in light of its economic ambitions. Accordingly, the world is moving towards the green economy concept, which depends on renewable energy or clean energy such as green nitrogen, and away from fossil fuels that increase carbon

emissions. Certain parts of the circular economy are included in the green economy, such as lowering material and energy consumption in the manufacturing process, recycling and reuse, and more sustainable supply chains. The circular economy is gaining traction in the EU and around the world as a way to boost wealth while reducing reliance on scarce natural resources and energy (Mihai, et al. 2021).

After a product's expiration date, it's dumped or delivered to a location that doesn't have a waste-accepting license. The majority of illicit dumping has occurred in developing or low-income countries. Illegal dumping is a severe concern since waste items, primarily from e-waste products, are recycled in these sites without any safety precautions. As a result, extra caution is required while recycling and handling the assembly or disassembly of spent consumables so that no harm comes to end-users or the environment. Waste management is now a top priority in order to protect and save our planet. There is no time for promises, rethinking, or debating; now is the time to work for sustainability (Nandy et al. 2022).

A key idea behind the "green economy" is the significance of accounting for the value of the environment in economic decision-making. Market prices can frequently provide deceptive information regarding the effects of economic activity on the environment and society, which results in production and consumption patterns that do not support the well-being of recent and future generations (EEA, 2011).

The green economy concept is guided by a few basic ideas. These recommendations support those putting the green economy concept into practice. In the lead-up to Rio+20, several groups published the green economic guiding principles. In that year, the UN Division for Sustainable Development investigated many sets of principles. Numerous ideas have been proposed to improve the understanding and use of the

green economy. The following is a list of the most prevalent principles of the green economy (UNEP);

- The green economy is a strategy for ensuring long-term sustainability.
- The green economy should provide good-paying jobs for the environment.
- The green economy is cost-effective in terms of both resources and energy.
- The green economy is mindful of planetary limits, ecological limits, and scarcity.
- The green economy promotes equality, justice, and fairness for all nations and generations.
- Ecosystems and biodiversity are safeguarded via the green economy.
- The green economy offers access to essential services, well-being, livelihoods, social protection, and poverty reduction.

#### **4. The impact of recycling on the green economy**

Recycling produces a win-win situation: on the one hand, it simplifies end-of-life treatment, and on the other, it ensures the availability of high-quality secondary raw materials. Design from recycling explores what design requirements are and to which extent new products may be produced from a current flow of recycled plastics (Veelaert et al. 2017). Although recycling is important, it's also important to make sure that products and materials are produced to be repaired, reused, and restored from the start (Lisitsa, et al. 2022).

Recycling industries are significant employers globally, employing roughly 1.6 million people globally. They handle more than 600 million tonnes of recyclables annually. With a \$200 billion annual revenue, the sector has already established itself as a major force for tomorrow's sustainable

development (Unido, 2019).

A green economy strikes a balance between social justice, environmental sustainability, and economic objectives. Recycling encourages a green economy in several ways, such as by increasing resource efficiency, minimizing the environmental effects of raw material extraction, creating employment opportunities, and guaranteeing a stable supply of necessary resources (EEA, 2011).

In general, during the past 20 years, definitions of the "green economy" have stayed the same. Internalizing externalities, improving material and energy efficiency, eventually disconnecting material and energy consumption from economic growth, converting to a circular economy, and transitioning to renewable resources are some of the key elements.

Recycling promotes the green economy, according to Visvanathan and Modak (2013), in a number of ways, such as the separation of resource use from economic growth, increased resource efficiency, a reduction in the environmental effects of raw material exploitation, the change to a circular economy from a linear one, and the creation of green jobs.

#### **5. The Designer's Responsibility and Role**

Designers have always been advised to consider how their work would affect the environment. The designer was in a strong position since they could think about environmental concerns while developing environmentally friendly processes and products. Additionally, growing public awareness is resulting in action in several nations. People, for instance, can express their feelings by modifying their preferences, adapting their behavior to accommodate recycling or energy efficiency, or adopting environmental considerations while making purchases.

Designers will have greater obligations than

ever before, both in terms of difficulty and importance. Designers already have to take into account a wide range of factors as part of the design process, including marketing, production, financial, and technological factors. Environment-related factors may be considerably more complicated than these. Because it might be challenging to be informed about all the environmental concerns that surround design decisions. Furthermore, it is challenging to locate comprehensive information on how environmentally friendly alternative materials and methods are (Deniz, 2002).

Nowadays, designers must get benefit from waste. This is through designing products from waste. These products will give benefits to users, decrease the negative environmental impact, provide job opportunities, and enhance people's income. Designers need considerations as guidelines to design products from recycling and achieve green economy principles. The considerations are as follows;

- Use of similar materials to reduce operations.
- Alignment between the form of the product, the used material, and the dimensions of the product to achieve user satisfaction.
- The product performs its function to the fullest.
- Utilize recyclable materials rather than non-recyclable ones.
- The product performs its function with the fewest possible number of parts and components.
- Use standard assembly joints for easy replacement.

## 6. Case Study

The environmental design course at October 6 University assigned a design project to its product design students. The pupils were instructed in various sustainability and green economy concepts and principles.

Implementing the consideration list is the project's aim. The pupils attempted to make use of rubbish by creating a lamp out of various unwanted parts, harming the environment and causing pollution.

The design project depended on I) researching recycling materials, using human measurements and standards, II) putting the design process into practice through idea sketches, using recycled materials, and assembly techniques, choosing the final design idea, and finally; III) implementing the 3D model.

## 7. The result

Students succeeded to design products from waste and unused items, figure (2). These products are aesthetical and Functional. The designs are considered ideas for Entrepreneurial projects, which will provide jobs and reduce poverty.



**Figure 2.** Students' work on different lamps

## 8. Conclusion

The products automatically become waste after use and are discarded in landfills by both the manufacturer and the consumer. The waste amount produced annually all over the

world has greatly expanded as a result of globalization and mass industry, inadvertently damaging our ecosystem. The limits of the linear traditional economic system have been reached. Nature's regenerating capacities are insufficient to address the issue of environmental protection.

These problems can be partially resolved by the green economy. The green economy strives to enhance energy and resource efficiency while lowering environmental risks, carbon emissions, and pollution. Design

serves as the dividing line between these opportunities and issues, and industrial designers are crucial to achieving the objectives of the green economy. This paper gives the industrial designer the guidelines considerations to design from recycling and transferring waste to products.

The product design students at October 6 University understood and applied the considerations list in the design studio. The students created different lamps designs from waste and different unused items.

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## **ASSESSMENT OF DOMESTIC WASTEWATER MANAGEMENT PRACTICES IN ASMARA, CAPITAL OF ERITREA**

***Abstract:** The haphazard handling of wastewater (WW) is presently one of the biggest challenges facing Asmara, potentially crippling development undertakings in the near future. In order to overcome the issue, present research lays the foundation by providing a holistic understanding of current practices and regulating policies of managing domestic WW inclusive of the challenges, both at the household and municipal levels. This study also examined the safety of current practice of discharging WW directly into rivers flowing out of Asmara. In its endeavor to acquire primary data for analysis, 100 respondent quotas were divided proportionally according to populations of the 13 districts of Asmara. The graphical representation of the quantitative data rendered from the survey was drawn in Excel® and the findings of the study revealed that most of the respondents were moderately aware about WW management. The household activities of bathing, dishwashing, laundry, housecleaning and flushing generated averages of 17.13, 15.8, 16.85, 17.63 and 45.316 liters per day respectively. The wastewater generated was an average of 22.4 liters per capita in a day. By extrapolation, the domestic WW generated in Asmara was estimated at 9243.38 m<sup>3</sup>/day for the Asmara population of 421,651. The major wastewater challenges encompass population growth, infrastructural shortcomings and the ineffectiveness of the legal framework. Nevertheless, the study found the absence of robust sewer system and treatment plant to be the root causes for the improper disposal of WW in addition to the lack of technical guide lines and standards. Based on the findings, the study proposed a workable WW management model to tackle the issue in a sustainable way, such that the stakeholders work jointly to ensure proper wastewater policy adoption and enforcement*

***Keywords:** Domestic Wastewater, Management Model, Household Activities, Asmara City, Quantitative Assessment*

### **1. Introduction**

Domestic wastewater is generated due to everyday household activities and may be classified into grey water and black water.

Greywater encompasses WW from dishwashing, showering, laundry and other activities, comprises the bulk of the domestic WW production. It constitutes all the WW produced in the home except toilet waste

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[Ridderstolpe, P, 2004]. Black water, on the other hand is WW from toilets, which can contain feces, urine and harmful pathogens. Domestic WW therefore, must be regarded as a pollutant with a potential to adversely affect the environment and human health. Evidently, many microbial pathogens in domestic wastewater can cause chronic diseases with long-term effects such as degenerative heart disease and stomach ulcer [Paillard, D et al 2005]. Moreover, pathogenic bacteria forms that cause diseases such as typhoid, dysentery and other intestinal disorders may be present in domestic WW [Absar A.K 2006]. Domestic WW generation is ubiquitous in our everyday lives, deeming a broad and robust management scheme necessary to avoid detriment.

In the contemporaneous times, the world population is burgeoning at unprecedented rates, with cities and urban centers housing populations in the tens of millions. Whereas 30 per cent of the world population lived in urban areas in 1950, the proportion of urban dwellers rose to 47 per cent by 2000 and is projected to attain 60 per cent by 2030 [UN Report 2001]. Relative to these developments, the rate of domestic wastewater production has been on the rise, with adequate and proper disposal framework struggling to keep up with the pace. At a global level, appropriate wastewater treatment is still lacking in many countries as around 80% of wastewater produced is discharged into the environment untreated, causing widespread water pollution [WWAP 2017]. This problem is better addressed in developed countries as they possess the technology and legal framework to regulate the indiscriminate discharge of wastewater, whereas this mechanism is amiss in most developing countries, especially in Africa.

The importance of proper management of domestic wastewater is further obviated not only due to pollution and diseases caused by

improper disposal of domestic WW but also because of the need for economic use of water resources. Within developing economies today, water scarcity is an extremely common and prevalent issue. Millions of people live with insufficient fresh water [Howard K.W.F, 2003]. Currently, 2.2 billion people worldwide lack access to safe drinking water. Further, around 4.2 billion people lack access to safely managed sanitation service, increasing the risks of water born illness and making it difficult to maintain hygiene and sanitation practices [World Bank UN Report, 2021]. This is caused by polluted freshwater resources, overexploited groundwater resources, insufficient harvesting capacities in the rural areas, poorly constructed and maintained water supply systems, the high amount of informal water use, and insufficient technical and water management capacities [Mund]. Moreover, availability of water is diminishing due to competing demands from agriculture, mining and industry and from deteriorating water quality and climate change [Jacobsen, M et al 2012]. Proper management of domestic WW can play a role to alleviate the aforementioned causes for shortage of water.

The Global warming phenomena, at present, is causing increased occurrences of extreme events due to shifting temperature regimes. This in turn makes rainfall patterns erratic and disrupted. Uncertainty of rainfall patterns and associated shortages of water make the prospect of reclaiming wastewater, a low quality water resource even more appealing, especially in arid areas. Moreover, benefits of water reclamation and reuse are recognized as a method of preventing the pollution of surface and ground waters [Hespanhol, I 1992]. Reuse of WW is essential to reduce water stress in cities, promote consciousness, and reduce pollutants merging into water bodies. Treated WW can be utilized for multiple purposes such as being reused for crop and



landscape irrigation, groundwater recharge, or recreational purposes, depending on variable levels of treatment. In addition, treatment of WW, aside from enabling reuse of water simultaneously prevents potential harm, as WW contains many hazardous materials and if not disposed carefully, will lead to increased water pollution, potential problems in public health and ecological as well as socioeconomic impacts.

In consideration of the immense stakes wastewater handling has on the wellbeing of society, this study was conducted with the objective of exploring domestic waste water management at household level and municipal level in Asmara. A modular approach of study was adapted, taking a keen interest in the regulating policy as well as current wastewater management, within the framework of yielding sound and robust management models.

## 2. Area of the study

Asmara is the capital and most populous city of Eritrea, located in the highlands of the Central Region. It is situated on a rocky highland plateau, which separates the western lowlands from the eastern coastal plains and specifically has two types of prevailing climates, subtropical highland climate and cold semi-arid climate [CATBT 2020]. It has warm, but not hot summers and mild winters. Due to its high altitude at 2,325-metre (7,628 ft.), temperatures are relatively mild although it is not particularly far from the hotter surroundings in the country. This climate is characteristic of rainy, wet seasons and dry seasons. The long rainy season of the year extends from June until September while the short rainy season occurs from March until April. Asmara's climate is also characterized by drought.

Ambient temperature in the Asmara area is relatively cool (annual daily average of 16.4 °C) [EIA 2007]. the drainage network has a

naturally formed contours driven by gravity from east to west. Subsequently, the surface water from Asmara area drains predominantly to the West and Northwest. Some of the streams continue to flow beyond the Asmara area, eventually joining the Barka River in the West, the Mereb River in the South and the Anseba River in the North. The Mai-Bela and Sembel sewerage streams are both tributaries to the Anseba, making up the Northern and Southern drainage systems of Asmara respectively. Shortages in water supply occur in Asmara, due to the insufficient expanse of the tap system. The shortcomings in tap water supply is mostly covered by water trucks. Whilst there are no significant aquifers in the Asmara area, most groundwater is stored in localized shallow alluvial deposits near the streams Sembel and Mai Bela. Asmara is divided into 13 districts or sub-zones as shown in figure 2.

## 3. Methodology

Qualitative approach was considered more suitable for this study insofar as it will give a holistic description of the wastewater management mechanisms. Nevertheless, quantitative approach was not to be neglected in quantifying the amount of wastewater produced per capita and per household. The use of both primary and secondary data was employed in order to broaden understanding in this study. The primary data collected from the field was aimed at providing the necessary information about the extent of wastewater management deficits in Asmara. In that vein, the necessary primary data was obtained through questionnaires distributed to partially selected respondents in a survey, scheduled interviews with key officials of the government, captured images that reflected the situation on the ground and laboratory experiments to assess the wastewater characteristics. The necessary secondary data was obtained from records on wastewater

management, documents on wastewater related issues, literature (books, journals) and institutional reports.

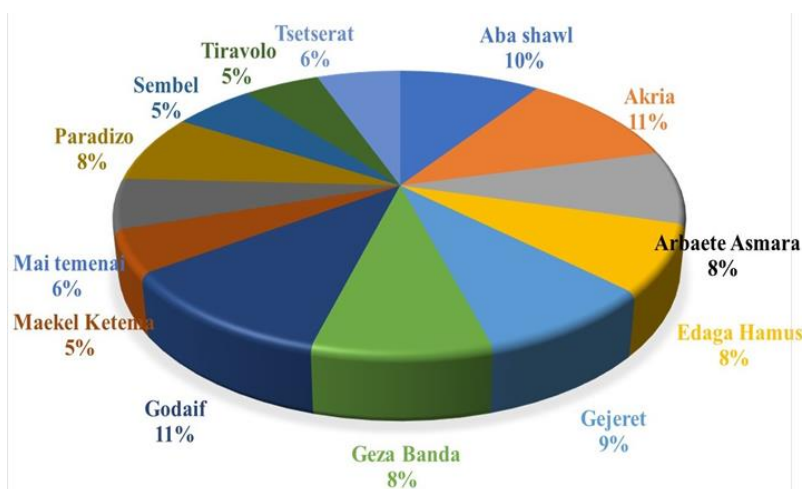
**3.1. Data Collection and Interpretation**

In conducting the survey, one hundred households were involved in the study. Since the survey was carried out in the face-to-face method of data collection, all the participants filled and returned the questionnaires. Moreover, taking into account that women may have more knowledge of domestic wastewater production and way of management practices at household level than men, due to the handling of most domestic activities by the former, the sampling was gender conscious, such that out of all respondents, 55% were female and the remaining 45% male. As mentioned earlier, the study establishes sample of 100 respondents from different households of 13 Asmara administrative regions and in order to truly represent the population, sampling was done in proportion to population distribution of the districts.

The factors addressed in this questionnaire were availability of access to sewer system and most importantly awareness on conservative use of water and potential harms of improper wastewater disposal. Average family size in Asmara was taken as 5

members to a family according to the Administration of ZobaMaekel. Nevertheless, regarding the attainment of information on municipal administrative issues of wastewater and related laws and policy, qualified interviewees were considered from the relevant institutions; Ministry of local government and Ministry of Land, Water and Environment-from the department of water resource and environment. In depth Interviews were held in successive follow-ups in an effort to cover previously undiscovered topics.

The data from the questionnaires was coded into tabular representation after which graphical representation using Excel® was undertaken. Processing and analysis involved rigorous sorting of data. This entailed ordering of questionnaires and other field records for the purpose of subsequent processing and analysis. The questionnaires were numbered and arranged systematically with most of the questions designed as close ended. In order to set the stage for analysis, the answers were transcribed, grouped and coded depending on the topic. Subsequent data presentation was supported by use of pie charts as well as graphs.



**Figure 1.**Percentage make-up of the Asmara population according to sub-zones



Figure 2. Map of Asmara city with delineated districts

## 4. Results and Discussion

### 4.1. Overview of wastewater management in Asmara

The Asmara wastewater management model follows two approaches, use of onsite disposal facility, the septic tank (25 %) and connection to sewer system (64%) with the rest 11 % uncatered for [Umuhoza MFA 2010]. The septic tanks in Asmara, designed for private use of individual households, have a typical size of 22.5 m<sup>3</sup> which generally fills over an average period of 4 years. The septic sewage, after unsealing the tank, is disposed of by desludgers that dump it into the sewer stream north of the Adi Segdo village. As far as has been revealed, septic tanks seem to be a viable alternative to the high-cost construction of sewer system, intuitively speaking. Yet the performance-dependency of septic tanks on the soil type, or rather its permeability, disturbs the balance. For

instance, the rocky soil in Akria district, exhibits reduced water leaching, which leads to rapid filling. Moreover, the desludging process is undertaken when the customer estimates the tank is nearly full, a reasonably flawed estimate, so the desludging trucks are always in full demand and not readily available. This causes a conundrum as some tanks are emptied half-full and others, requiring Immediate desludging, have to wait, at the cost of disposing wastewater haphazardly. To further complicate things, septic tank users in Asmara report an unpleasant odor stemming from the collected waste, which may cause or contribute to the development of respiratory issues such as asthma. Groundwater pollution is also suspected in some areas. In general, people are satisfied when they are connected to the sewage network since septic tank usage would necessitate more follow up with more constraints as far as water consumption restrictions, sewage overflow and disposal tank servicing costs are considered.

The sewer system is composed of the northern sub-system, a combined type sewer system constructed during the Italian colonization era (1889-1941), and the southern sub-system, constructed and expanded over the last three decades. The northern sewer system, covering the central areas of Asmara, consists of open type stone masonry channels in some areas, where residents are reported to dump solid waste and defecate into the wastewater stream, which contributes to the high concentration at the exit. Nevertheless, the concentration of the exit stream tends to be lower during the rainy season, with flooding cases observed during heavy rains. This flooding phenomena, suspected to arise from insufficient tube sizing, is unique to the northern sub-system as the southern sub-system, being a separate type system, is equipped for separate channeling of rainwater and on top of that, can accommodate larger volumes of wastewater albeit requiring seasonal desilting. Another factor affecting the volume output of the southern sub-system is the wastewater originating from open channels in the sub-system leaching towards aquifers that in turn feed groundwater-irrigation activities. All in all, the sewer system in Asmara can be considered non-robust because of inadequacy in its coverage and the eventual flow of the wastewater stream into the Anseba river with zero treatment.

#### 4.2. Source and amount of domestic wastewater generation

As the study identifies there are five main sources for domestic WW generation namely, bathing, house cleaning, dishwashing, laundry and toilet flushing. The following numerical results were obtained from the questionnaire. The study found that, WW generated from toilet flushing is the highest, which needs due consideration to introduce good management simplest of which is

reusing WW from other sources.

Based on the above results, the daily average WW production per capita was found to be 22.4 liters. This level of WW production is considered satisfactorily low as compared to other African capitals. For instance, the domestic WW quantity in Kigali, Rwanda was 32040 liters /day in 2007 [Electrogaz et al 2007] to a population of 970,000 during that same period [MWW] giving a per capita generation of 33.03 liter per day. To determine the daily WW production of Asmara, the per-capita value was multiplied by the latest census as provided by the Administration of Zoba Maekel, and found to be,

$$412,651 * 22.4 = 9,243.3824 \text{ liters}$$

approximately equivalent to 9.2434 cubic meters per day.

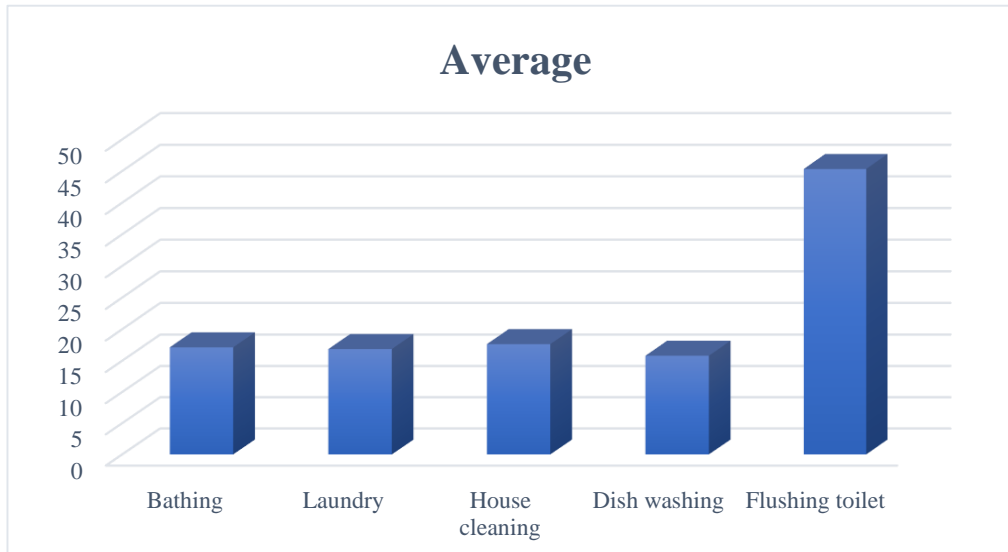
#### 4.3. Wastewater management practices and disposal method at household level

This section of the study tried to explain different management practices at household levels, and the extent to which they are adapted in the population. It first addresses the WW reuse practices in each of the household activities. According to results of the survey shown in figure 4, 81% of respondent's reuse laundry WW for other purposes which makes for a high proportion of the households. On the contrary, WW originating from bathing and house cleaning that could have been reused is disposed in 96% and 57% of respondents respectively.

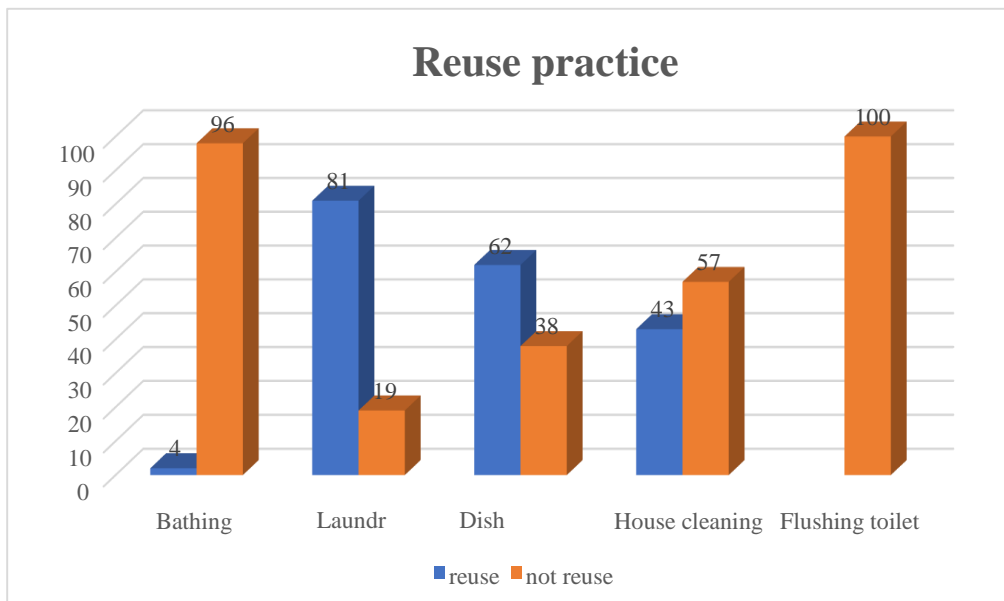
Of the sample respondents, 72% reported that their neighborhood is connected to sewer system, 24% use septic tank and the remaining 4% have no disposal services for their WW. Yet even serviced respondents disposed of wastewater in open areas mainly due to lack of awareness for those connected to sewer system or limited volumetric availability for the septic tank users. Disposal practices for each household activity are presented in the following figure. For

activities such as bathing, laundry dishwashing and flushing toilet WW are predominantly disposed of in the proper

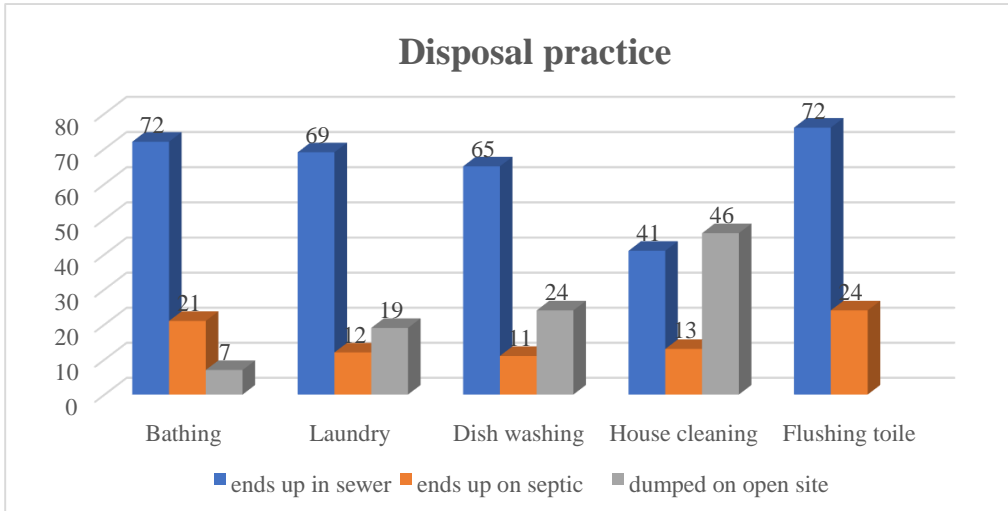
manner, as per the respondents' mode of serviced disposal, septic tank or sewer system.



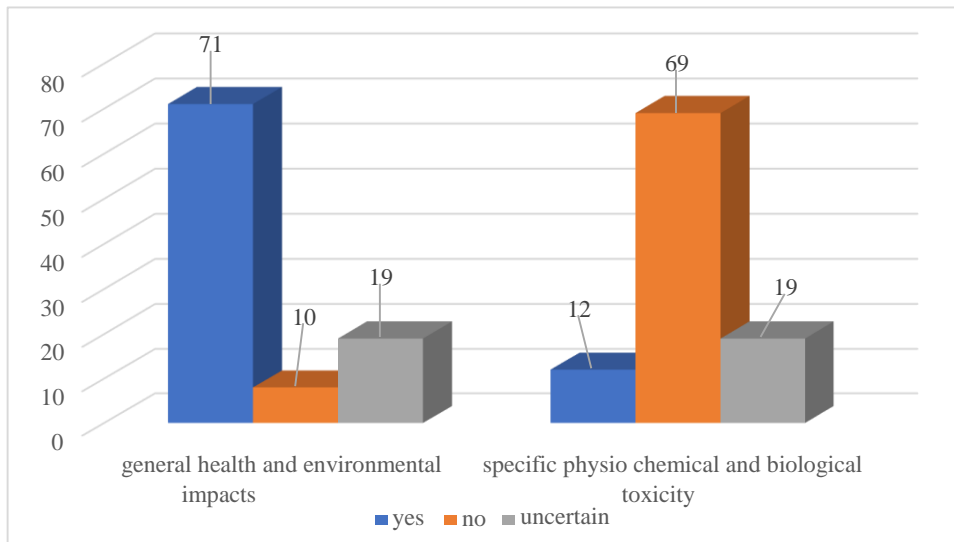
**Figure 3.**Amount of WW generated in liters per day for different household activities



**Figure 4.**Reuse practices for individual household activities



**Figure 5.** Disposal practices for individual household activities



**Figure 6.** Awareness of respondents toward specific and general health and environmental impacts

But in the case of housecleaning, although 96 % were serviced for wastewater disposal,

almost half of the respondents dumped the WW in open sites. This can be attributed to

lack of floor drains in most of the households or their personal reluctance.

The awareness of the population on the health and environmental impacts of improper WW disposal have a non-negligible influence on the handling practice. In view of that relation, the following results were obtained from the questionnaire. From the results, it can be deduced that the awareness on negative impacts of WW on general health and the environment is quite satisfactory. However, most of the public is not aware of the specific physio-chemical and biological toxicity which can be posed from wastewater. The formulation of WW guidelines and promulgation of laws must be followed by awareness creation in order to function. In this regard, the awareness level proves crucial so that people should abide by those laws and guidelines during their daily activities. As per this study, the awareness level remains alarmingly low with 87% reporting that they were not aware of laws and guidelines of WW management.

#### **4.4. Wastewater pollutant levels and impact on water bodies**

In Asmara the widespread use of septic tanks, unsanctioned dumping of WW in open areas and agricultural use of untreated WW have caused an alarming increase in the nitrates and salinity of groundwater as given in the table 1. In addition, recurrent leakages in the sewer system, attributed to improper siting, inappropriate choice of technology, faulty design, poor installation practices, poor operation, or inadequate maintenance may contribute to the phenomena. Groundwater contamination is not readily detectable as contamination does not occur visibly. Nevertheless, groundwater contamination is precarious because inadvertent use of surface water that has its flow basis on the contaminated groundwater is possible.

To determine the pollutant levels in the Asmara WW stream, sample were taken and

analyzed for different pollutant levels. The tests proved conclusively that the merging of WW stream into the Anseba river is undoubtedly a hazardous practice as pollutant levels exceeded by-far the acceptable levels for draining into rivers.

#### **4.5. Challenges to the effectiveness of the wastewater management system**

Concerning the challenges to the effective and eco-friendly functioning of the WW management systems in Asmara, the absence of a treatment plant tops the list. For wastewater to join water bodies, it must meet certain quality criteria based on hygienic standards. Wastewater prior to treatment is characterized by consistently higher levels of pollutants. Nonetheless WW streams in Asmara terminate into the Anseba river untreated.

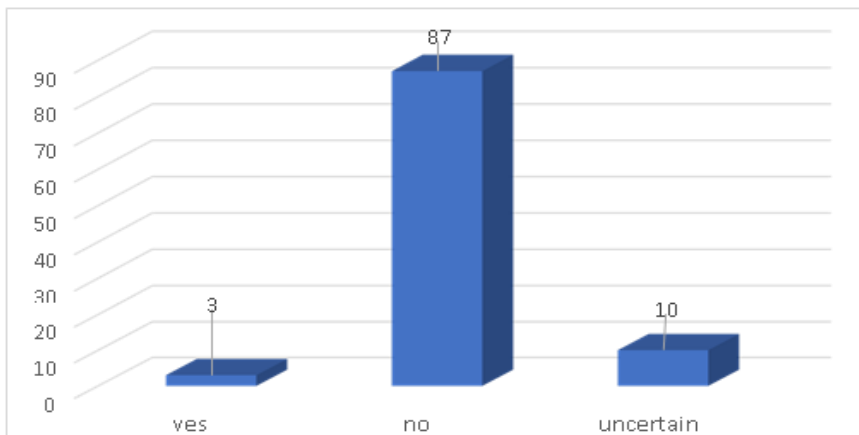
The sewer systems in Asmara provide coverage for less than three quarters of the households in Asmara and are prone to frequent leakages due to old age and out-phased construction material, especially in the northern sub-system, where concrete piping is predominantly used instead of PVC. Over the years, access manhole covers have gotten buried during road construction and maintenance, making maintenance and upgrade of the sewer system a daunting task. Moreover, the wastewater department has shortage of qualified administrative professionals as well as experienced laborers reducing its duty performance capability. The absence of enough workers creates delays in maintenance and repair works.

Besides the old historic and planned housings, Asmara has some dwellings constructed without a master plan, making some un-sewered communities difficult to be added to the sewage network. Most of the unplanned settlements are densely populated, adversely influencing wastewater management in these areas.

#### **4.6. Proposed management Model**

A management model deemed suitable for the WW management of Asmara is the waste management hierarchy, or simply waste hierarchy.

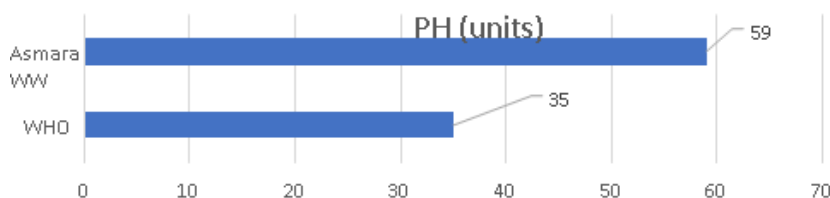
The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste.



**Figure 7.** Awareness of respondents toward existing policies

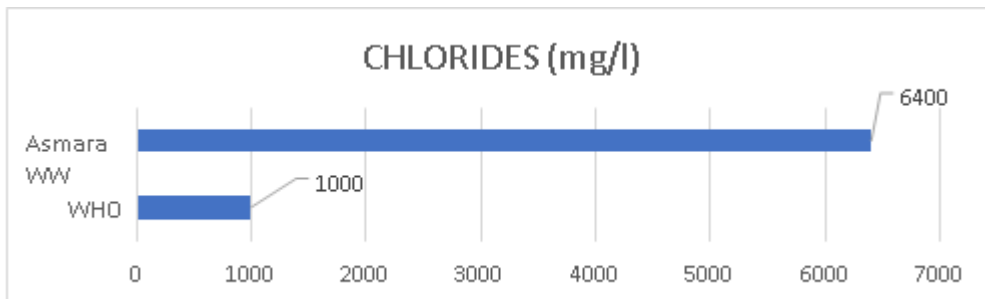
**Table 1.** Salinity and Nitrates levels in Asmara aquifers [15]

Place	Number of analysed aquifers		Amount of Salinity (>=2000) (mg/l)		Amount of Nitrate (>=50) (mg/l)		Level of salinity (mg/l)	
	Partial analysis	Complete Analysis	No	%	No	%		
			27	87	40	35.1	41	47.1
Asmara							<1000	21%
							1000-2000	44%
							2000-3000	17.5%
							3000-5000	12.3%
							5000-10000	4.3%
							>10000	0.9%

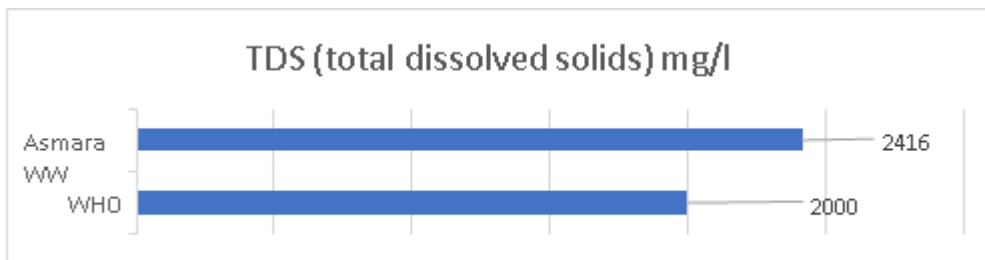


**Figure 8.** PH comparison of Asmara WW stream with WHO standard





**Figure 9.**Chlorides comparison of Asmara WW stream with WHO standard



**Figure 10.**TDS comparison of Asmara WW stream with WHO standard

The waste hierarchy is represented as a pyramid because the basic premise is for policy to take action first and prevent the generation of waste. The next step or preferred action is to reduce the generation of waste i.e. by re-use. The next is recycling which would include treatment. Following this step is material recovery and waste-to-energy transformation where energy can be recovered from processes. The final action is mere disposal, in wet lands without energy recovery. This last step is the final resort for waste which has not been prevented, diverted or recovered. The waste hierarchy represents the progression of a product or material through the sequential stages of the pyramid of waste management.

The WW minimization is the first of the sequential stages of WW management in the waste hierarchy, considering the infeasibility of total prevention. It involves redesigning products and changing societal patterns, concerning both consumption and

production of waste generation, to prevent the creation of waste. . For instance, the use of machines makes it possible to use less water as they provide more agitation and come pre- equipped with a drying faculty, which enables collection of potentially reusable WW which would otherwise have been evaporated while drying the clothes. Some other mindful practices are reducing time in the shower, turning off faucets during intermittent use, adjusting water levels to match the clothes washed in laundry machines and addressing dripping faucets swiftly. Technological solutions such as toilets with tank inserts that maintain flushing pressure as water level decreases or reduced-flow-rate showerheads that restrict flow rates also contribute to the minimization of WW production. A more recent innovation would be the use of hand-sensors that switch on faucets when the user places his hands below the orifice. All these aforementioned systems may mitigate the

production of WW.

Reuse of WW is the next stage of the waste hierarchy. It can be performed smoothly by matching the quality of the WW at hand, often by treatment, with the hygienic requirements of the water-requiring task to be executed. This can be carried out at the household level, for example, using dishwashing WW for flushing the toilet, or at institutional level, for instance, treating WW effluents to use for agricultural purposes, tantamount to recycling. This would involve a viable treatment system suited to the particular location. Herein Proposed to be suitable for Asmara is the waste stabilization pond, based on its simplicity, low energy consumption and minimal maintenance required. sunlight being it's main source of energy, the all year-round sunlight presents an excellent opportunity for high pollutant removal efficiencies. Regarding to running cost, stabilization ponds have advantage of very low operating costs since they use no energy compared to other wastewater treatment technologies but its demerit is that it is land intensive. With further extension of Asmara, there is a chance of potentially increasing the issues in future relevant to wastewater management. After building robust economic strength this treatment plant can be replaced by a chemically enhanced primary treatment and the land from the former stabilization ponds site can be repurposed for construction of buildings.

The last stage in the waste hierarchy is disposal. The WW or the recycle remnants thereof, must be disposed in an eco-friendly manner. A wetland is a distinct ecosystem that is flooded by water, either permanently or seasonally, where oxygen-free processes prevail. They are generally distinguished from other water bodies or landforms based on their water level and on the types of plants that live within them. Constructed wetlands are engineered systems that mimic natural sustainable solutions and use natural

functions, vegetation, soil, and organisms to treat wastewater. Constructed wetlands can possibly serve as disposal means for wastewater, yet they are usually only a follow-up to primary septic tank treatment and have difficulty removing pathogens. Furthermore, they are extremely land intensive and can process relatively low volumes of wastewater at a time. In the same vein, they are susceptible to disturbances including eutrophication, toxicity, acidification, salinization, sedimentation, aridification, flooding and vegetation removal. Ultimately, environmental disposal of wastewater is a practice that invariably harms the ecological stability as well as the human health, although the harm may be undoubtedly mitigated by such mechanisms as the use of wetlands. In conclusion, recycling via wastewater treatment is a more viable option for the safe disposal of wastewater on account of the environmental footprint.

## 5. Conclusions and Recommendations

With regard to wastewater generated, the study found that the per capita levels are quite low in Asmara. This is attributed to the high level of consciousness with respect to minimization of wastewater production, mainly manifested through reuse, which may be partially credited to the lack of consistent supply of water. Moreover, the awareness of the general public about the harms of irresponsible wastewater disposal was satisfactorily high. The WW generated is currently being majorly collected by the sewer system although a significant portion of the population still use the septic tank, while still some others dump outside. Sewer extension works are always in progress yet the sewer system still does not cover the whole of Asmara. Experiments were conducted to test the viability of Mai-Bella joining water streams, with conclusive

results of pollutant levels exceeding pre-specified standards. The situation requires remedying by the institution of a compatible treatment plant.

The recommendations as per the study have been classified as near-future and far-future implementable, in consideration of the required resources or infrastructure.

## 5.1. Recommendation for near-future implementation

- The speculation that excessive use of septic tanks is causing the observed groundwater contamination in Asmara needs to be investigated.
- Moreover, adequate monitoring measures and systems are required for existing treatment facilities to ensure that they comply with safe environmental standards.
- Widespread adaption and use of innovative Approach to minimize wastewater as expressed elsewhere in this document must be instituted to further reduce its generation.
- Equipment acquisition (such as vacuum trucks for desludging) and organization of training sessions to add momentum to and strengthen the maintenance and extension works of the wastewater department.
- Undertaking at least a small-scale rehabilitation and extension program for existing infrastructure to gradually cover the whole Asmara area, out-phasing septic tanks.
- Re-establishing the sewer manholes accessibility in order to allow for an appropriate diagnosis of the system. The analysis of results will allow to identify areas where improvements or rehabilitation works are needed (cleaning operation, pipe replacement or reinforcement, etc..).
- Policies must be drafted such that all stakeholders are considered. In addition, mature and workable technical guidelines must be created to facilitate implementation of laws and policies.
- The development of professionals and practitioners in wastewater management by government and educational institutions which would stimulate the adoption of appropriate wastewater management practice to monitor and supervise the wastewater management of the city.
- Construction of public toilets to serve unconnected areas within Asmara must be pursued. These public toilets will alleviate the problem of open defecation by the use of septic tank public toilets in unsewered areas.
- Immediate halting of the untreated wastewater-based agricultural activities through the institution of strongly prohibitive laws and extensive monitoring.
- Use of reclaimed wastewater for irrigation of agricultural lands should be developed. However, there needs to be a robust policy and legislation in place that gives regulation and control on the quality of wastewater to be used for agricultural purposes. Intending to further improve the awareness of the public in wastewater management by encouraging the participation and cooperation in sanitation and wastewater campaigns.
- Wastewater effluents are presently being discharged in the environment without treatment, a situation which is not sustainable

and requires urgent attention.

- Establishment of the waste stabilization pond treatment plant. For its area of construction, we propose it be in an extensive land at the northern part of Adi-Qonxi which is a low-altitude site that aids natural drainage. Provision of a sludge lagoon for the disposal of the collected sludge from on-site sanitation facilities in order to stop the over spilling of the collected sludge into the watercourse is also an inalienable task

### **5.2. Recommendation for far-future implementation**

- Inspection of the existing sewerage system and preparation of digitized drawings showing the different sections of the sewer lines with their main characteristics.
- Completion of the sewage system to cover the whole existing City and bond New areas
- Replacement of the waste

stabilization pond (WSP)

wastewater treatment facilities to the less land intensive mechanically and chemically enhanced primary treatment as the borders of Asmara city progressively swell.

- Installation of separated pipe lines or collection culverts for northern sub-systems to harvest rainwater.

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## THE COMMUNICATION OF THE HEAD OF SEMANGAT DALAM VILLAGE ON DOMESTIC WASTE MANAGEMENT IN BARITO KUALA REGENCY

**Abstract:** *This research aims to analyze the communication patterns of the Head of Semangat Dalam Village on housing waste management in Barito Kuala Regency. to change people's behavior in carrying out waste management. Qualitative descriptive research methods, in the form of descriptive content analysis, with data collection techniques such as literature studies, Internet Searching, Field Studies (observation, interviews, documentation and literature studies) through the stages of data reduction, data presentation, drawing conclusions and verification. The research was conducted using the theory of Communication Management. The results of the study found that effective communication patterns can help leaders, such as village heads, to build good relationships by awareness of community behavior and attitudes in managing waste This can help achieve desired goals and provide benefits to the community as a whole, through understanding, pleasure, influence on attitudes, better relationships and actions such as language acquisition, means of communication, ability to think and a good environment.*

**Keywords:** *Communication Patterns, and Strategies, Village Head Communication Management*

### 1. Introduction

The implementation of good government will affect and determine good environmental management. Likewise, good environmental management will reflect the level of good governance and vice versa without good governance, it is difficult to expect good environmental management as well.

National development goals related to waste processing can be seen from two sides, namely the sustainable development side and the environmental sustainability side. In this context, Pancasila and the 1945 Constitution of the Republic of Indonesia became the main

foundation in regulating and developing waste management in Indonesia. Pancasila, there are values that support sustainable development, such as mutual cooperation, social justice, and diversity. These values can be applied in waste management by involving all levels of society and paying attention to social justice in the equitable distribution of waste management services.

Meanwhile, in the 1945 Constitution of the Republic of Indonesia, there is Article 33 which emphasizes the importance of the government in managing natural resources and the environment for the welfare of the people. Waste management is the

responsibility of the government to ensure a healthy living environment and equitable waste management services throughout Indonesia.

There are effective and efficient waste management efforts in order to maintain environmental cleanliness and public health based on Law Number 18 of 2008, regulated regarding waste management from upstream to downstream, starting from reducing waste sources, collecting, transporting, processing, and final disposal of waste. Waste management can provide dual benefits, namely maintaining environmental cleanliness and generating economic value such as processing organic waste into compost and non-organic waste such as paper, plastic, and metal can be recycled into new products

Research on the Communication Pattern of the Head of the Village Spirit in Housing Waste Management in Barito Kuala Regency, the basis or reference in the form of theoretical theories or findings through the results of various studies before it is very necessary and can be used as supporting data, researchers take steps to study several research results in the form of theses and journals via the internet.

Nanang Mizwar Hasyim (2019) The title of the research is Increasing the Independence of Panggunharjo Village through Development Communication, through qualitative-descriptive methods can produce a new perspective in independent village development. The most notable research finding is that social service programs (education, health, and economy) are well centralized through the effective and efficient management of BUMDesa. BUMDesa is the driving force of services because the income economically every year continues to increase so that this condition makes the village's income increase.

Syuaib Iman Mu'tamaddin, Noor Rachmat, Yusuf Ismail (2014), The title of the study is Communication Patterns in Waste Treatment

According to an Islamic Perspective (Case Study: Integrated Waste Disposal Site (TPST) Bantar Gebang Bekasi). In this study, two approaches were used as the basis, namely the phenomenological approach and the symbolic interaction approach using John B Watson's Behaviorism Communication Theory where data collection techniques, namely observation, depth interviews, and documentation. The results of the study show that of all the communication patterns described by the author and his activities, the more dominant in its application is mass communication. In this mass communication, the public understands more about waste treatment, because TPST administrators put up banners around jalan bantar gebang bekasi. so that the community around TPST can apply this communication pattern. teaches the values of caring for the environment organization tells by explaining the impact caused by not managing waste properly.

Titi Antin, Hermin Indah Wahyuni Dan Partini (2018) with the title of the research, namely The Dynamics of the Role of Waste Management Networks in Waste Literacy Communication. The method used qualitative method with data collection techniques such as interviews, observations, and focus group discussions with participatory communication theory. From the results of the study, it is known that the role of JPSM "AMOR" in waste literacy communication is as a facilitator between the government and the community and as an agent of empowerment through communication patterns at the macro and micro levels.

Tamrin Muchin and Sri Sudono Saliro (2020) . With the title of the research, namely The Role of Village Governments in Waste Management from the Perspective of Regional Regulation Number 2 of 2015 concerning Waste Management. This research method uses empirical research methods with a statutory approach, to obtain data, researchers conduct observations and



interviews with the village government, and the community using purposive sampling. The results of the study revealed that the role of the village government was in accordance with Article 11 of Regional Regulation Number 2 of 2015 concerning Waste Management. The inhibiting factors are community factors, facilities factors and village government factors.

Kaveri Kala a, ÿ, Nomesh B. Bolia a, Sushil, (2020) with the research title namely Waste Management Communication Policy for Effective Citizen Awareness. In this study, the Multinomial Logistic Regression (MLR) approach was suggested and applied to develop the right strategy. This research shows that the methodology proposed in this study can be applied to develop WMCP for any city around the world to generate actionable perspectives for targeted outreach. In particular, the evidence provided by the MLR model in the SDMC case study can help all stakeholders involved in the Waste Management Policy.

Marlinda Irwanti and Totok Prasetyo (2020) with the research title Environmental Communication Strategy in Efforts to Empower Communities to Process Domestic Waste. This research uses a qualitative approach with a case study method. This study uses the Strategic Impact & Assumptions Identification Method (SIAM) to determine the target audience for communication of Domestic waste disposal problems. This method uses a qualitative approach in assessing the feasibility of non-technical matters from an environmental problem about communication of environmental management of Domestic waste in the form of waste. The results showed that the Management of Domestic Waste in the form of waste into Biogas has been carried out by identifying the strategy of the environmental management audience through stakeholder analysis. To identify message strategies through priority and critical assumption keys and to determine

appropriate communication management strategies to address critical issues of affected entities.

Based on the National Waste Management Information System (SIPSN) website, Domestic are ranked at the top of waste sources with a figure of 40.78% in 2021, followed by commerce with 19.51% and the market with 15.97%. In 2021, in South Kalimantan, waste generation amounted to 782,592.38 tons / year and 34,660.04 tons / year or 94.96 tons / day for waste generation in Barito Kuala Regency (Source: SIPSN 2021) while the waste generation of Alalak District reached 16 tons / day (Source: Barito Kuala Regency Environmental Agency, 2022).

According to Kumalawati et al., (2016) in a journal entitled "Location Analysis of Temporary Waste Shelters in Alalak District, Barito Kuala Regency, South Kalimantan" that the ability of local governments in large and medium-sized cities in Indonesia to handle waste is still limited. The threat of poorly managed waste is one of the causes of increasing water, soil and air pollution and increasing the potential for flooding in urban areas.

Waste problems in general need to be handled seriously with appropriate and integrated techniques/strategies, operations and management based on the conditions and policies of each region. As stated above, this waste management problem occurs almost all over the world, including in Indonesia, especially Semangat Dalam Village which is one of the villages in Alalak District, Barito Kuala Regency, South Kalimantan Province Semangat Dalam Village, headed by a Village Head, has the most population in Kecamatan Alalak, which is estimated to reach approximately 16 thousand people, with so much population density that it causes existing social problems, one of which is the increasing fulfillment of housing needs for residents to live in.

The problem of the existence of increasing housing needs for residents is not balanced with the availability of public facilities, namely the provision of Landfills (TPS) in waste management, this has a bad impact on the performance of waste management itself if the provision does not meet the standards of quality and quantity of services, which then results in a culture of community behavior in handling waste that has the potential to occur is burning waste, hoarding garbage, and throwing garbage in any place.

The provision of the TPS is the responsibility of the Developer to provide public facilities in accordance with South Kalimantan Regional Regulation Number 11 of 2019 concerning the Implementation of Housing and Domestic Areas, and is strengthened by the Regional Regulation of the Regent of Barito Kuala Number 6 of 2019 that "Everyone is prohibited from erecting buildings on spaces owned by roads, spaces owned by rivers, parks and green lanes".

According to the Head of Waste Management of the Barito Kuala Regency Environmental Service, Mety Monita in an initial interview with researchers on November 1, 2022, stated that waste management in Alalak District is classified as the most difficult where community residents are not aware of waste management and infrastructure in handling waste management is very limited such as Temporary Landfills (TPS).

The Alalak Subdistrict area only has two polling stations but previously had more polling stations on the side of the road, but along with the regulations, namely the Barito Kuala Regent Regional Regulation Number 6 of 2019, along the protocol road including the handling of Ambrol and all kinds of landfills while no TPS is allowed.

The impact of not being disseminated by TPS at certain points this causes many residents of the community who do not have awareness and are far from the TPS causing residents to be lazy to go to the TPS and throw a lot of garbage on the sidewalks of the protocol road,

and throw at wild TPS in the area around the housing, the phenomenon of waste generation in this housing complex is a problem that arises in waste management that has not been maximized.

Although Barito Kuala Regency already has Perda Number 3 of 2018 concerning Waste Management, such as article 57 paragraphs (1) to (5) which regulates sanctions for individuals, in reality there are still people in Barito Kuala Regency, especially Semangat Dalam Village, who throw garbage out of place.

According to the observations of researchers in the field, in Semangat Dalam Village, which has an area of 7.50 km<sup>2</sup> consisting of 53 RTs and there are approximately 40 (forty) housing complexes in the Semangat Dalam Village area, some of which do not provide public facilities or TPS, such as in Nur Sari Alam Complex Housing, Citra Permata Housing, Asyifa Perdana Mandiri complex and other housing, but researchers only found 1 (one) housing complex (Lyandra Housing) that provides Public Facilities such as TPS which is located at the entrance to the housing.

Researchers see the phenomenon in The Village of Semangat Dalam to the problem of phenomena such as limited public facilities as landfills, community culture that is not yet environmentally friendly, law enforcement that is not optimal, in this case communication is needed for a Village Government Apparatus as the main figure in the implementation of village government.

The village government apparatus as a communicator in this case the role of the Village Head as the main authority holder in village government needs to have innovative abilities and initiatives as policy stakeholders to change the mindset and boost awareness of the people of Semangat Dalam Village to create healthy environmental conditions, of course, it cannot be separated from the strategies and communication patterns used by the Village Head to his community.

As a leader at the village level, the village head has an important role in managing waste in his area. Village heads must be able to establish effective communication with the community to provide information and education on how to manage waste properly and correctly. In this case, the communication pattern carried out by the village head can provide public awareness in carrying out the effectiveness of waste management programs in Domestic areas.

## 2. Research methodology

The research in this study uses a descriptive-qualitative approach (qualitative research) to discuss the Communication Patterns of the Head of the Semangat Dalam Village on Waste Management in Barito Kuala Regency. Qualitative content analysis is simply a descriptive content analysis, which describes only the aspects and characteristics of a particular message or text. Qualitative content analysis here is in the form of words, sentences, or narratives that can be obtained through observation (Kriyantono, 2012: 196).

The use of the main method of case study research according to Robert K. Yin (2011:2) is to explain how the existence and why the case occurs. So that in case study research is not just answering research questions about the "what" of the object under study, but more thoroughly and comprehensively regarding "how" and "why".

The selection of resource persons or informants in this study is based on Purposive Sampling. Purposive sampling is a technique of retrieving a data source with certain considerations, a person or something is taken as a sample because the researcher considers that the person or something has the necessary information for his research. While Snowball Sampling is a technique of determining samples that at first the number is small then increases in size (Sugiyono, 2014: 120).

So, the criteria for the resource persons of this study are parties who know clearly or are involved in activities regarding the communication patterns of the Head of The Village of Semangat Dalam on waste management in Barito Kuala Regency. With details as:

**Table 1.** Research subjects processed in 2023

No	Informant Name	Capacity
1	Norman (N)	Head of Semangat Dalam Village as a stakeholder and policy official in Semangat Dalam Village, Alalak District, Barito Kuala Regency
2	Metty Monita (MM)	The representative of the Environmental Agency of Batola Regency who specializes in handling waste problems is the Head of Waste Management who is responsible for handling waste and reducing waste in Barito Kuala Regency
3	M. Sya'rawi (MS)	Alalak Sub-district, as an Official of stakeholders and policies in Alalak District, Batola District
4	Agus Suwani Isyra (ASI)	Community Leader/Chairman of BPD Semangat Dalam as supervisory official in the village government
5	Fauzi Noor (FN)	Community Leader/Chairman of RT 07, as an existing community institution that is directly related to the community
6	Aini (A)	Community Leader /Chairman of RT 06, as an existing community institution that is directly related to the community

No	Informant Name	Capacity
7	Supardi (S)	The Head of the Tabing Rimba Landfill Unit, an extension of the Batola Regency Environmental Agency, is the official responsible for distributing waste transportation to landfills in Barito Kuala Regency

### 3. Results and discussion

At a glance, Barito Kuala Regency, Barito Kuala Regency is one of the regency governments located in the province of South Kalimantan, Indonesia. The capital of the district is located in Marabahan. The district has an area of 2,996.46 km<sup>2</sup> and has a population of 318,044 (results of the 2020 Indonesian Population Census). Part of the Barito Kuala area is included in the candidate for the Banjar Bakula Metropolitan Area. Barito Kuala Regency borders the province of Central Kalimantan, precisely in the Kapuas regency, and its location is by the sea. Barito Kuala Regency, which is the capital city of Marabahan, is located in the westernmost part of South Kalimantan Province with boundaries: north of Hulu Sungai Utara Regency and Tapin Regency, the south of the Java Sea to the east is bordered by Banjar Regency and Banjarmasin City, while the west is bordered by Kapuas Regency, Central Kalimantan Province. Astronomically located at 2°29'50" - 3°30'18" South Latitude and 114°20'50" - 114°50'18" East Longitude. (Barito Kuala P. K.) Barito Kuala Regency was established on July 4, 1959 based on Law No. 27 of 1959 concerning the Establishment of Emergency Law No. 3 of 1953 concerning the Extension of the Establishment of Level II Regions in Kalimantan (Statute-Book of 1953 Number 9) as an Act with the capital marabahan.

#### Alalak Subdistrict

Alalak District was established before the formation of Barito Kuala Regency which used to be part of the Banjar Regency Kewedanaan, which had its capital in West Berangas Village until 2000, because in 2000

the District Office located in West Berangas Village moved to Handil Bakti Village occupying the Former office. Assistant Regent Barito Kuala, automatically now the capital of Alalak District is in Handil Bakti Handil Bakti Village and in 2019 occupies the New Office of Jalan Trans Kalimantan Km 11 RT 03 Handil Bakti Village. Alalak Subdistrict has an area of 106.85 km<sup>2</sup> divided into 15 village areas and 3 villages with berangas village as the district capital. Alalak subdistrict has administrative boundaries:  
 North : Belawang District  
 West : Anjir Muara And Mekarsari District  
 East : Mandastana District  
 South : Banjarmasin City

As the most populated sub-district in Barito Kuala Regency, Alalak District faces problems that are fairly complex compared to other districts. The population density of Alalak District reaches 60,603 people, with a male population of 30,946 and a female population of 29,657. Population growth is relatively high, especially the Handil Bakti area and its surroundings, so the acceleration of supporting infrastructure is very important to adjust.

#### Semangat Dalam Village

At the beginning of the formation of the Semangat Dalam Village in 1982, due to the expansion of the Semangat Bakti Village area. There was a division into 4 (four) areas, namely Semangat Bakti Village, Semangat Dalam Village, Semangat Karya Village and Handil Bakti Village with Village Regulation Number 01 of 1982. In general, Semangat Dalam Village is a village bordering 3 villages in the Alalak District, Barito Kuala Regency. Semangat Dalam Village is one of

the villages that has the most population among 15 villages in Alalak District. The general condition of The Semangat Dalam Village is described geographically and demographically as the village.

Semangat Dalam village is one of the villages in Alalak District located in the Southern part of the capital of Barito Kuala Regency. Located at -3.263517 South Latitude and 86 East Longitude with the following regional boundaries:

North, bordered by Mandastana District,  
East, bordered by Semangat Bakti Village,  
South, bordered by Banjarmasin City,  
West, bordered by Handil Bakti Village.

The area of Semangat Dalam Village is 7.50

km<sup>2</sup> consisting of 53 RTs, and – RW Semangat Dalam Village is at an altitude of 0.2 – 3 meters above sea level whose soil ability and fertility are affected by tides and are partially flooded and dominated by swamps. Overall, the area of Semangat Dalam Village is a relatively flat lowland area. Based on Village Administration Data, the number of administratively recorded population is 18,290 people. The details of the residents of Semangat Dalam Village, Alalak District, calculated based on the gender of the population from 2017 to 2022 can be seen in detail as shown in the following table:

**Table 2.** Total Population of Spirit Village in 2017-2022 (in Soul)

NO	Year	Population	Man	%	Woman	%
1	2017	1.189	624	50,67	565	49,33
2	2018	1.192	626	50,87	566	49,13
3	2019	14.753	7.604	51,54	7.149	48,45
4	2020	16.575	8500	51,28	7975	48,11
5	2022	18.290	9346	51,09	8944	48,90

Based on 2022 data, the largest population is in the age group of 15-39 years which reaches 6,570 people. While the least number of residents is the population with retirement age, namely the population of the age group

of 70-74 years which reaches 439 people. The state of the population based on the age structure of 2020 can be seen in the following table:

**Table 3.** Number of Semangat Dalam Villagers From Age Level (in Soul)

No	Age Group	Man	Women	Sum
1	Usia 0 - 4 Thn	522	495	1017
2	Usia 5 - 9 Thn	795	792	1587
3	Usia 10 - 14 Thn	887	853	1740
4	Usia 15 – 19 Thn	858	836	1694
5	Usia 20 – 24 tahun	843	805	1648
6	Usia 25-29 tahun	754	687	1441
7	Usia 30 - 34 tahun	801	761	1562
8	Usia 35 – 39 tahun	855	835	1690
9	Usia 40 – 44 tahun	854	810	1664
10	Usia 45 – 49 tahun	788	744	1532
11	Usia 50 - 54 tahun	597	595	1192
12	Usia 55 - 59 tahun	354	328	682
13	Usia 60 – 64 tahun	195	176	371

No	Age Group	Man	Women	Sum
14	Usia > 65 tahun	243	227	470
<b>JUMLAH</b>		<b>9.346</b>	<b>8.944</b>	<b>18.290</b>

### Waste Management in Barito Kuala

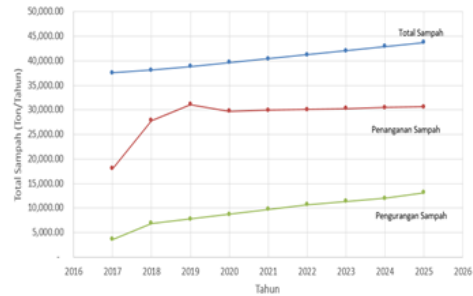
The new paradigm views waste as a resource that has economic value and can be used, for example for energy, compost, or for fertilizer. Waste management with the new paradigm is carried out with waste reduction and handling activities, waste is basically a material that is wasted or disposed of as a result of human activities and natural processes. Based on Law Number 18 of 2008 concerning Waste Management, waste management cannot be completed only by the government by collecting, transporting and disposing of waste to landfills only, but must be carried out in an integrated and integrated manner so that the Principles of Waste Management provide economic benefits, are healthy for the community and are safe for the environment, and can change people's behavior. Waste as a resource that has economic value and can be used, for example for energy, compost, or for fertilizer. Tabel 4 Target Pengelolaan Sampah Kabupaten Barito Kuala

**Table 4.** Waste Management in Barito Kuala

Tahun	Jawa	Total Sampah Ton/Tahun	Sampah yang terkelola Penanganan Ton/Tahun	Pengurangan Ton/Tahun	Sampah yang tidak dikelola Ton/Tahun
2017	293,808	37,533.94	18,016.29	3,588.24	15,929.41
2018	298,282	38,105.53	27,817.03	6,858.99	3,429.50
2019	304,248	38,867.64	31,094.11	7,773.53	-
2020	310,333	39,644.99	29,733.74	8,721.90	1,189.35
2021	316,539	40,437.89	29,924.04	9,705.09	808.76
2022	322,870	41,246.65	30,110.05	10,724.13	412.47
2023	329,327	42,071.58	30,291.54	11,359.33	420.72
2024	335,914	42,913.01	30,468.24	12,015.64	429.13
2025	342,632	43,771.27	30,639.89	13,131.38	-

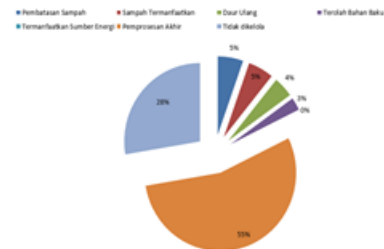
To minimize the waste problem, there must be waste management from the source. Waste management is a systematic, comprehensive and sustainable activity that includes reducing and handling waste. Waste management needs to be carried out comprehensively and integrated from upstream to downstream in order to provide

economic benefits, be healthy for the community and be safe for the environment and can change people's behavior.



**Figure 1.** Graph of Barito Kuala Regency Waste Management Figure 1 Graph of Barito Kuala Regency Waste Management Figure 1 Graph of Barito Kuala Regency Waste Management

Waste handling includes sorting, collecting, transporting, processing, and final processing (landfill). Waste is basically a material that is wasted or disposed of as a result of human activities and natural processes. Waste management and management will be more complex and complicated with the increasing complexity of the type and composition of waste.



**Figure 2.** Handling and Reducing Waste in Barito Kuala Regency in 2018

Waste reduction includes restriction, reuse,

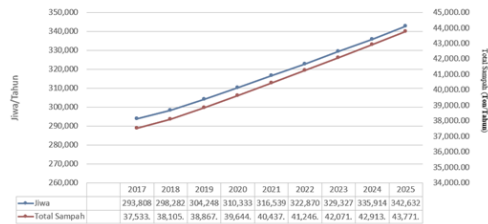
and recycling activities (Reduse, Reuse, Recycle / 3R) Waste Reduction at the source can reduce the burden of waste entering the final processing site (TPA) through public awareness to sort waste from home. Society has an important role because in essence waste is produced by the community itself.

The waste problem cannot be solved only by the Government. It is time as waste producers we help, even take responsibility for at least taking care of their own waste. The number of Domestic will determine the amount of waste produced. Waste management and transportation is a separate problem that is still difficult to overcome. If not handled properly, it will cause unwanted waste generation and will eventually pollute the environment. The community has an important role in Domestic waste management, because in essence waste is produced by the community itself. One of the things that the community can do to participate in managing waste and preserving the environment, is to abandon the old pattern of managing domestic waste such as throwing garbage in rivers and burning waste, by applying the 3R principle, namely:

- Reduce means that people can make less effort in producing waste, each shopping brings their own plastic from home, thus reducing plastic use.
- Reuse (reusing a product for the same purpose), that is, utilizing used containers that can be used such as gallons, used bottles or used cans.
- Recycle (recycling) to apply the principle of recycling, including by making compost from organic waste, pots from used plastics, or other creativity so that waste can be recycled and can be reused.

The amount of waste generation in Barito Kuala Regency is around 0.01412 million tons / year or around 80 tons / day with a fleet of 13 units of garbage transport trucks can only serve 10 sub-districts from 17 sub-

districts in Barito Kuala Regency.



**Figure e.** Waste Generation of Barito Kuala Regency

The condition of the Tabing Rimbah TPA UPT is currently in full condition (Overload) the amount of waste that enters every day is an average of 25 tons / day or equivalent to 40 M3 serving 10 districts in Barito Kuala Regency. Tabing Rimbah landfill cells built in 2012 have been utilized since 2014 the cell size of 80 meters X 60 meters is currently 12 meters high. To increase the height again endangers the safety of the machine operator.

In handling daily waste, currently utilizing the Banjarbakula Regional Landfill UPT in Banjarbaru. The PUPR Office has proposed adding new cell construction to the Directorate of Sanitation, Directorate General of Cipta Karya, Ministry of Public Works and Spatial Planning of the Republic of Indonesia and proposed a request for the construction of a new cell through the head of the South Kalimantan Regional Settlement Infrastructure Center.

The Communication Pattern of the Village Head is Enthusiastic in Managing Housing Waste.

Communication patterns are the way an individual or group communicates. The communication pattern in this paper is the way a group or individual works in communicating which is based on communication theories in conveying messages or influencing communicants. (Purwasito, 2002:96). We can illustrate this understanding of this pattern as when we are

going to make clothes. When someone is going to make clothes he will make a pattern or often called a pattern, this pattern is flexible and easy to change. This pattern will determine the shape and model of a shirt, then after going through several processes, finally from a shirt it will be visible and the actual model will be clearly visible.

From the illustration above, communication patterns can be understood from a communication that is flexible and easy to change. This pattern is strongly influenced by the symbols of the language used and agreed upon by a particular group.

One of the patterns used to describe the process of communication is the circular pattern created by Osgood with Schramm (1954). Both of these figures devote their attention to the role of the source and receiver as the main actors of communication. This pattern describes communication as a dynamic process, in which messages are transliterated through a process of encoding and decoding. Encoding is a translation performed by the source of a message, and decoding is a translation performed by the recipient of a message coming from the source. The relationship between encoding and decoding is the relationship between the source and receiver simultaneously and influencing each other, as shown in the drawing scheme. As a dynamic process, the interpreter in this circular pattern can double as the sender and receiver of the message. At the initial stage, the source serves as the encoder and the receiver as the decoder. But at the next stage the receiver serves as the sender (encoder) and the source as the receiver (decoder), in other words the first source will be the second recipient and the first receiver serves as the second source, and so on.

If in the mathematical communication pattern Shannon and Weaver in 1949 saw the communication process end after arriving at the destination then in the circular pattern Osgood and Schramm saw the

communication process of both the source and receiver in this pattern as having the same position. Because the communication process can start and end anywhere and anytime. From the research conducted, there are researchers' findings, including:

1. Providing understanding to the community, the Village Head communicates by giving advice on waste management in addition to that through community activity forums and religious and other activities. The Village Head directly conveys environmental awareness, this is considered effective because it reaches the target community directly.
2. The appeal given by the village head is an educational appeal. The role of the village head is as a facilitator, creating conducive conditions for the implementation of village development. As a facilitator in handling waste management, the government is engaged in the field of assistance to encourage progress in waste management in villages.
3. The influence of the Village Head on waste management in the Spirit of the Village has a very important role. The results of the interviews revealed the role of the Village Head in constantly reminding his residents to increase awareness of the environment through routine appeals to the community.
4. Researchers found that efforts to establish communication create good relationships with various parties that can make it easier for the Village Head to effectively manage waste with good and effective communication, it will be easy for an organization to achieve the desired goals.
5. Communication patterns created from communication actions can be



carried out directly and indirectly. Talking face to face, talking on the telephone, writing a letter to a person, group of people or organization are examples of direct acts of communication.

Likewise the village head. In spirit of taking action, the effectiveness of communication is measured by concrete actions, communication patterns have been carried out both directly and indirectly. By participating in mutual cooperation with residents, making appeals on social media and sending circulars to the Head of the RT to disseminate to the community. This is done solely for the accumulation of the communication process and involves the participation and participation of the community in efforts to manage waste in the Spirit of the Village.

Communication Management Strategy for the Village Head Enthusiasm to Change Community Behavior in Domestic Waste Management.

The function of public relations for the leadership of an organization in the community is to create "good relations" with the public, so that they have a good image of the organization concerned, in fostering a relationship of mutual understanding, continuity is needed.

The Village Head as the Leading Sector of a village must have relationship activities with various stakeholders (Local Government, Camat, Community Leaders and others) to establish good relations and cooperation with various parties with various forms of routine activities carried out, including in terms of management communicating in the program existing activity.

The concept of management from the perspective of communication science is essentially understood as a process of influencing others, suggesting that the ability to communicate well is not only something that is inherent in oneself, but as something that can be learned and developed.

This is in accordance with the spirit of the village head for the communication management strategy in accordance with the Theory of Communication Management according to Parag Diwan (1999) which says that communication management is the process of using various communication resources in an integrated manner through the process of planning, organizing, implementing and controlling the elements communication to achieve the set goals.

### 1. Planning

Planning in conveying messages through a combination of various communication elements such as frequency, formality, content and communication channels so that the message conveyed is easily received and understood and can change attitudes or behavior according to the purpose of communication.

The Village Head uses a communication management strategy with planning in waste management by utilizing existing stakeholder communication, namely submitting a proposal for assistance with garbage uncle carts, and in tune with the existing program at the Environmental Service, namely the Anjur Transport Program. In line with planning and carrying out effective communication means that the communicator and communicant both have the same understanding of a message. Therefore, in foreign languages people call it "the communication is in tune", that is, both parties communicating both understand what the message is being conveyed

### 2. Organizing

Organizing is the process of assigning tasks, allocating resources and organizing activities in a coordinated manner to each individual and group to establish a plan. The organizing function here includes assigning separate tasks to each party, forming sections, delegating and establishing lines of authority/responsibility and communication systems, as well as being organized.

From the results of the interview summary

regarding the planning strategy of the Village Head of Roh Dalam, namely carrying out an organizing strategy that must be carried out in waste management, namely the Village Head has a strategy to function the role of the village organization that is given authority and responsibility in waste management in the Village of Rohan Dalam, namely management will be carried out by the Agency Village Owned Enterprises "Joint Spirit" Internal Spirit.

According to Sherry R Arnstein (1969) quoted by Sigit (2013: 27) states that dividing the levels of community participation in development programs implemented by the government in 8 (eight) levels of community participation based on the power given to the community, one of 8 (eight) ) level, namely Partnership, Partnership means that it can be called working together, the Village Government treats the community as a work partner, jointly formulating and implementing work programs, especially in waste management in Rohan Dalam Village.

### 3. Implementation

The communication management strategy for implementation in waste management in terms of the process of directing and influencing activities in increasing public awareness requires a method or in this case using an Appeal either through Letters, outreach to each RT RT.

The Village Head's approach in influencing the community to make behavior changes with persuasive communication in socializing to residents has the aim of providing knowledge and providing appeals so that people have awareness in protecting the environment. According to Erwin P. Bettinghaus (1973) that this persuasive communication can affect one's thoughts and actions, the relationship of activity between the speaker and the listener where the speaker tries to influence the listener's behavior through the intermediary of hearing and sight. According to the researchers, the form of a

persuasive strategy is with waste management outreach activities, communicating by inviting and providing educational information but not forcing, but giving the intended audience a sense of comfort. A persuasive approach is an effective way to increase environmental awareness in society.

### 4. Controlling the elements of communication to achieve the goals set.

A community empowerment program will not run well if it is not managed properly, which should also be preceded by good planning. The planning referred to here must of course be participatory in nature, involving all relevant elements of society, especially those that will become the target group, must also include the problem identification process carried out with the community.

Management has certain goals and is intangible, because it cannot be seen, but the results can be felt, namely the realization of optimal activity output, personal satisfaction, better products and services, and reaching the target. Management includes activities to achieve goals, which are carried out by individuals who give their best efforts through predetermined actions.

The efforts and actions in question include knowledge about what must be done, determining how to implement it, understanding how to do it and measuring the effectiveness of the efforts made. Furthermore, it is necessary to establish and maintain an environmental condition and situation that provides economic, psychological, social, political responses and technical contributions and their control (Terry, 2009:10).

The control function assumes that effective leadership must be able to guide the activities of its members in a directed and deep manner. Effective coordination, thus enabling the maximum achievement of common goals. In carrying out the control function the leader can manifest through guidance, directing,

coordinating and supervising activities.

The strategy implemented in terms of control or control that has been carried out in participatory waste handling by the village community, the Village Head and his staff through communication forums to make it more effective.

The results of controlling or controlling become the basis for discussion of village meetings which are attended by the Village Consultative Body, community leaders, RT heads and community representatives as well as other relational parties.

Based on the discussion, to achieve an effective communication management strategy, several things that need to be considered include:

1. The village head must have good communication skills, both verbally and non-verbally.
2. The message conveyed must be clear and easily understood by the public.
3. Communication must be carried out regularly and consistently, so that messages can be conveyed effectively.
4. The use of appropriate media or modes of communication must be considered, depending on the context and communication needs.
5. Social factors such as community norms and values must be considered in managing communication.
6. The village head must build good relations with the community, so that the message conveyed can be accepted and trusted by the community.
7. The use of campaign strategies or other promotional media can help influence people's behavior and attitudes.

Based on the Communication Management Theory, communication management

strategies that can be carried out by the Village Head of Pesona in changing people's behavior in housing waste management include implementing effective communication management strategies in changing people's behavior. The village head can apply a deterrent effect in imposing sanctions due to littering, which is one way to increase community awareness and responsibility for the environment. The deterrent effect can be in the form of fear or fear that arises as a result of bad experiences or sanctions received.

Applying sanctions related to waste management, the Village Head must comply with applicable regulations, including local laws and regulations related to waste management in his area. Sanctions applied must be in accordance with applicable regulations and not contrary to human rights and the principles of justice. In addition, it is important to carry out outreach regarding these sanctions so that people can understand the consequences of littering behavior and feel more responsible for the environment around them.

Another strategy besides using a deterrent effect, the Village Head can also use a persuasive approach in the communication management strategy to change community behavior regarding waste management. The persuasive approach involves using polite, empathetic, and persuasive language to influence people's views and behavior. The Village Head can carry out environmental campaigns with a persuasive approach to motivate the community to behave better in waste management. This can be done by holding meetings with the community, utilizing social media or village websites, placing banners and posters in Domestic areas, and so on.

Utilizing mass media such as newspapers, radio, television and online media to campaign the importance of good waste management. The mass media can be an effective means of reaching a wider audience

and providing useful and persuasive information. The Village Head can collaborate with the local mass media to campaign for the importance of waste management and provide useful information on how to manage waste properly.

The Village Head can also take advantage of the power of social and cultural relations that exist in the community to change behavior related to waste management. The village community has its own characteristics and has a different value system and culture. Furthermore, the Village Head can take advantage of the values and culture that exist in the community to motivate them to carry out waste management properly. For example, it can carry out outreach through respected community leaders or organize activities that combine cultural values with waste management campaigns.

By implementing an effective communication management strategy, the Village Head can motivate and increase public awareness about the importance of good and sustainable waste management. This can help create a cleaner, healthier and more comfortable environment for rural communities.

#### **4. Conclusion**

Effective communication patterns can help leaders, such as village heads, to build good relationships with the community and influence the behavior and attitudes of the community in managing waste or in other contexts. This can help achieve desired goals and benefit society as a whole, through

understanding, enjoyment, impact on attitudes, improved relationships and action. To achieve an effective communication pattern for the Village Head, the communication approach adopted by the village head is very important in shaping the attitude of the villagers. A good and effective approach will help create positive relationships and build trust between the village head and residents.

The communication management strategy used by the Village Head to change people's behavior in housing waste management uses the process of using various communication resources in an integrated manner through the process of planning, organizing, implementing and controlling communication elements to achieve the goals set. In implementing an effective communication management strategy in changing people's behavior, the Village Head can apply a deterrent effect in imposing sanctions due to littering is one way to increase community awareness and responsibility for the environment. The deterrent effect can be in the form of fear or fear that arises as a result of bad experiences or sanctions received. Apart from giving strict sanctions, it is also important to carry out effective environmental education and campaigns to raise public awareness about the importance of keeping the environment clean. This can help people understand the negative impact of littering and motivate them to behave better.

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## EPIDEMIOLOGIC IMPACTS OF WATER AND WASTE POLLUTANTS ON HUMAN WELL BEING. A CASE STUDY OF APAPA, LAGOS -NIGERIA

**Abstract:** Water quality, trace gas (SO<sub>2</sub>, CO<sub>2</sub>, and NO<sub>2</sub>), particulate matter (PM 10 as well as PM<sub>2.5</sub>), and effluents emissions were quantified at near cements and oil factories and nearby suburban areas within Apapa Lagos Nigeria. Results display that ambient air particulate matter PM<sub>2.5</sub> varies between 2.1 to 7.9 µg/m<sup>3</sup> and VOC (0.013 – 8.53 µg/m<sup>3</sup>), while CO and CO<sub>2</sub> was 100% and 30% respectively not within regulatory limits, consequently leads to asthma, coughing and difficulty breathing. Four out of nine sites investigated for noise effect were above WHO stipulated limits. While some parameters such as BOD and COD displays critical level for effluent scrutiny and conductivity, calcium, TDS, total hardness, Do and total alkalinity was also above clean water specification. Wastewater consists of spills and other water effects which produced pollutants such as soluble organic chemicals that deplete dissolved oxygen, anions, volatile materials and other heavy metals. Based on age, the greatest impact (52%) was seen in ages varying from 0 to 16 while that of the age set 16 to 60 was 45%. Curb of oil and cement particulate pollutants and requesting a buffer region between the cement and oil depots and neighborhood complemented with regulatory enforcement and persistent monitoring, should be a top precedence to the regulatory authority.

**Keywords:** Emission, Particulate, Combustible, Monoxide, Contagion

### 1. Introduction

Emissions of effluents, anions, metals, cations and particulates pollutants from industrial establishments are one of the key sources of environmental contagion (Gena et al. 2020; Deziel et al. 2020). Anions, gaseous emission and other metals such as SO<sub>2</sub>, Particulate matter (PM), Combustible gas (CHN), Carbon monoxide (CO), hazardous materials in contagion soils can be transported by wind, water, and other human

deeds with their resultant health impacts and effects on the environment (Everseen 2018; Fernando et al. 2021). Cement and oil factories have been reported to be a main source of various emission and air pollutants to the environs with numerous reports displaying higher concentrations of contagion around oil and cement factories.

Air quality is an appraiser of the appropriateness of air for breathing by animals, populace, and plants in terms of potential fitness impacts. Good outdoor air

quality is fundamental to human wellbeing (Jacquet et al. 2021; Haggerty et al. 2018). Averagely, a person gasps about fourteen thousands litres of air every day, and the presence of contagions in this air can harmfully affect public healthiness. Poor air quality has been ascertained in having somber effects on human fitness and wellbeing as well as the environment. Air pollution is implicated as the major cause of many environmental problems to include ozone layer destruction, acerbic rain, mercury contagion and global warming. Hygienic air is indispensable for sustaining the insubstantial balance of existence on the globe — not only human populace, but flora and fauna, water, foliage, shrubbery, and soil (Walsh et al. 2020; Luke et al. 2018). Air contamination isn't just an al fresco matter, but its enclosed spaces, for instances workplaces, habitat or schools can also be contaminated via contagions that have emitted through the outdoor and indoor sources. Furthermore, some categories of air contagion may be worse for indoors than outdoors, for instances chemicals discharged from synthetic textiles, cigarette, and fittings and home-use products (Berman et al. 2000; Biern et al. 2015). Contamination of the environment by particulates, effluents, metals and other pollutants is of major concern due to their toxicity and risk to environment and human life. Particulate and emissions toxicity seems to be dependent on exposure route, duration, dose and exposure frequency. For instance, when oil is explored in water sparse zones the water resources become strained. Off-shore oil exploration creates threats for the oceanic life whereas oil circulation and haulage will creates extreme hazard for the ecosystem in case of seep out or accidents (Abramson et al. 2010; Anderson et al. 2011). When oil spills-out transpires or when there is waste matter expulsion, it percolate into the soil and blend with underground water system. It has been ascertained that contaminated underground water takes scores

of years before it can be cure (Bongers et al. 2008; Brewton et al. 2013). Nonetheless this underground water move into brook, stream, rivulet and boreholes or wells which are the key sources of local water supply in the neighborhood which consequences are upsurge of water-borne sicknesses. This has disturbed the traditional rapport of the inhabitant within the oil-bearing enclaves. There is a discernible trepidation that instead of being the life-giver, these water scenarios have become sources of death, misery, and sicknesses (Buttke et al. 2012; Caress and Steinemann 2004; Carrasco et al. 2007; Cheng et al. 2011).

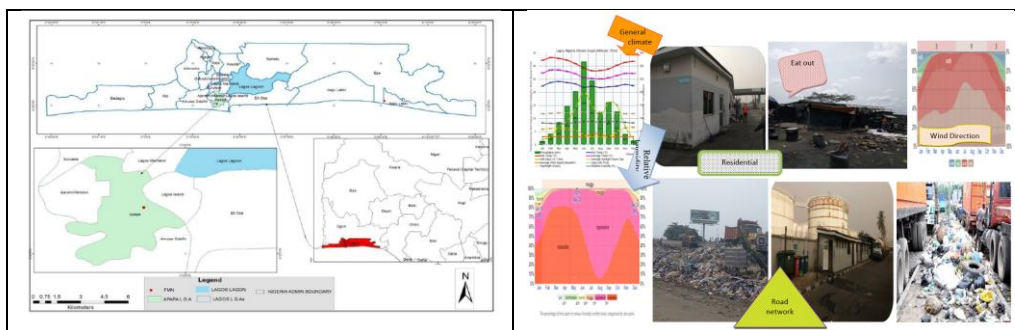
## **2. Materials and Techniques**

### **2.1. Region of Study**

Apapa, one of Local Government Area, Lagos State, which falls within the tropical savannah climate based on the Köppen climate categorization, as there's a momentous precipitation discrepancy between the humid and the arid season. The average temperature in January is 27°C (Figure 1 (a&b)). Temperatures in Lagos rarely get colder than 20°C, and rarely get hotter than 30°C. Temperature values are high throughout the year over the project environment. The temperature within the study location was between 32°C and 35°C. Because the project area has a tropical savannah climate, there are 2 different rainy seasons. The heavy rain season is between April and July, and the milder rain season occurs from October to November. A very brief dry season occurs in August and September usually called "August Break" and a long dry spell occurs from December to March. The rainfall between May and July averages over 300mm, while the average rainfall in August and September is only 75mm. In January, the average rainfall is only about 35mm. Relative humidity is normally in surplus of 80%, in particular the peak of the

wet period as shown in Figure 3. The standard yearly relative humidity is 84.7% and mean monthly relative humidity varies from 80.0% in March to 88.1% in June. This is understandable given the geographical location of Lagos and the fact that rain falls almost all the year round. The micro-climatic condition of the study area falls within the historical humidity of 66.2 – 90.9% peculiar to the Lagos area. The climate is influenced via two key trade winds – the warm, humid Southern-west trade winds during the rainy period and the Northern-east trade wind during the arid and grimy harmattan. The wind speed directions are synchronous to the

periodic attitude of the Inter-Tropical Convergence Region. During the wet season, the Southwest winds prevail, and during the dry season, the Northeast winds prevail as they sweep in the arid season. The wet season begins around April and ends around October. August is the coolest and also the windiest with a mean wind speed of 13km/h. Weather tracker a sophisticated multi-function environment monitoring instrument was utilized to measure key environmental condition such as altitude, temperature, wind speed, relative humidity, barometer pressure, density and wind chill. It can also measure wet bulb and heat index.



**Figure 1.** a) Study region, b) Climate and activities around its environ

## 2.2. Techniques

A pilot origin categorization and separation was carried out at the company and its environ in Lagos metropolis of Nigeria from July 2021 to October, 2022 for gathering of data on water attribute as well as composition, generation level and compliance rate of waste management.

### 2.2.1 Air Emission

Air emissions associated with the operations of the study zones are basically gaseous emissions and particulate matter. The sources of particulate emissions include the general

depot operations, loading and offloading activities and truck movement while sources of gaseous emissions within zones includes working losses, fugitive losses and generator operations, as well as operations of trucks. Therefore, Suspended Particulate Matter (SPM), Volatile Organic Compounds (VOCs), Carbon monoxide (CO), Sulphur dioxide (SO<sub>2</sub>), Hydrogen Sulphide (H<sub>2</sub>S), Oxides of Nitrogen (NO<sub>x</sub>), in the ambient environment were measured during the study. The in-situ ambient air quality measurements were carried out in line with regulatory requirement to ascertain outdoor air condition of the facility's environment.

**Table 1.** Measurement techniques with its water attributes physiognomies

Parameters	Units	Acronyms	Techniques and Instruments
Total Suspended Particle		TSP	Temptop PMD 351 Handheld air borne aerosol meter (HPPC 6+) sum efficiency ~50.0% @0.30µm.
Temperature, Dew point, Relative Humidity and Wind speed		T (°C), DP RH and WS	Kestrel 5500 weather meter was utilized for the microclimate measurement.
<i>Heavy metals</i>			
Manganese, Lead, Copper, Nickel		Mg, Pb, Cu	APHA 3111B, UNICAM 969 AAS
Cadmium, Cobalt, Zinc		Ni, Cd, Co, Zn	
<i>Microbiology (cfu/mi)</i>			
Coliform, E coli, Staphylococcus Vibrio, Total coliforms, Aerobic plant count, Yeast & Mould			APHA 9215C
<i>Anions</i>			
Nitrate, Nitrite	(mg/l)	NO <sub>3</sub> <sup>-</sup> , NO <sub>2</sub> <sup>-</sup>	APHA 4500, UN spectrophotometer
Sulphate, Phosphate	(mg/l)	SO <sub>4</sub> , PO <sub>4</sub> <sup>3-</sup>	APHA 4500B, UN spectrophotometer
Calcium	(mg/l)	Ca	APHA 4500A, UN spectrophotometer
<i>Physico-chemical</i>			
Hydrogen ion concentration		pH	pH meter/insitu
Colour	(Pt.Co)		APHA 2120A
Dissolved oxygen	(mg/l)	DO	APHA 5220A, DO meter
Conductivity	(µs/cm)	Cond	APHA 2510A, multi- parameter
Chloride	(mg/l)	Cl <sup>-</sup>	APHA 4500 B, titration
Total dissolve solids	(mg/l)	TDS	APHA 2540A, gravimetric
Total suspended solids	(mg/l)	TSS	APHA 2540D
Appearance			APHA 2110
Acidity	(mg/l)		APHA 2310B
Ammonial Nitrogen	(mg/l)	NH <sub>3</sub> C	APHA 4500
Turbidity	(mg/l)	Turb	APHA 2130B, turbidity meter
Bacterial oxygen demand	(mg/l)	BOD	APHA 5210B, Incubator/winkler
Chemical oxygen demand	(mg/l)	COD	APHA 5220D, K2C-207 reflux
Alkalinity	(mg/l)	Alk	APHA 2320B, Titration
Detergent	(mg/l)		APHA 5540C
Oil and grease	(mg/l)		APHA 5520B

### 2.2.2 Particulate, Gaseous Emission & Environmental Condition Level Measurement

Airborne particulates were collected from several sampling locations using a Bosean Airborne Particulate Counter. The dust monitor was zeroed and set at the run mode 15s. This is to directly measure the exact concentration of the air borne particulates in 1liter on air. The concentrations of the air borne particulates were then read off the

screen of the monitor. Sampling and Measurement for Temperature, Humidity was carried out using same Bosean Equipment (Figure 2). Noise Level was carried out using the Bosean Noise Level Monitor capable of measuring wind speed & wind flow, equipped with back-lit LCD dual display and a variety of choice of readings in km/hour, knots, or meters/second. These instruments like any other digital instrument is powered by a battery cell and is hand held.



**Figure 2.** Bosean; a) Airborne Particulate; b) Noise Level Monitor Counter; c) Multigas Monitor

### 3. Results and Discussion

#### 3.1. Air quality Outcome

##### 3.1.1 Sulphur(iv)oxide, Nitrogen Oxide and Carbon monoxide (CO)

Inhalation air with extreme concentration of NO<sub>2</sub> may infuriate airways in the human respiratory system, and within shorter time exacerbate respiratory sicknesses, for

instance asthma, with signs like difficulty breathing, coughing, or wheezing (Walsh et al. 2020; Gene et al. 2022). While, longer exposures to huge quantities of NO<sub>2</sub> might increase vulnerability to respiratory infections. The result of sampling at Apapa for the presence and concentration of Nitrogen -iv- oxide (NO<sub>2</sub>) were less than 0.01ppm thus within the NAAQS (FEPA 1991) stipulated limit of 0.113ppm, while all CO and 30% of CO<sub>2</sub> measured was above specified limits.

**Table 2.** Scrutiny Techniques and Some Health impact of Contagions

Parameters	Instrument	Techniques	Above Permissible Limit Health Impact
Sulphur IV oxide (SO <sub>2</sub> )	SO <sub>2</sub> Gas Alert test meter	Direct reading	Causes irritation of the respiratory tract
Particulate matter (PM)	Gas Alert test meter	Gravimetric	Causes catarrh, cough, lung infections and other respiratory diseases
Combustible gas (CHN)	Gas Alert test meter	Direct reading	Induces a despondent and depressed state
Carbon monoxide (CO)	CO test meter	Direct reading	Lessens the oxygen-carrying blood capability to damage of the central nervous system
Oxides of Nitrogen (NO <sub>x</sub> )	NO <sub>x</sub> test meter	Direct reading	Causes inflammation of the lungs but less toxic.
Noise	Noise Meter, Rion sound level meter NA model	Direct Reading	

**Table 3.** Outcome of Ambient Air Quality at Apapa Lagos

Sites	Parameters and Units											
Units	PM <sub>10</sub> (ug/m <sup>3</sup> )	PM <sub>25</sub> (ug/m <sup>3</sup> )	CO (ppm)	NO <sub>2</sub> (ppm)	H <sub>2</sub> S (ppm)	CO <sub>2</sub> (ppm)	VOC (ppm)	SO <sub>2</sub> (ppm)	O <sub>2</sub> (%)	Comb (ppm)	HM (%)	Temp (°C)
FMEnv Limits	250	NS	0.03	0.313	0.008	425	8.53	0.01	NS	NS	NS	NS
1 (Near Gate)	10.9	5.2	<0.10	<0.01	<0.1	417.1	0.014	<0.01	21.1	<0.10	62.3	35.1
2 (Generator)	8.1	4.3	<0.10	<0.01	<0.1	398.2	0.013	<0.01	20.8	<0.10	61.1	33.9
3 (Sitting room)	5.3	2.1	<0.10	<0.01	<0.1	401.9	0.019	<0.01	20.9	<0.10	60.9	29.0
4 (Water pump area)	12.1	6.9	<0.10	<0.01	<0.1	692.8	0.357	<0.01	21.0	<0.10	63.2	34.1
5 (Laboratory zone)	9.2	6.3	<0.10	<0.01	<0.1	460.1	0.162	<0.01	21.1	<0.10	67.2	31.9
6 (Tank Farm region)	10.8	7.9	<0.10	<0.01	<0.1	397.9	0.000	<0.01	21.0	<0.10	68.9	32.0
7 (Water Treatment)	8.9	4.1	<0.10	<0.01	<0.1	468.2	0.194	<0.01	21.0	<0.10	69.0	31.8
8 (Water separator)	8.2	4.0	<0.10	<0.01	<0.1	527.8	0.036	<0.01	20.9	<0.10	68.4	33.2
9 (Loading zone)	9.3	2.0	<0.10	<0.01	<0.1	575.4	0.194	<0.01	20.8	<0.10	61.9	35.3
10 (Jetty region)	7.2	3.0	<0.10	<0.01	<0.1	397.9	0.056	<0.01	21.0	<0.10	65.3	35.0
Within Limits (%)	100		0	100	100	70	100	100	-	-	-	-
Not Within Limits (%)	0		100	0	0	30	0	0	-	-	-	-

The most important oxides of Sulphur are Sulphur (iv) oxide (SO<sub>2</sub>) and Sulphur trioxide (SO<sub>3</sub>), when SO<sub>2</sub> soften inside water vapour in the atmosphere/sky to create acids as well as interrelate with other gas plus particles to also generate particles identified as sulphates, which in turn have unsympathetic impacts on human healthiness and the ecosystem. The impacts of Sulphur (iv) oxide (SO<sub>2</sub>) are feel very swiftly, and most populace would felt the most awful signs within 10 - 15minutes, once breathing it in. Those people with asthma or any similar health issue or health condition are at high risk of developing problems after exposed to Sulphur (iv) oxide. Measurement for the presence of SO<sub>2</sub> at all sampled locations were less than 0.01ppm which is less than the NAAQS (FEPA 1991) statutory limits of 0.3ppm. The presence and amount of Carbon monoxide (CO) and CO<sub>2</sub> in the environment might be allied from sources such as; reprehensively vented appliances with hydrocarbon fuel sources. Outdoor vehicular hydrocarbon emissions, Boilers, heating systems, or other industrial sources (Anderson et al. 2011; Fernando et al. 2021). CO might thus louden or accumulate within buildings where there is derisory aeration. Measurement for the presence of CO at all sampled locations were less than 0.1ppm which is greater than the NAAQS (FEPA 1991) statutory limits of 0.03ppm.

### *3.1.2 Hydrogen Sulphide and Suspended Particulate Matter (SPM)*

Hydrogen Sulphide is a colorless, monochrome, combustible, tremendously hazardous gas with a “putrid egg” scent. It can be created by the cessation of animal/ or human being waste, for instance sewage as well as organic matter. When exposed at small quantities it triggers eyes irritant, upper respiratory system and its effects can be delayed. At moderate concentration it causes more irritation of the eyes and respiratory effects, headache, dizziness, coughing and vomiting while at higher concentration it

causes shock, convulsion, coma and potentially death. People with asthma may be at greater risk as a result of difficulty in breathing. Detection of Hydrogen Sulphide at all sampling point was less than 0.1ppm. Particulates are tiny solid or liquid particles suspended in air. Particulates such as dust, smoke, diesel soot and products resulting from burning can be emitted directly into the air. It might also be created via photochemical reactions, like polluting gases (Nitrogen plus Sulphur oxides). Particulates may have a short as well as long-term effect on human healthiness and the environment (Gene et al. 2022; Jacquet et al. 2021). These effects range from eye and throat irritation to chronic respiratory diseases to cancer. Fine particulates which are microscopic and less than 10 microns (PM<sub>10</sub>) are of greatest concern because of their ability to by-pass the body’s natural filtering system, and thus pose a threat to the respiratory system. The concentration of particulate matter (PM<sub>10</sub>) at all the sampled locations ranged from 5µg/m<sup>3</sup> at the Reception and Pump House to 12µg/m<sup>3</sup> at the Water Booster Pump which is within the NAAQS (FEPA 1991) permissible limit of 250µg/m<sup>3</sup>. Particulate matter (dust) is generated from general cleaning operations and movement of tanker trucks. Although the particulate levels measured show they are within permissible limits, however, depending on the duration of exposure, particulate emissions can impact negatively on workers’ health and exacerbate existing health condition e.g. asthma.

### **3.2. Noise Scrutiny Outcome**

Noise is mostly sound that is anti-information intensity of which usually fluctuates erratically with time. Noise is the term frequently used to describe unwanted sound, which impedes with the sensitivity of wanted sound and is probable to be physiologically damaging. Environmental noise is the accretion of all noise available in a precise environment. Exposure to noise is

correlated with numerous pessimistic health outcomes, based on the level of exposure and extent (Haggerty et al. 2018; Evensen 2018). Noise might prop up cardiovascular sicknesses, hearing loss, sleep turbulence, high blood pressure, as well as birth defects. The ambient noise levels within the facility were measured in some selected locations with the use of a Mastech Multi-Environmental Survey Meter as showing in Tables 4&5 and Figure 3. The highest noise value recorded was 89.9dBA at the site 2 (Generator House one) while the lowest was

57.2dBA at Pump House. The noise level at 4 sites sampled locations was found to be above the WHO 2007 and FME<sub>nv</sub> regulatory limit. High noise level could be injurious to employees' hearing ability if exposed for prolonged periods without adequate hearing protection. Exposure to high noise levels is implicated in increased stress levels and high blood pressure, insomnia, partial hearing loss etc. Noise levels were measured at a range no more than 3m from source (Deziel et al. 2020; Cheong et al. 2011).

**Table 4.** Guideline Limits

<u>WHO Limits 2007</u>		
Receptor/ Noise Level (dBA)	Daylight (7.00am-22.00pm)	Nocturnal (22.00pm-7.00am)
Built-up, Institutional & Education	55	45
Business, shopping, marketable, indoors, Outdoors and traffic region	70	70
<u>Berglund et al. 1999</u>		
Environ	Health Effect	Noise Level (dBA)
Indoors bedrooms	Speech intelligibility & moderate annoyance (daytime)	35
	Sleep fracas (Nocturnal)	30
Outside bedrooms	Sleep fracas window open	45
Outdoor, Living room	Serious annoyance (Night time)	55
	Moderate annoyance (day/ evening time)	50

**Table 5.** Outcome of Ambient noise in Apapa Lagos during day time

Sites	GPS Coordinated	Noise Level (dBA)	Limits	Remarks
1 (Near Gate)	N6°26'23.27649" E3°20'1.36792"	61.42		Not
2 (Generator)	N6°26'20.63513" E3°20'0.899"	89.88		Not
3 (Sitting room)	N6°26'19.01821" E3°20'1.1585"	59.48		Not
4 (Water pump area)	N6°26'18.85029" E3°20'1.72881"	61.79		Within
5 (Laboratory zone)	N6°26'17.65008" E3°20'0.24541"	67.12		Within
6 (Tank Farm region)	N6°26'18.24981" E3°19'57.87729"	63.42		Within
7 (Water Treatment)	N6°26'16.64496" E3°19'57.845"	62.79		Within
8 (Water separator)	N6°26'16.93323" E3°20'0.22097"	66.40		Within
9 (Loading zone)	N6°26'17.69233" E3°20'0.54988"	70.39		Not

World Bank % Within – 44.4%; % Not Within – 55.6%.

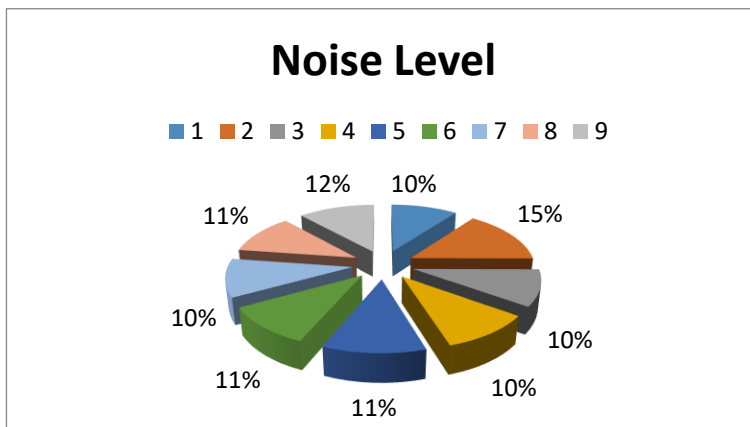


Figure 3. Outcome of noise level scrutiny

### 3.3. Outcome of Effluent and hazardous materials

The analysis of effluent sample from the Oil Water Separator (OWS) showed that parameters such as Oil and Grease (0.04mg/l), Total Dissolved Solids (78.0mg/L) and Total Suspended Solids (0.11mg/L) were found to be within their stipulated regulated limits. However, parameters such as COD (48.2, 47.9 & 48.1 mg/l), BOD5 (11.4, 11.2 & 11.1mg/l), Ammonia (0.24, 0.23 & 0.23 mg/l), Turbidity (22.1, 22.3 & 22.4 mg/l) and Manganese (0.52, 0.51 & 0.53mg/L) were above their prescribed limits as stated in Guidelines for Noise, Industrial Effluent, and Gaseous Emissions Limitations (FEPA 1991). The pH of 6.8 indicates that the sample is slightly acidic and also within the stipulated regulatory limit of 6.5-8.5 (Tables 6 and 7a&b). Microbial analysis was also carried out on the raw water sample and the result for Salmonella was negative. Wastewater (effluent) from the region encompasses depot operations which arises from mixture of minor spills and water as well as wastewater from the laboratory, kitchen, equipment maintenance etc. can impact negatively on the environment if discharged directly to public

drains without treatment. The contagions in such wastewater might encompass soluble macrobiotic chemicals creating exhaustion of heavy metals, DO, suspended solids plus volatile materials, hydrocarbons, bases or acids (displayed as small or high pH). Though some depot's installed OWS works to skim out the oil from the water and ensure it is tested and treated before discharge. Hazardous materials within the study zone involve the storage of bulk quantities of petroleum products and in smaller quantities, chemicals such as foam, caustic, solvents, lubricants etc. Hazardous materials carrying, storage, and managing causes spills or other kinds of releases with potentially pessimistic effects on water, atmosphere, and soil resources. Besides, their combustibility and other impending hazardous physiognomies likewise present a threat of fire and blasts. Used/spent oil at some depots within the study zone is derived basically from maintenance operations of equipment and generators. The improper collection and disposal of used/spent oil will adversely impact the environment. Spilled oils on the floor can also cause slips and falls resulting in injuries if not properly cleaned and floors kept dry at all times.



**Table 6.** Outcome of Effluent from Oil water separator

Variables	Unit	Sites			Limits		Compliant Status (%)	
		1	2	3	EGASPIN 2018	FEPA 1991	Compliant	Non-within
Calcium	mg/l	26.7	26.8	26.5	NS	NS	100	0
Sulphate	mg/l	15.7	15.6	15.8	NS	100	-	-
Dissolved Oxygen	mg/l	4.88	4.90	4.87	NS	NS	-	-
COD	mg/l	48.2	47.9	48.1	NS	40	0	100
BOD	mg/l	11.4	11.2	11.1	NS	10	0	100
Ammonia	mg/l	0.24	0.23	0.23	NS	0.2	0	100
Total Hardness	mg/l	66.3	66.1	66.4	NS	200	100	0
Total Nitrogen	mg/l	0.53	0.54	0.53	NS	10	100	0
Total Suspended Solid	mg/l	0.12	0.14	0.10	30	10	100	0
Total Suspended Matter	mg/l	124.9	124.8	125.1	NS	NS	-	-
Conductivity	µS/cm	155.9	156.1	156.0	NS	1000	100	0
Total Dissolved Solid	mg/l	78.2	78.0	79.8	<2000	500	100	0
Turbidity	NTU	22.1	22.3	22.4	10	5	0	100
True colour/ Lovibond	Hz	0.17	0.15	0.16	NS	7	100	0
pH		6.7	6.8	6.9	6.5-8.5	6.5-8.5	100	0
Temperature	°C	24.8	24.9	25.1	Ambient ±2	<40	100	0
Total Alkalinity	mg/l	51.8	51.9	52.0	NS	NS	-	-
Total Phosphorus	mg/l	0.34	0.32	0.33	NS	NS	-	-
Salinity	%	0.00	0.01	0.00	NS	NS	-	-
Sodium	mg/l	5.82	5.84	5.83	NS	NS	-	-
Nitrate	mg/l	<0.01	<0.01	<0.01	NS	NS	-	-
Hydroxide Alkalinity	mg/l	0.01	0.02	0.00	NS	NS	-	-
Carbonate Alkalinity	mg/l	0.01	0.02	0.00	NS	NS	-	-
Magnesium	mg/l	9.67	9.68	9.69	NS	NS	-	-
Manganese	mg/l	0.52	0.51	0.53	NS	0.05	0	100
Chloride	mg/l	14.7	14.8	14.9	NS	250	100	0
Silica (SiO <sub>2</sub> )	as mg/l	1.12	1.13	1.11	NS	NS	-	-
Acidity (CaCO <sub>3</sub> )	as mg/l	1.12	1.13	1.11	NS	NS	-	-
Nitrite	mg/l	0.32	0.33	0.31	NS	NS	-	-
Total Iron	mg/l	1.14	1.12	1.13	1.0	1.0	0	100
Total oil & grease	mg/l	0.03	0.04	0.03	NS	10	100	0
Detergent	as mg/l	ND	ND	ND	NS	NS	-	-

**Table 7a.** Outcome of Effluent (Microbiological & others) from Oil water separator

Variables	Unit	Sites			Limits		Compliant Status (%)	
		1	2	3	EGASPIN 2018	FEPA 1991	Compliant	Non-within
Salmonella	in 25ml	Absent	Absent	Absent	NS	NS	-	-
Shigella	in 25ml	Present	Present	Present	NS	NS	-	-
E. coli	CFU/ml	7.1	7.0	7.1	NS	NS	-	-
Yeast & Mould	CFU/ml	27.9	28.0	28.1	NS	NS	-	-
Staphylococcus	CFU/ml	9.2	9.0	9.1	NS	NS	-	-
Vibrio	CFU/ml	12.0	12.2	12.1	NS	NS	-	-
Total coliforms	CFU/ml	11.2	11.1	11.0	NS	NS	-	-
Aerobic plant count	CFU/ml	9.0	8.9	9.0	NS	NS	-	-
Others								
BTEX	mg/l	<0.001	<0.001	<0.001	NS	NS	-	-
PAH	mg/l	<0.001	<0.001	<0.001	10	NS	100	0
Odour		Objectionable			NS	NS	-	-
Appearance		Light brown with particles			Colourless			

### 3.4. Outcome of water attribute analysis

The outcomes of physico-chemical variables gotten from groundwater within project region (Tables 8 - 10 and Figures 4 - 6) indicated that the Conductivity (1094.0, 1695.0 & 1695.1 mg/l), Calcium (109.1, 108.9 & 109.2 mg/l), Ammonia (0.48, 0.47 & 0.49mg/l), DO (2.07, 2.06 & 2.07mg/l) and Total dissolved solid (847.2, 847.4 & 847.3 mg/l) values were high, indicating freshwater aquifer. The turbidity values (1.00 – 1.13 NTU) reveals that all the sampled

borehole was well within the standard for hygienic water criterion of 5 NTU. The pH values displayed neutral measured was because of the bicarbonate quantity with values within 30.0 – 500.0 mg/lCaCO<sub>3</sub> WHO limit. The carbonate alkalinity perceived in the sampling was very low. TD values of the groundwater samplings vary between 51.8 mg/L CaCO<sub>3</sub> as well as 48.6 mg/L CaCO<sub>3</sub>. Discrepancy between the TD values for the boreholes was awfully low, signifying recharge from the equivalent origin. Hardness in water encompasses calcium plus magnesium as the key constituents. For

instance, magnesium ions quantified in the groundwater varied from 39.7 – 39.8 mg/L respectively, Small phosphate, chloride, and sulphate amounts were seen in groundwater samplings compared to the WHO limits. Likewise, small anions quantities substantiate the airiness of groundwater from the research site. Sulphide and Nitrate ion was not perceived in the groundwater sampling. Oil and grease (O&G) were not detected within the facility area, two of the sample points were below instrument detection limit. Total hydrocarbon was not detected in the ground water samplings of the project influence zone. The origin can, however, be ascribed to biogenic instead of anthropogenic involvement since petroleum hydrocarbon correlated deeds was not seen in the region as at the period of this research. Heavy metals ascertained in the samplings displayed varied quantities with Cd having values of 0.02 mg/l in one of the points and not detected in the two other BH water sample. The concentration span of other metals are in the order of Cu < Pb < Zn < Ni < Mn < Fe. Zinc as well as copper displays concentrations beneath their maximum tolerable limits in hygienic water, whereas Pb, Cr, Ni, Fe, Cd, Hg plus Mn were available at extreme concentrations than intervention and target WHO criterion level. The happening and concentrations of these metals in the samplings imitate the general physiognomies of groundwater systems in nearly all parts of Nigeria. The microbial characteristic of groundwater samplings from the research region is presented that the total coliform, faecal coliform feecal streptococci and enterococci determined ranged from 1.9x10<sup>2</sup> to 2.0x10<sup>2</sup> cfu/100ml, 0.5x10<sup>2</sup> to 1.2x10<sup>2</sup> cfu/100ml, 0.29x10<sup>2</sup> to 0.82x10<sup>2</sup> and 0.43x10<sup>2</sup> to 0.57x10<sup>2</sup>cfu/100ml respectively, while no detection was recorded at GW2. Fungi are, however, not recorded in the

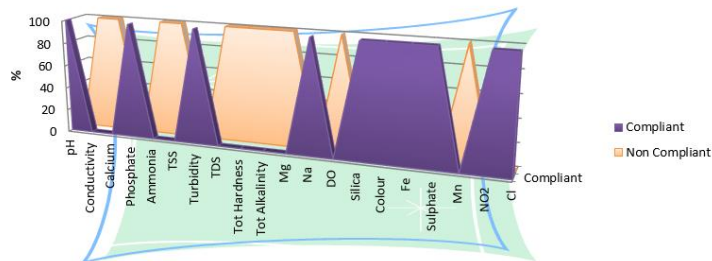
**Table 8. Outcome of Water Attribute**

sample, showing no growth. faecal coliform was not detected. For PAHs, It is branded that PAHs are comparatively intractable in soils, and some PAHs have been recognized as teratogens, carcinogens, or mutagens (Biern et al. 2015; Fernando et al. 2021). Further scrutiny through algorithm cluster produce 2 step with 28 input, for cluster quality between 0.5 – 1.0 was classified as good and 0 – 0.5 as fair water. Cluster A is greatly loaded with parameters like DO, Conductivity, Salinity and Ammonia, while Cluster B parameters are Turbidity, TDS and TSS. Cluster quality displays that Conductivity initial and final scrutiny was the highest (156mg/l), followed by TSM with value of 125.1mg/l at initial and slightly reduce to 124.85 at final scrutiny.

**Table 7b. Outcome of Effluent (Microbiological & others) from Oil water separator**

Contagions	Health impacts	
	Short term	Long term
Ethylbenzene Benzene n-Hexane Toluene Xylenes	Dizziness, eye and throat irritation Skin blister and irritation, upper respiratory tract Headache, giddiness and nausea. Sleep difficulty, dizziness, skin and eyes irritation Nose, gastric and throat irritation, neurological, vomiting and nausea	Blood disorders Developmental and reproductive disorders Blurred vision, fatigue, extremities and headaches. Birth defects Nervous system disorder

Variables	Unit	Sites			Limits					Compliant Status (%)	
		1	2	3	FEPA	WHO	USEPA	NIS	EU	Compliant	Non-within
pH		7.08	7.09	7.07		6.5-8.5			6.5-8.5	100	0
Conductivity	µs/cm	1694.9	1695.0	1695.1	1000	-	1000	1000	2500	0	100
Calcium	mg/l	109.1	108.9	109.2				75		0	100
Phosphate	mg/l	1.01	1.00	1.00	<5.0	-	-	NS	-	100	0
Ammonia	mg/l	0.48	0.47	0.49				0.05		0	100
TSS	mg/l	0.09	0.08	0.10	<10	-	-	NS	-	100	0
Temperature	°C	25.4	25.5	25.3				Ambient		100	0
Turbidity	NTU	0.01	0.02	0.01	5	5	5	5	-	100	0
Total acidity	mg/l	61.4	61.3	61.4				NS		-	-
TDS	mg/l	847.2	847.4	847.3	500	-	500	500	-	0	100
Total Hardness	mg/l	272.4	272.3	273.3	200	80-100	-	150	-	0	100
Total alkalinity	mg/l	408.4	408.2	408.3	-	-	-	200	-	0	100
Total solids	mg/l	1039.9	1040.2	1040.3				NS		-	-
Magnesium	mg/l	39.8	39.7	39.8				20		0	100
Sodium	mg/l	10.7	10.8	10.6				200		100	0
Chloride	mg/l	26.8	26.9	26.7	250	250	250	250	250	100	0
DO	mg/l	2.07	2.06	2.07				2		0	100
Nitrite	mg/l	0.13	0.14	0.12				0.2		100	0
Manganese	mg/l	0.23	0.22	0.21				0.2		0	100
Total iron	mg/l	<0.01	<0.01	<0.01				0.3		100	0
Sulphate	mg/l	50.2	50.3	50.1	500	250	250	250	250	100	0
Silica	mg/l	3.93	3.94	3.92				40		100	0
Salinity	%	0.09	0.08	0.07				NS		-	-
Nitrate	mg/l	<0.01	<0.01	<0.01	50	50	50	50	50	100	0
Total oil/grease	mg/l	0.08	0.09	0.10				10		100	0
Colour	TCU	0.17	0.16	0.18				15		100	0
Appearance		Colourless			colourless						
Odour		Objectionable								Unobjectionable	
Taste		Objectionable								Unobjectionable	



**Figure 4.** Compliant and noncompliant level of water attribute parameters

**Table 9.** Outcome of Water Attribute

Variables	Unit	Sites			Limits					Compliant Status (%)	
		1	2	3	FEPA	WHO	EU	USEPA	NIS	Compliant	Non-within
Salmonella	in 25ml	Absent	Absent	Absent	NS-	-	-	-	NS	-	-
Shigella	in 25ml	Absent	Absent	Absent	-	-	-	-	NS	-	-
E. coli	CFU/ml	0.00	0.00	0.00	0	-	-	-	0	100	0
Yeast/Mould	CFU/ml	7	7.1	7.0	-	-	-	-	0	100	0
Staphylococcus	CFU/ml	0	0	0	NS	-	-	-	NS	-	-
Vibrio	CFU/ml	0	0	0	NS	-	-	-	NS	-	-
Aerobic plate count	CFU/ml	26.0	26.1	26.2	NS-	-	-	-	100	100	0

Nigerian Industrial Standards for Drinking Water (NIS 554:2015)

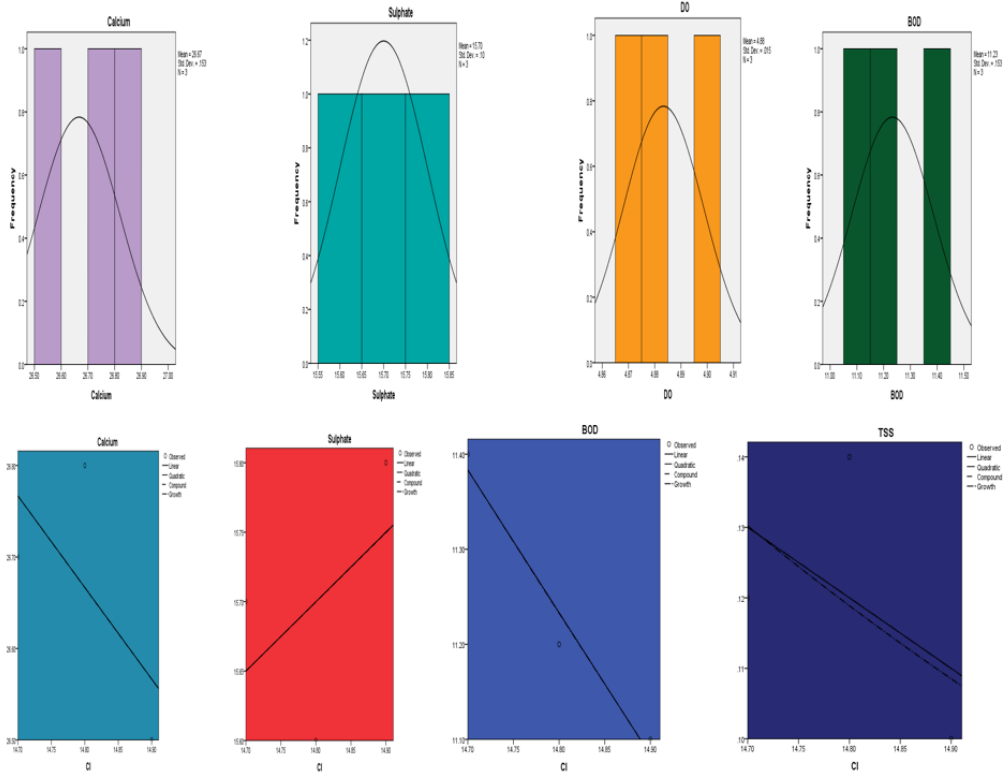
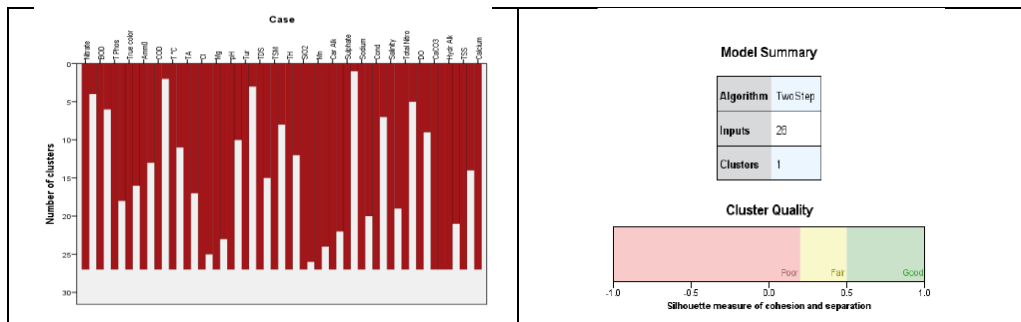
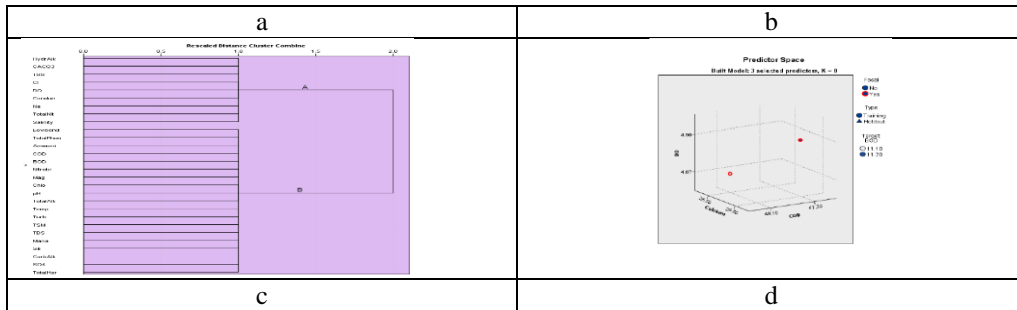


Figure 5. Water attribute scrutiny outcome for some parameters

Table 10. Cluster Scrutiny outcome

Initial	Cl	SO2	DO	COD	BOD	AMMO	TH	Total Nitr	TSS	TSM	Cond	TDS	Tur	True Color
C1	26.5	15.8	4.87	48.1	11.1	0.23	66.4	0.53	0.1	125.1	156	79.8	22.4	0.16
C2	26.8	15.6	4.9	47.9	11.2	0.22	66.1	0.54	0.14	124.8	156.1	78	22.3	0.15
	pH	T0C	TA	TPhos	Mg	Salinity	Na	HydrAlk	NO2	Mn	Cl	SiO2	CaCO3	CarAlk
C1	6.9	25.1	52	0.33	9.69	0	5.83	0	0.53	14.9	1.13	1.11	1.13	0.02
C2	6.8	24.9	51.9	0.32	9.68	0.01	5.84	0.02	0	0.51	14.8	1.11	1.13	0
Final	Cl	SO2	DO	COD	BOD	AMMO	TH	Total Nitr	TSS	TSM	Cond	TDS	Tur	True Color
C2	26.75	15.65	4.89	48.05	11.3	0.23	66.2	0.54	0.13	124.85	156	78.1	22.2	0.16
	pH	T °C	TA	TPhos	Mg	Salinity	Na	HydrAlk	NO2	Mn	Cl	SiO2	CaCO3	CarAlk
C2	6.75	24.85	51.85	0.33	9.68	0.01	5.83	0.02	0	0.52	14.75	1.12	1.13	0.01



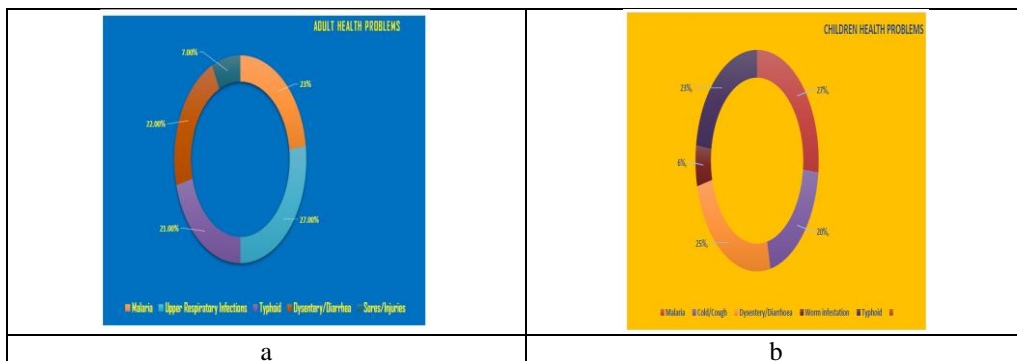


**Figure 6.** Cluster investigation outcome of some parameters scrutinized

The expulsion of produced water creates serious environmental threats to human and the ecosystems. Besides usage of technologies like high proficient halophile oil-degrading microbes in genetic treatment must be coalesce with membranes (SBR) genetic treatment systems for efficient management of generated water, since the Lagos (South-west Nigeria) crude oil is tart in nature and have heavy metals, The pipelines are creating serious problems via leaking, then causing substantial oil spills along the haulage line to the sea terminal at haven Nigeria necessitate appropriate monitoring plus maintenance. At the moment, most oil manufacturers re-inject created water or reclaim it for onshore wells at 98.0%. Conversely, 91.0% of created water from offshore wells is expulse into the deep-sea.

Table 11 and Figure 7 displays that the common health problems identified among the adult population were Malaria (23%), Upper Respiratory Infections (Cough, Catarrh, sore throats etc.) (27%), Typhoid (21%), Dysentery/diarrhea (22%), and Sores/injuries (7%). While among the children the most common health problems are malaria (27%), Dysentery/Diarrhoea (25%), worm infestation (6%) and Typhoid (23%), while Upper Respiratory Infections (cough, catarrh, sore throats etc. accounted for 19% Most of the diseases recorded are those that have been endemic in the communities since the inception of the communities apart from upper respiratory tract infection which is associated to mining activities, cement production and heavy vehicular movement in the area.

### 3.5. Health and Well-being in the Apapa Communities



**Figure 7.** Common Health Problems among the; a) Adult, b) Children Population

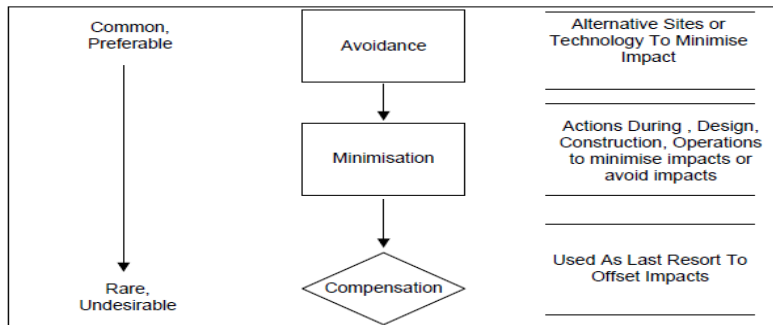
#### **4. Air, Effluent, Wastewater & Domestic Water Quality Management**

Secretion and air attribute monitoring programs afford information that might be utilized for assessing the efficacy of emissions management stratagems. The systematic planning of air attribute monitoring is vital to ensuring that the data gathered are ample for their wished-for rationales. The effluent and water attribute monitoring program that have tolerable resources and management overseeing must be created. Also elements such as: monitoring parameters (that indicate contagions apprehension, should encompass variables that are synchronized under the Standards for Noise , Industrial Effluent, and Gaseous Emissions Limitations and Environmental Guidelines for the Petroleum Industry in Nigeria acquiescence requirements), monitoring kind and rate of recurrence (monthly/quarterly effluent monitoring that will take into consideration the discharge physiognomies from the operation of the depots and any other area with more potential for spills), monitoring locations (effluent sampling positions should be located at the final discharge point from the Oil Water Separator, also process expulsion must not be diluted preceding or after treatment), data quality (application of nationally approved techniques for sampling gathering, preservation and analysis. Besides, sample must be carried out under or by trained individuals and test to be performed by accredited laboratories or by the entities allowed or expert for this rationale). Although opportunities for water savings in industrial processes are highly industry-specific, there are opportunities for water-use monitoring in the Apapa Lagos State. Thus the

indispensable elements of water management program should encompass: upgrade of treatment process to meet needs for domestic purposes e.g., handwashing etc.; classification, recurring measurement, and demo of principal flow within the region. This can be achieved through the installation of flow meters. Also constant similarity of water flows with functioning targets to ascertain where action must be taken to lessen water usage and water metering should accentuate zones with peak water usage (Luke et al. 2018; Deziel et al. 2020).

#### **5. Outcome of Mitigation**

Generally, where a structure is already on ground, the chances for impact averting are constricted and the main issue is how to curtail and reimburse for inevitable impacts. Conversely, these dissimilarities are not inflexible and chances for artistic mitigation must be hunted for at all phases of assessment and task management. The rudiments of mitigation are structured into a hierarchy of deeds (Figure 8) based on the principle of Avoidance, Minimize/Reduce, Remedy and/or compensate namely: Circumvent unhelpful impacts as far as possible via usage of precautionary actions; curtail undesirable impacts to 'as low as convincingly practicable' (ALARP) states. Likewise, main ethics for the usage of mitigation must be unswerving and to include: preference to avoidance together with preventive measures; choose realistic substitutes for the proposal as well as ascertain the preeminent practicable ecosystem preference; spot out modified measures to lessen each of the key impacts envisaged; apt environmentally reverberation and cheap; and use reimbursement or curative measures as a final remedy (Biern et al. 2015; Buttke et al. 2012).



**Figure 8.** Outcome of mitigation fundamental for Apapa

**Table 11.** Probability trends and impact consequences on Apapa populace.

CONSEQUENCE					INCREASING PROBABILITY				
					A	B	C	D	E
Severity	People	Asset Damage	Environmental Effect	Reputation	Never heard of in the industry	Has occurred in the industry	Incident has occurred in	Happens several times/year	Happens several times/year
0	No injury	None	None	None	Low Risk				
1	Slight injury	Slight	Slight	Slight					
2	Minor injury	Minor	Minor	Limited					
3	Major Injury	Localised	Localised	Considerable			Medium Risk		
4	Single Fatality	Major	Major	National					
5	Multiple Fatalities	Extensive	Massive	International					High Risk

## 6. Conclusion

In the last decades, spill out from aging, ailing maintained or incapacitated pipelines have upsurge, and no clear inclination with respect to nosh-up, that is number of happenings or total of spilled-out oil. This scrutiny displays the secretion of effluents, particulates contagions and anions from Apapa, Lagos Nigeria. The outcomes flaunt that the presence and concentration of Nitrogen -iv-oxide (NO<sub>2</sub>) were less than 0.01ppm thus within stipulated limit of 0.113ppm, whereas 100% CO and 30% of CO<sub>2</sub> measured was

above regulatory limits. Similarly, the highest noise value recorded was 89.9dBA at the site Generator House one while the lowest was 57.2dBA at Pump House. The noise level at 4 sites sampled locations was found to be above the WHO 2007 and FMEnv regulatory limit. The concentration span of other metals arrangement are in the order of Cu < Pb < Zn < Ni < Mn < Fe. Zinc as well as copper displays concentrations beneath their maximum tolerable limits in hygienic water, whereas Pb, Cr, Ni, Fe, Cd, Hg plus Mn were available at extreme concentrations than intervention and target WHO criterion level.

Furthermore, the inhabitants of the shoreline regions disturbed by the spill-out are also indirectly or diametrically exposed to the oil chemicals are facing economic together with social consequences of the spill-out. For this reason, epidemiologic research that centered on threat appraisal must consider all the

variables ascribed to exposure of oil spills-out, no matter what the source, as these are indispensable for thorough appraiser of the possible impacts on human healthiness at various levels and also launch proper precautionary programs

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## **THE INFLUENCE OF LEADERSHIP STYLE, WORK MOTIVATION AND WORK DISCIPLINE ON THE PERFORMANCE OF EAST RUMBAI SUB-DISTRICT OFFICE EMPLOYEES**

***Abstract:** This study aims to see the effect of leadership style, work motivation, and work discipline on the performance of the employees of the East Rumbai District office and the Pekanbaru East Rumbai District office. The population in this study were all employees of the Rumbai District and East Rumbai Pekanbaru, which amounted to 51 employees, did not use a sampling technique because in this study only a population of 51 employees was used. The data analysis used in this research is descriptive and quantitative analysis. The analysis method used is multiple linear regression equation. The results show that leadership style, work motivation, and work discipline have a positive and significant effect, this can be seen from the coefficient of determination ( $R^2$ ) of 0.652 indicating that 65.2% of employee performance at the Rumbai sub-district office and the Rumbai Timur sub-district office can be explained or caused by leadership style, work motivation and work discipline. In other words, leadership style, work motivation and work discipline have an effect of 65.2% on employee performance. While the remaining 34.8% is the influence of other factors outside of leadership style, work motivation and work discipline.*

***Keywords:** Leadership Style, Work Motivation, Work Discipline, Employee Performance*

### **1. Introduction**

The success of an organization to achieve goals cannot be separated from the factor (HR) of its human resources. Human resources are very strategic in organizations, meaning that humans play an important role in carrying out activities to achieve goals. For this reason, the existence of human resources in the organization is very strong. Humans

always play an active role in every organizational activity because humans become planners, actors, and determinants of the realization of organizational goals. This goal will not be realized without the active role of employees even though the tools of an organization are so modern.

Work motivation is a person's desire that causes the person to act. People act for one reason which is to achieve goals. So, work

motivation is a goal governed by goals. Work discipline is a process of rules that have been made in carrying out work, where work

discipline will make the measure of each individual in developing himself and the agency.

**Table 1.** District Office Employee Attendance Report

No	Tahun	Jumlah Pegawai	Jumlah Hari Kerja (dalam 1 tahun/orang)	Jumlah Hari Kerja Pegawai Pertahun	Jumlah Absen			Persentase (%)
					Alpa	Izin	Sakit	
1	2017	21	288	6048	3	7	10	0,050
2	2018	23	288	6624	5	5	7	0,075
3	2019	23	288	6624	6	8	13	0,090
4	2020	25	288	7200	5	11	9	0,069
5	2021	25	288	7200	9	8	13	0,125

That way the work environment is also a measure of success in an agency. the process of rules that have been made in carrying out work, where work discipline will make the measure of each individual in developing himself and the agency. That way the work environment is also a measure of success in an agency.

Based on observations in the field or preliminary pre-research interviews, from the data above, it can be seen that the number of sub-district employees at the end of 2017 was 23 people with the number of work results in 1 year 288 days with an attendance rate of 26 times, namely: 5 alpa people, 9 permit people, and 12 sick people with percentage results amounting to 0.075%. In 2018 the number of employees was 23 people with the number of working days in 1 year 288 with an

attendance rate of 26 times, namely: 5 alpa people, 11 permit people, 10 sick people with a percentage result of 0.075%. In 2019 the number of employees was 23 people with the number of working days in 1 year 288 with an attendance rate of 30 times, namely 8 alpa people, 10 permit people, 12 sick people with a percentage result of 0.120%.

In 2020 the number of employees was 25 people with the number of working days in 1 year 288 with an attendance rate of 28 times, namely: 7 alpa people, 8 permit people, 13 sick people with a percentage result of 0.097%. And in 2021 the number of employees is 26 people with the number of working days in 1 year 288 with an attendance rate of 31 times, namely: 6 alpa people, 11 permit people, 14 sick people with a percentage result of 0.080%.

**Table 2.** Report on the Attendance Rate of Employees of the East Rumbai District Office of Pekanbaru for 2017-2021

No	Tahun	Jumlah Pegawai	Jumlah Hari Kerja (dalam 1 tahun/orang)	Jumlah Hari Kerja Pegawai Pertahun	Jumlah Absen			Persentase (%)
					Alpa	Izin	Sakit	
1	2017	23	288	6624	5	9	12	0,075
2	2018	23	288	6624	5	11	10	0,075
3	2019	23	288	6624	8	10	12	0,120
4	2020	25	288	7200	7	8	13	0,097
5	2021	26	288	7488	6	11	14	0,080

Based on observations in the field or preliminary pre-research interviews, from the data above, it can be seen that the number of sub-district employees at the end of 2017 was 21 people with the number of work results in 1 year 288 days with an attendance rate of 20 times, namely: 3 alpa people, 7 permit people, and 10 sick people with percentage results amounting to 0.050%. In 2018 the number of employees was 23 people with the number of working days in 1 year 288 with an attendance rate of 17 times, namely: 5 alpa people, 5 permit people, 7 sick people with a percentage result of 0.075%. In 2019 the number of employees was 23 people with the number of working days in 1 year 288 with an attendance rate of 27 times, namely 6 alpa people, 8 permit people, 13 sick people with a percentage result of 0.090%. In 2020 the number of employees was 25 people with the number of working days in 1 year 288 with an attendance rate of 25 times, namely: 5 alpa people, 11 permit people, 9 sick people with a percentage result of 0.069%. And in 2021 the number of employees is 25 people with the number of working days in 1 year 288 with an attendance rate of 30 times, namely:

9 alpa people, 8 permit people, 13 sick people with a percentage result of 0.125%.

Based on observations in the field or preliminary pre-research interviews, in the table above, it can be seen that the performance assessment of employees of the RumbaiPekanbaru Sub-district office from 2017 to 2021 is in the good category with the following description, in 2017 the number of employees was 23 people with the number of performance assessments of sub-district employees 1784.8% and the average employee performance amounted to 77.6% with good categories. In 2018 the number of employees was 23 people with the number of performance assessments of sub-district employees 1767.09% and the average employee performance was 76.83% with good categories. In 2019, the number of employees was 23 people with the number of performance assessments of sub-district employees increased by 1801.59% and the average employee performance amounted to 78.33% with good categories. In 2020 the number of employees was 25 people with the

number of performance assessments of sub-district employees decreased by 1915% and the average employee performance amounted to 76.6% with good categories, and in 2021 the number of employees was 26 people with

the number of employee performance assessments increasing again, namely 2036.58% and the average employee performance amounted to 78.33% with good categories.

**Table 3.** Average Performance Assessment of Employees of the RumbaiPekanbaruSubdistrict Office

<b>No</b>	<b><u>Tahun</u></b>	<b><u>Jumlah pegawai</u></b>	<b><u>Jumlah penilaian kinerja pegawai</u></b>	<b><u>Rata-rata kinerja pegawai</u></b>	<b><u>Keterangan</u></b>
1	2017	23	1784,8	77,6	<u>Baik</u>
2	2018	23	1767,09	76,83	<u>Baik</u>
3	2019	23	1801,59	78,33	<u>Baik</u>
4	2020	25	1915	76,6	<u>Baik</u>
5	2021	26	2036,58	78,33	<u>Baik</u>

**Table 4.** Average Performance Assessment of Employees of the East Rumbai District Office in Pekanbaru

<b>No</b>	<b><u>Tahun</u></b>	<b><u>Jumlah pegawai</u></b>	<b><u>Jumlah penilaian kinerja pegawai</u></b>	<b><u>Rata-rata kinerja pegawai</u></b>	<b><u>Keterangan</u></b>
1	2017	21	1638	78	<u>Baik</u>
2	2018	23	1786,18	77,66	<u>Baik</u>
3	2019	23	1778,59	77,33	<u>Baik</u>
4	2020	25	1937,5	77,5	<u>Baik</u>
5	2021	25	1975	79	<u>Baik</u>

Based on observations in the field or preliminary pre-research interviews, in the table above, it can be seen that the performance of employees of the East RumbaiPekanbaru Sub-district office from 2017 to 2021 is in the good category with the

following description, in 2017 the number of employees was 21 people with the number of performance assessments of sub-district employees of 1638% and the average performance of sub-district employees of 78% with good categories. In 2018 the

number of employees was 23 people with the number of employee performance assessments of 1786.18% and the average performance of sub-district employees decreased to 77.66% with good categories, in 2019 the number of employees was 23 people with the number of employee performance assessments decreased again, namely 1778.59% and the average performance of sub-district employees was 77.33% with good categories. In 2020 the number of employees of 25 people with the number of employee performance assessments decreased again by 1937.5% and the average employee performance of 77.5% with good categories and in 2021 the number of employees of 25 people with the number of employee performance assessments increased significantly, namely by 1975% and the average performance of sub-district employees by 79% with good categories.

## 2. Library Review and Hypothesis Development

### 2.1. Understanding Leadership Style

Schermerhorn in Nurmansyah (2020: 163) leadership is the process of inspiring others to work hard to accomplish important tasks.

### 2.2. Leadership Style Indicators

- 1) Characteristic
- 2) Habit
- 3) Temperament
- 4) Character
- 5) Personality

### 2.3. Understanding Work Motivation

Motive or motivation comes from the Latin word "movere" which means the impulse from within the human being to act/ behave. The definition of motivation is inseparable from the word need "needs" or "want". Need is a potential in man that needs to be

responded to (Notoatmodjo;2013;114).

### 2.4. Work Motivation Indicators

Mangkunegara (2016:95) Indicators of work motivation are:

- 1) Physiological needs
- 2) The need for a sense of security
- 3) The need to feel belonging
- 4) The need for awards
- 5) The need to self-actualize

### 2.5. Definition of Work Discipline

Sherlie and Hikmah (2020:757) Work discipline is a constructive method of development for employees who have an interest that results in discipline being shown to the actions of non-persons. Broadly speaking, work discipline is an attitude, behavior, and actions according to the rules that have been applied from the company in writing / unwritten and if an employee has violated the regulations that have been applied, sanctions will be imposed.

### 2.6. Indicators of Work Discipline

Mangkunegara (2015:93) indicators of labor discipline as follows:

- 1) Punctuality comes to work
- 2) The accuracy of the hours of returning home
- 3) Compliance with applicable regulations
- 4) Responsibility in doing tasks
- 5) Punctuality in carrying out tasks

### 2.7. Definition of Employee Performance

Mangkunegara (2015: 67) performance is the result of work in quality and quantity achieved by employees in carrying out their duties in accordance with the responsibilities given. In an organization, performance has a great influence on the achievement of the goals of the organization.

**2.8. Employee Performance Indicators**

Government Regulation No. 46 of 2011 in Nurmansyah (2021: 114) Employee performance indicators based on the assessment of the State Civil Apparatus (ASN) on the SKP (Employee Work Targets) are as follows:

- 1) Employee Work Goals (SKP)
- 2) Work Behavior
- 3) Leadership

**3. Research Methods**

**3.1. Types of Research**

This research uses quantitative research methods with a descriptive approach.

**3.2. Object of Study**

This research was conducted at the Rumbai and East Rumbai Subdistrict Offices in Pekanbaru. The object of this study was employees of the Rumbai and East Rumbai Subdistrict Offices.

**3.3. Research Population and Sample**

The population in the study was 51 employees of the Rumbai District Office in 2021. Meanwhile, the sample in this study was 51 employees.

**3.4. Research Population and Sample**

In this study, researchers chose a saturated sampling technique. Where are the techniques and samples that the researcher uses as a whole, regardless of the sample on any basis.

**3.5. Sampling Techniques**

In this study, researchers chose a saturated sampling technique. Where are the techniques and samples that the researcher uses as a whole, regardless of the sample on any basis.

**3.6. Data Collection Techniques**

To obtain the data in this study, the following data collection techniques were used:

- 1) Interview
- 2) Documentation
- 3) Questionnaire

**3.7. Data Analysis Techniques**

The data analysis that the authors used in this study used quantitative analysis. Data analysis techniques in quantitative research use statistics. Inferential statistics, (often also called inductive statistics or probability statistics) is a statistical technique used to analyze sample data and the results are applied to the population.

**4. Results of Research and Discussion**

**4.1. Characteristics of Respondents**

**Table 5.** Response Recapitulation Respondents About Employee Performance

No	Indikator	Frekuensi					Skor
		SS	S	CS	TS	STS	
1	Kuantitas	24	23	4	0	0	4,38
		48%	44%	8%	0%	0%	
2	Kualitas	24	23	4	0	0	4,38
		48%	44%	8%	0%	0%	
3	Waktu	25	20	6	0	0	4,33
		50%	45%	5%	0%	0%	
4	Biaya	23	21	7	0	0	4,30
		46%	42%	12%	0%	0%	
5	Orientasi Pelayanan	24	19	8	0	0	4,30
		50%	32%	18%	0%	0%	
6	Integritas	20	23	8	0	0	4,20
		45%	35%	20%	0%	0%	
7	Komitmen	19	25	7	0	0	4,20
		30%	50%	20%	0%	0%	
8	Disiplin	25	21	5	0	0	4,38
		50%	40%	10%	0%	0%	
9	Kerjasama	26	19	6	0	0	4,38
		55%	35%	10%	0%	0%	
10	Kepemimpinan	22	22	7	0	0	4,24
		45%	45%	10%	0%	0%	
Jumlah		232	216	25	0	0	43,01
Rata-Rata		23,2	21,6	2,5	0	0	4,301
Persentase		46%	41%	13%	0%	0%	100%



**Table 6.** Recapitulation of Leadership Style Respondents' Responses

No	Indikator	Frekuensi					Skor
		SS	S	CS	TS	STS	
1	Sifat	37	11	3	0	0	4,67
		60%	30%	10%	0%	0%	
2	Kebiasaan	33	14	4	0	0	4,55
		70%	20%	10%	0%	0%	
3	Temperamen	26	20	4	1	0	4,36
		45%	40%	10%	5%	0%	
4	Watak	27	19	5	0	0	4,45
		60%	30%	10%	0%	0%	
5	Kepribadian	26	22	3	0	0	4,49
		50%	40%	10%	0%	0%	
Jumlah		149	86	19	1	0	22,52
Rata-Rata		29,8	17,2	9,5	0,2	0	4,504
Persentase		57%	32%	10%	1%	0%	100%

**Table 7.** Recapitulation of Respondents' Responses About Work Motivation

No	Indikator	Frekuensi					Skor
		SS	S	CS	TS	STS	
1	Kebutuhan Fisiologi	17	21	13	0	0	4,07
		40%	50%	10%	0%	0%	
2	Kebutuhan Rasa Aman	17	23	11	0	0	4,16
		40%	50%	10%	0%	0%	
3	Kebutuhan Sosial	20	24	7	0	0	4,26
		45%	50%	5%	0%	0%	
4	Kebutuhan Penghargaan	19	24	8	0	0	4,24
		30%	60%	10%	0%	0%	
5	Kebutuhan Mengaktualisasikan Diri	25	19	7	0	0	4,38
		60%	30%	10%	0%	0%	
Jumlah		98	87	46	0	0	21,11
Rata-Rata		19,6	17,4	9,2	0	0	4,222
Persentase		43%	48%	9%	0%	0%	100%

**Table 8.** Recapitulation of Responses of Respondents to Work Discipline Variables

No	Indikator	Frekuensi					Skor
		SS	S	CS	TS	STS	
1	Ketepatan Waktu Datang Ketempat Kerja	30	18	3	0	0	4,56
		70%	25%	5%	0%	0%	
2	Ketepatan Jam Pulang Kerumah	27	19	5	0	0	4,45
		50%	45%	5%	0%	0%	
3	Kepatuhan Terhadap Peraturan Yang Berlaku	30	16	5	0	0	4,48
		60%	35%	5%	0%	0%	
4	Tanggung Jawab Dalam Mengerjakan Tugas	30	16	5	0	0	4,48
		60%	35%	5%	0%	0%	
5	Tepat Waktu Dalam Melaksanakan Tugas	30	17	4	0	0	4,52
		60%	35%	5%	0%	0%	
Jumlah		147	86	22	0	0	22,49
Rata-Rata		29,4	17,2	4,4	0	0	4,498
Persentase		60%	35%	5%	0%	0%	100%

#### 4.2. Validity Test

**Table 9.** Instrument Validity Test Results

Variabel	Indikator	r-Hitung	r-Tabel N=51	Keterangan
Kinerja Pegawai (Y)	Kuantitas	0,875	0,276	Valid
	Kualitas	0,907	0,276	Valid
	Waktu	0,855	0,276	Valid
	Biaya	0,827	0,276	Valid
	Orientasi Pelayanan	0,834	0,276	Valid
	Integritas	0,881	0,276	Valid
	Komitmen	0,894	0,276	Valid
	Disiplin	0,858	0,276	Valid
	Kerjasama	0,858	0,276	Valid
	Kepemimpinan	0,777	0,276	Valid
Gaya Kepemimpinan (X1)	Sifat	0,874	0,276	Valid
	Kebiasaan	0,904	0,276	Valid
	Temperamen	0,927	0,276	Valid
	Watak	0,917	0,276	Valid
	Kepribadian	0,859	0,276	Valid
Motivasi Kerja (X2)	Kebutuhan Fisiologi	0,886	0,276	Valid
	Kebutuhan Rasa Aman	0,932	0,276	Valid
	Kebutuhan Sosial	0,920	0,276	Valid
	Kebutuhan Penghargaan	0,920	0,276	Valid
	Kebutuhan Aktualisasi Diri	0,875	0,276	Valid
Disiplin Kerja (X3)	Ketepatan Waktu Kerja	0,879	0,276	Valid
	Ketepatan Jam Pulang	0,884	0,276	Valid
	Kepatuhan Pada Peraturan	0,926	0,276	Valid
	Tanggung Jawab Atas Tugas	0,946	0,276	Valid
	Tepat Waktu Atas Tugas	0,892	0,276	Valid

Based on the diats table, it can be seen that the variables of employee performance, leadership style, work motivation, and work discipline have been declared valid. And from the table above the four variables in this study obtained the test results of the r value of calculating all statements > r table (0.276). This means that the measuring instrument used is valid and feasible to be used as research data.

#### 4.3. Reability Test

**Table 10.** Instrument Reliability Test Results

No	Variabel	Cronbach Alpha	Standar Reliabilitas	Keterangan
1	Gaya Kepemimpinan	0,938	0,60	Reliabel
2	Motivasi Kerja	0,945	0,60	Reliabel
3	Disiplin Kerja	0,945	0,60	Reliabel
4	Kinerja Pegawai	0,959	0,60	Reliabel

Based on the table above, it shows that the research instrument has passed the

requirements that have been required to be said to be reliable. Each of the values of the three variables > 0.60, which means that these three variables have met the reliable requirements. Thus the instruments in this study have been considered reliable.

#### 4.4. Normality Test

**Table 11.** Normality Test Results

Variabel	Shapiro-Wilk		
	Statistic	df	Sig
Gaya Kepemimpinan	0,964	51	0,119
Motivasi Kerja	0,967	51	0,164
Disiplin Kerja	0,960	51	0,087
Kinerja Pegawai	0,960	51	0,087

Based on the test results from Shapiro-Wilk in the table obtained significance values of 0.119, 0.164, 0.087, 0.087 > 0.05. Mardiatmoko (2020) explained that if a variable obtains a significance value of > 0.05, then the variable can be interpreted as

having passed the normality test. Thus, it can be interpreted that the variables above the regression model have met the assumption of normality.

#### 4.5. Multicollinearity Test

**Table 12.** Multicollinearity Test Results

Model	Collinearity Statistics	
	Tolerance	VIF
1 (Constant)		
Gaya Kepemimpinan	.493	2,027
Motivasi Kerja	.533	1,877
Disiplin Kerja	.600	1,666

Based on the table above, it is known that the variable VIF values are 2.027, 1.877, 1.666 <

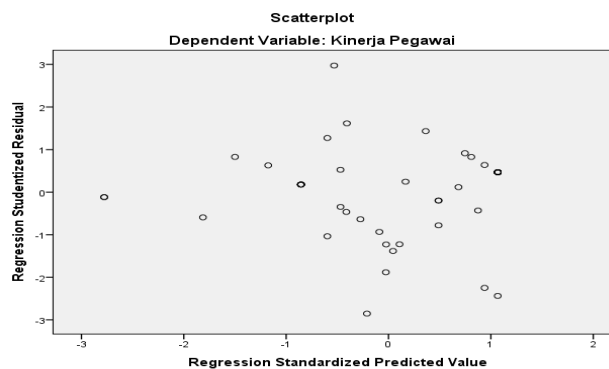
10 and tolerance values 0.493, 0.533, 0.600 > 0.1. Ghozali (2016) explained that if a variable VIF value < 10 and a tolerance value > 0.1 then the data does not occur multicollinearity. Thus, the whole variable does not occur multicollinearity.

#### 4.6. Auto Correlation Test

**Table 12.** Autocorrelation Test Results ModelSummary b

Model	R	R Square	Adjusted R Square	Std. Error of The Estimate	Durbin-Watson
1	.807 <sup>a</sup>	.652	.630	3,532	1,863

#### 4.7. Heteroskedasticity Test



**Figure 1.** Heteroskedasticity Test Results

**Table 13.** Glejser method

Model	Coefficients <sup>a</sup>				
	Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig
	B	Std. Error			
1 (Constant)	3.033	2.274		1.334	.189
Gaya Kepemimpinan	.096	.114	.154	.840	.405
Motivasi Kerja	-.133	.094	-.248	-1.409	.165
Disiplin Kerja	.008	.085	.015	.095	.925

Based on the table above, from the Glejser test, the result was obtained that each independent variable is insignificant to the residual absolute (0.405, 0.165, 0.925 > 0.05). Thus, it can be interpreted that there is no heteroskedasticity in the regression model of this study. The point of heteroskedasticity is

that there is a variant inequality of error for all observations of each variable free on the regression model.

#### 4.8. Multiple Regression Test

Based on the table above, the constant value

(a) is -10.784. The value of the regression coefficient of the leadership style variable is 0.868, the work motivation variable is 0.516, while the work discipline variable is 1.016.

**Table 14.** Glejser method

**ANOVA<sup>a</sup>**

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1097.821	3	365.940	29.333	.000 <sup>b</sup>
	Residual	586.336	47	12.475		
	Total	1684.157	50			

a. Dependent Variabel : Kinerja Pegawai

b. Predictors : (Constant), Disiplin Kerja, Motivasi Kerja, Gaya Kepemimpinan

Sumber : Data Olahan SPSS,2022

**Coefficients<sup>a</sup>**

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-10.784	5.505		-1.959	.056
	Gaya Kepemimpinan	.868	.246	.355	3.536	.001
	Motivasi Kerja	.516	.175	.249	2.941	.005
	Disiplin Kerja	1.016	.227	.460	4.485	.000

a. Dependent Variabel : Kinerja Pegawai  
 Sumber : Data Olahan SPSS,2022

**4.9. Partial Test (t-test)**

Simultaneous Test (F Test)

t Test Results (Hypothesis)

**Table 15.** F Test Results (Simultaneous)

**ANOVA<sup>a</sup>**

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1097.821	3	365.940	29.333	.000 <sup>b</sup>
	Residual	586.336	47	12.475		
	Total	1684.157	50			

a. Dependent Variabel : Kinerja Pegawai

b. Predictors : (Constant), Disiplin Kerja, Motivasi Kerja, Gaya Kepemimpinan

Sumber : Data Olahan SPSS,2022

**Table 15.** Determination Test Results

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.807 <sup>a</sup>	.652	.630	3.532

Predictors : (Constant), Disiplin Kerja, Motivasi Kerja, Gaya Kepemimpinan  
 Sumber : Data Olahan SPSS,2022

**5. Discussion**

**5.1. The Effect of Leadership Style on Employee Performance**

Based on the test results, it can be seen that the leadership style variable affects employee

performance significantly as seen from the t test where the t-count of 3.536 is greater than the t-table of 2.011 with a significant 0.001 smaller than 0.05 and with a coefficient value of 0.868. As for seeing the magnitude of the influence of leadership style on employee performance, it is to look at the values in the

beta table in the Standardized Coefficient column. The beta value for the leadership style variable is 0.355 or 35.5%.

### 5.2. The Effect of Work Motivation on Employee Performance

Based on the test results, it can be seen that the work motivation variable affects employee performance significantly as seen from the t test where the t-count of 2.941 is greater than the t-table of 2.011 with a significant 0.005 smaller than 0.05 and with a coefficient value of 0.249. As for seeing the magnitude of the influence of work motivation on employee performance, it is to look at the values in the beta table in the Standardized Coefficient column. The beta value for the work motivation variable was 0.249 or 24.9%.

### 5.3. The Effect of Work Discipline on Employee Performance

Based on the test results, it can be seen that the work discipline variable affects employee performance significantly as seen from the t test where the t-count of 4.485 is greater than the t-table of 2.011 with a significant 0.000 smaller than 0.05 and with a coefficient value of 0.460. As for seeing the magnitude of the influence of leadership style on employee performance, it is to look at the values in the beta table in the Standardized Coefficient column. The beta value for the leadership style variable is 0.1016 or 10.16%.

### 5.4. The Influence of Leadership Style, Work Motivation, and Work Discipline on Employee Performance

The results of his research stated that leadership style, work motivation, and work discipline affect employee performance. This can be seen from the results of the t test in table B, the highest value is found in the work discipline variable, which is 0.460 with a

significant value of 0.000, so it can be concluded that the work discipline variable that most affects employee performance.

From the test results, it can be seen that simultaneously independent variables against dependent variables are carried out by comparing the F-table with the F-count. The hypothesis is accepted if  $F\text{-count} > F\text{-table}$  and  $Sig < 0.05$ . The value of F-table at  $\alpha 0.05$  is 3.19. The F-count value is 29.333 with a significant value of 0.000. Then the F-value is calculated  $> F\text{-table}$   $29.333 > 3.19$  with a sig value of  $0.000 < 0.05$ . Thus, based on the results of such t-testing (hypothesis) it is proved that the value of F-count is greater than that of F-table. So it can be concluded that in this study the results of t testing (hypothesis) are acceptable.

## 6. Conclusions and Suggestions

### 6.1. Conclusion

Based on the results of the study, the following conclusions can be drawn:

- 1) The leadership style variable affects employee performance significantly, it can be seen from the recapitulation of respondents' responses about leadership style which shows that the trait indicator has the highest score with a score of 4.67.
- 2) The variable of work motivation affects employee performance significantly, it can be seen from the recapitulation of respondents' responses about work motivation which shows that the indicator of self-actualizing needs has the highest score with a value of 4.38.
- 3) The variable of work discipline significantly affects employee performance, which can be seen from the recapitulation of respondents' responses about work discipline which shows that the

indicator of punctuality to the workplace has the highest score with a score of 4.56.

- 4) The variables of leadership style, work motivation, and work discipline together affect employee performance significantly. With a significant rate of  $0.000 < 0.05$ . This shows that simultaneously, leadership style, work motivation and work discipline affect the performance of employees of the Rumbai District office and the East Rumbai District Pekanbaru office.

## 6.2. Suggestion

Based on the results of research that has been carried out, here are some suggestions that can be given:

- 1) Leaders must be able to manage the emotions they have well in order to

evaluate the work of their employees, assess the level of ability of employees to carry out their work, and reward outstanding employees.

- 2) The leader must pay attention to the basic and non-basic physiological needs of the employee. This is to ensure that the employee's work motivation and employee performance in carrying out their duties are not disturbed.
- 3) Employees must be able to manage their time well so that their time can be used massively,
- 4) Agency leaders should be fair and prudent so that employee performance improves and employees should be able to commit to work.
- 5) For subsequent researchers, it is necessary to add other variables that affect employee performance.

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## **INFLUENCE OF ORGANIZATIONAL CULTURE AND COMPENSATION ON JOB SATISFACTION WITH ORGANIZATIONAL COMMITMENT AS INTERVENING VARIABLE AT PT. SOSRO MEDAN**

***Abstract:** Human resources (HR) are factors that play an important role in the activities of a company. In the business world, for example in the corporate business world, human resources, namely employees, are the main business drivers. Employees in a company will give the best for the company where they work. On the other hand, employees are looking for job satisfaction. Therefore, job satisfaction is a research topic that is always interesting to study because of its complex nature and produces various findings around the world. Job satisfaction is a positive attitude shown by the workforce towards their work, which arises based on an assessment of the work situation.*

***Keywords:** HR, organizational, culture, compensation, job*

### **1. Introduction**

According to Mangkunegara (2013), job satisfaction is a feeling of support or not support from employees related to their work and their condition. Meanwhile, according to Siagian (2013) said that job satisfaction is a person's perspective both positive and negative about his work. PT. SinarSosro Medan Indonesia, founded in 1974, is a packaged flavored beverage company that runs its business in producing several types of soft drinks, both fizzy and non-soda. PT. SinarSosro Medan produces its products which are distributed throughout Indonesia, some even abroad. This company employs many employees to support the work, especially the success of the company's mission of success. PT. SinarSosro Medan strives to create high value products that are expected to last and be liked by consumers.

As a large company in charge of producing and being responsible for the company's

products, it strives to provide the best both in terms of product quality, safe distribution and affordable prices, this commitment has been started since the company was founded in 1974. Various trainings, studies have been given to each employee to provide learning related to the company's work system, all of which are intended so that the company's products and work are completed so that satisfaction will be achieved. The satisfaction achieved is not only talking about customer satisfaction but also the satisfaction of employees who are employed.

As a product provider company, PT. SinarSosro Medan has been committed to ensuring that clients can focus more on carrying out their main business activities and achieving business efficiencies even before we start our services. This commitment began in 1974 and has become a corporate culture that focuses on client needs, and human resource development through basic learning, training, transformational education systems

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for our staff. In addition, employees must be serious in focusing their actions on their satisfaction. In relation to the importance of service satisfaction at PT SinarSosro Medan, employee job satisfaction also needs to be considered by the organization because an organization will run smoothly if all services contributed by individuals to the organization receive balanced attention and rewards.

However, PT. SinarSosro Medan experienced several problems, namely the low level of employee attendance and high employee turnover rates. These problems are caused by authoritarian leadership style actors, top-down leadership decision-making, a work environment that often causes discomfort and poor communication patterns. So that employees can work with high morale, discipline, morale, and dedication with high commitment, there are many things that need to be considered, one of which is the need to cultivate a good organizational culture. In relation to the importance of service satisfaction, employee job satisfaction also needs to be considered by the organization because an organization will run smoothly if all services contributed by individuals to the organization get balanced attention and rewards.

Organizations in getting qualified employees must leave the policy of management practices that are intrinsic and functional, shift to new practices in the field of management that are more innovative, and adaptive in responding to a rapidly changing environment. Efforts to achieve the goals and survival of the company depend on the level of job satisfaction that affects the quality of work of the employees in it, increasing employee job satisfaction is the most serious management challenge so that the company's vision and mission can be realized.

A strong and rooted organizational culture will be able to make a significant contribution to organizational members in terms of a clear and straightforward understanding of a problem being resolved. Culture has a

significant influence on the attitudes and behavior of organizational members. There is a lot of evidence that illustrates that the success of an organization is due to its strong culture which makes the organization more confident and ultimately more effective.

In an era of globalization that is full of changes, changes which are often so fast and very difficult to predict but have a huge impact on the future of the organization, the presence of a flexible organizational culture is becoming increasingly relevant. The strategy in anticipating changes that will be carried out by an organization also needs to consider aspects of the culture that has existed so far, whether the designed strategy is in accordance with the existing values, or if the existing values are actually counter-productive for the organization in its journey.

## **2. Literature Review**

According to Robbins (2011) that organizational culture refers to a system of shared meanings held by members that distinguishes the organization from other organizations. This system of shared meaning, when examined more closely, is a set of key characteristics valued by the organization. According to Armstrong (2009) Organizational culture can be described as values, norms and artifacts accepted by members of the organization as an organizational climate that will influence and be influenced by organizational strategy, structure and organizational systems.

According to Slocum and Hellriegel (2011), Organizational Culture is values, represents, collective beliefs, assumptions and feelings about what things are good, normal, rational and valuable. Cultural value can be quite different from organization to organization. In some cultures, employees may care deeply money, but in others they may care about technological innovation or employee wellbeing. These values tend to persist over time, even when organizational membership

change. (Organizational culture is a value, symbolizing a collection of people with beliefs, assumptions and feelings about things that are good, normal, rational and valuable, cultural values can differ between other organizations. In the same culture employees are still trapped in financial needs, in other cultures some employees trying to innovate technological advances for a prosperous life. And the value of the strength of the organization can succeed, even though the members are always changing).

This is in line with Umam (2010) explaining that organizational culture is a value system that is believed and can be learned, applied and developed continuously. Organizational culture also functions as an adhesive, unifier, identity, image, brand, motivator, development that is different from other organizations that can be learned and passed on to the next generation, and can be used as a reference for human behavior in an organization that is oriented towards achieving goals. or the results/targets set. Robbins and Judge in Hanggraeni (2011) define organizational culture as a system of shared meanings held by members that distinguishes an organization from other organizations. Organizational culture is a pattern of organizational beliefs and values that are understood, inspired and practiced by the organization so that in the end the pattern gives its own meaning and becomes the basis for the rules of behavior in the organization. Culture performs a number of functions within the organization. First, culture has the role of setting boundaries; that is, culture creates a difference between one organization and another. Second, culture provides a sense of identity to organizational members. Third, culture facilitates commitment to something broader than one's self-interest. Fourth, the culture increases the stability of the social system. Culture is the social glue that helps hold the organization together by providing

precise standards of what employees should say and do. Finally, culture functions as a meaning-making and controlling mechanism that guides and shapes the attitudes and behavior of employees.

### 3. Research Method

This study uses the quantitative method. The population in this study are employees who work at PT. SinarSosro Medan, totaling 86 people. The data used in this study are data obtained from questionnaires and interviews with employees related to the variables studied. The variables studied for analysis are Organizational Culture (X1), Compensation (X2), Job Satisfaction (Y) and Organizational Commitment (Z).

### 4. Results & Discussions

#### Descriptive Analysis

##### 1. Characteristics of Respondents

The instrument used in this research is a list of statements (questionnaire). The total number of statements is 80 statements, namely 20 (Twenty) statements for the Organizational Culture variable (X1), 20 (Twenty) statements for the Competence variable (X2), and 20 statements for the Teacher Job Satisfaction Variable (Y) and 20 items for work commitment

Descriptive analysis in this study was obtained from distributing questionnaires to 86 employees at PT. SinarSosro Medan. The questionnaire contains a description of the respondents and answers to the statements given. Characteristics of respondents in this study were based on gender, age, education and years of service.

##### a) Characteristics of Respondents by Gender

**Table 1** Description of employees by gender

No.	Gender	Number of Employees	Percent (%)
1.	Male	27	31.39
2.	Female	59	68.60
	Amount	86	100

Source: 2021 Research Questionnaire

Based on table 1 above, that male employees are fewer in number than female employees who are used as research samples, this can be seen from the respective percentages, namely

men as much as 31.39% and women 68.60%.

b) Characteristics of Respondents Based on Age

**Table 2.** Employee description by age

No.	Age (Years)	Number of employees	Percent (%)
1.	26 s/d 30	3	3.49
2.	31 s/d 35	4	4.65
3.	36 s/d 40	47	54.65
4.	41 s/d 45	17	19.77
5.	> 45 years	15	17.44
	Amount	86	100

Source: Processed Questionnaire 2021

Based on table 2 above, that the employees of PT. SinarSosro Medan consists of 5 age classes, where the age group of 36 to 40 years is more than the other age groups, namely 46

people (54.65%).

c) Characteristics of Respondents Based on Education

**Table 3.** Employee Description by education

No.	Education	Number of Employees	Percent (%)
1	SMA/SMK	26	30.23
2	Diploma	4	4.65
3	S1	56	65.11
4	S2	-	-
	Amount	86	100

Source: Processed Questionnaire 2020

Based on table 3 above, it shows that more IS educated employees are compared to others. In a row, there were 4 diploma employees (4.65%), 26 employees with high school education (30.23%), and 56 graduates (65.11%).

of measuring what is to be measured) and the accuracy of a measuring instrument in carrying out its measuring function, which can provide an overview of the smallest differences between one subject and another. The validity test in the research conducted with the help of the SPSS 22 application. The following data is presented on the results of the validity test.

C. Validity and Reliability Test

1. Validity test

Validity comes from the word validity which means the extent to which accuracy (capable

**Tabel 4.** Questionnaire Validity Test Results

Variable	Item	R <sub>hit</sub>	R <sub>tabel</sub>	Description
Organizational Culture(X1)	Item 1	0,482	0.2120	Valid
	Item 2	0,454		Valid
	Item 3	0,304		Valid
	Item 4	0,338		Valid
	Item 5	0,521		Valid
	Item 6	0,442		Valid
	Item 7	0,388		Valid
	Item 8	0,431		Valid
	Item 9	0,439		Valid
	Item 10	0,358		Valid
	Item 11	0,253		Valid
	Item 12	0,256		Valid
	Item 13	0,301		Valid
	Item 14	0,414		Valid
	Item 15	0,524		Valid
	Item 16	0,400		Valid
	Item 17	0,300		Valid
	Item 18	0,342		Valid
	Item 19	0,241		Valid
	Item 20	0,272		Valid
Competence ( X2)	Item 1	0,644	0.2120	Valid
	Item 2	0,480		Valid
	Item 3	0,508		Valid
	Item 4	0,511		Valid
	Item 5	0,468		Valid
	Item 6	0,665		Valid
	Item 7	0,554		Valid
	Item 8	0,572		Valid
	Item 9	0,448		Valid
	Item 10	0,640		Valid
	Item 11	0,586		Valid
	Item 12	0,521		Valid
	Item 13	0,455		Valid
	Item 14	0,418		Valid
	Item 15	0,432		Valid
	Item 16	0,422		Valid
	Item 17	0,356		Valid
	Item 18	0,331		Valid
	Item 19	0,296		Valid
	Item 20	0,304		Valid
Job satisfaction (Y)	Item 1	0,674	0.2120	Valid
	Item 2	0,746		Valid
	Item 3	0,740		Valid
	Item 4	0,718		Valid
	Item 5	0,611		Valid
	Item 6	0,551		Valid
	Item 7	0,656		Valid
	Item 8	0,492		Valid
	Item 9	0,569		Valid

	Item 10	0,522		Valid
	Item 11	0,233		Valid
	Item 12	0,379		Valid
	Item 13	0,201		Valid
	Item 14	0,331		Valid
	Item 15	0,418		Valid
	Item 16	0,400		Valid
	Item 17	0,389		Valid
	Item 18	0,315		Valid
	Item 19	0,295		Valid
Item 20	0,247	Valid		
Commitment	Item 1	0,654	0.2120	Valid
	Item 2	0,453		Valid
	Item 3	0,549		Valid
	Item 4	0,538		Valid
	Item 5	0,450		Valid
	Item 6	0,689		Valid
	Item 7	0,433		Valid
	Item 8	0,515		Valid
	Item 9	0,439		Valid
	Item 10	0,654		Valid
	Item 11	0,564		Valid
	Item 12	0,625		Valid
	Item 13	0,596		Valid
	Item 14	0,442		Valid
	Item 15	0,414		Valid
	Item 16	0,528		Valid
	Item 17	0,341		Valid
	Item 18	0,334		Valid
	Item 19	0,490		Valid
	Item 20	0,477		Valid

Source: Acquisition of research questionnaire data, 2021

From the statements filled in by the respondents with their respective responses, it was obtained that they were declared valid or suitable for use at the 5% (0.05) level.

### T-Test

The t-test was conducted to partially test whether the variables of Organizational

Culture (X1) and Competence (X2) partially or each had a significant effect on employee satisfaction at PT. SinarSosro Medan.

The test criteria are:

H0 : b1, b2 = 0, meaning that the variables of Organizational Culture and Competence partially have no positive and significant effect on the variable of employee satisfaction at PT. SinarSosro Medan.

**Table 5.** Partial Test Results (t-test)

Coefficients <sup>a</sup>											
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics		
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF	
1	(Constant)	37,179	12,666		<b>2,935</b>	<b>,004</b>					
	Organization	,277	,147	,200	<b>2,889</b>	<b>,042</b>	,333	,203	,184	,849	1,178
	Competence	,341	,105	,343	<b>3,239</b>	<b>,002</b>	,421	,335	,316	,849	1,178

a. Dependent Variable: Job Satisfaction

Based on the test results in Table 5, it can be seen that the tcount value of the Organizational Culture variable is greater than the ttable value ( $2.889 > 1.98896$ ) with a significant level below 0.05, namely 0.042. the tcount value of the Competence variable is greater than the ttable value ( $3.239 > 1.98896$ ) with a significant level below 0.05, namely 0.002. Based on the decision making of the partial test in the regression analysis, it can be concluded as follows:

- 1) The organizational culture variable partially has a significant effect on employee satisfaction at PT. SinarSosro Medan.
- 2) Competence variable partially has a significant effect on employee satisfaction at PT. SinarSosro Medan.

**Simultaneous Significant Test (F-Test)**

This test is carried out to see whether all the

independent variables included in the model have a joint effect on the dependent variable. The test criteria are as follows:

$H_0$  :  $b_1, b_2 = 0$ , meaning that together there is no positive influence

and significant from the independent variable to the dependent variable.

$H_0$  :  $b_1, b_2 \neq 0$ , meaning that together there is a positive and significant effect of the independent variable on the dependent variable. The value of Fcount will be compared with Ftable.

The decision-making criteria are:

$H_0$  is accepted if  $F_{count} < F_{table}$  at  $\alpha = 5\%$  with 95% confidence level.

$H_1$  is accepted if  $F_{count} > F_{table}$  at  $\alpha = 5\%$  with 95% confidence level.

The value of ttable for  $\alpha = 5\%$  (0.05) and (3:83) = 1.98896.

**Table 6.** F-Test

ANOVA <sup>a</sup>						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	519,916	2	259,958	11,092	,000 <sup>b</sup>
	Residual	1945,294	83	23,437		
	Total	2465,209	85			

a. Dependent Variable: Job Satisfaction  
b. Predictors: (Constant), Organizational Culture, Competence

Based on Table 6, it can be seen that the results of the F-test simultaneously, then obtained the value of  $F_{count} = 11.092$  with a significance level of 0.000. While  $F_{table} = 3.11$ .  $F_{count} > F_{table}$  ( $11.092 > 3.11$ ) and significant level ( $0.000 < 0.05$ ). So it can be

concluded that the variables of Organizational Culture and Competence together have a positive and significant effect on the variable of employee satisfaction at PT. SinarSosro Medan.

Coefficient of Determination Test ( $R^2$ )

The coefficient of determination ranges from 0 to 1 (0 R2 1). If R2 is getting closer to number 1, it can be said that the variables of Organizational Culture and Competence have a big effect on employee satisfaction at PT.

SinarSosro Medan. This means that the model used is getting stronger to explain the influence of the independent variable on the dependent variable and vice versa.

**Table 7.** Data Determination Test Results

Model Summary <sup>b</sup>									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	,459 <sup>a</sup>	,211	,192	4,841	,211	11,092	2	83	,000
a. Predictors: (Constant), Organizational Culture, Competence									
b. Dependent Variable: Job Satisfaction									

1. R Square of 0.211 means 21.1%, meaning that the relationship between Organizational Culture and Competence on the variable of employee satisfaction at PT. SinarSosro Medan amounted to 21.1% which has a fairly close relationship.

2. Standard Error of Estimated means measuring the variation of the predicted value. In this study the standard deviation of 4.841 where the smaller the standard deviation means the better the model.

3. R of 0.459 or 45.9% indicates a relationship between Organizational Culture and Competence on the variable of employee satisfaction at PT. SinarSosro Medan and the

remaining 54.1% are explained by other factors not examined in this study.

**5. Conclusion**

Therefore, that the relationship between Organizational Culture and Competence on the variable of employee satisfaction at PT. SinarSosro Medan amounted to 21.1% which has a fairly close relationship and a relationship between Organizational Culture and Competence on the variable of employee satisfaction at PT. SinarSosro Medan and the remaining 54.1% are explained by other factors not examined in this study.

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## **THE INFLUENCE OF ORGANIZATIONAL CULTURE ON EMPLOYEE PERFORMANCE MEDIATED BY JOB SATISFACTION AND ORGANIZATIONAL COMMITMENT**

***Abstract:** The purpose of this research is to explain the role of job satisfaction and organizational commitment in reducing the impact of organizational culture on employee performance. As many as 125 people who work at startup companies in Yogyakarta are included in the sample population of this study. The analytical tools used include path analysis with the Structural Equation Modeling (SEM) approach implemented in SmartPLS 3. The results show that organizational culture has a beneficial and substantial influence on happiness. Organizational culture has a significant and positive effect on employee productivity, as well as a positive influence on organizational commitment. Then, both job satisfaction and organizational commitment have a positive and significant effect on worker productivity. Employee job satisfaction may somewhat weaken the impact of organizational culture on worker productivity, and vice versa for employee organizational commitment and dedication. As a result, it is very important for business leaders to pay attention to, and cultivate, employee job satisfaction and organizational commitment so that corporate culture can increase worker productivity.*

***Keywords:** Organizational Culture, Job Satisfaction, Organizational Commitment, Employee Performance*

### **1. Introduction**

Organizational culture is a set of shared beliefs and practices that serve as a daily reference point for top management, guiding decision-making among employees and directing their actions towards achieving company goals (Antonakis & House, 2013). It is possible to judge an organization's culture as successful if it has an effect on a high-energy state. Organizational values that are actively practiced are more likely to influence employee productivity (Antonakis & House, 2013).

The low level of worker productivity also affects job satisfaction. If an employee or worker is not happy with the job they are doing or the responsibility assigned to them, that happiness is not hard to see. Compensation elements, whether in the form of salaries, commissions, or bonuses, are often associated with job satisfaction. Several researchers (Bakker and Demerouti, 2017) have found this.

Strong employee dedication to the company is a major factor in shaping the character and behavior of employees while working there. The organization's dedication points employees in the right direction so they can

start their jobs and see immediate results. Employees who have a strong sense of loyalty to their company are more likely to show up to work each day with a positive attitude, provide quality hours, and leave the company on good terms. Possible actions to increase worker productivity through employee commitment include retaining high-potential workers in each department (Kim et al., 2019).

Individual productivity is measured by the results they produce in accordance with the standards that apply to their field of work. The term "productivity" refers to the measurable results of an organization's efforts over a period of time. Effort can be defined as the result that a person obtains according to the applicable measures for sustained effort at one's workplace (Yong et al., 2019; Paillé et al., 2014)

By definition, organizational culture includes the values, beliefs, attitudes, and practices that drive the day-to-day operations of the organization (Miska et al., 2018). Because culture has such a strong effect on employee productivity, understanding it can help business owners and managers make good decisions for the company as a whole, not just when it comes to following rules and procedures. Employees' belief in upholding organizational culture has a multiplicative effect on efficiency in carrying out their duties (Arayesh et al., 2017).

Employee satisfaction at work can be defined as an emotional state that results from a positive view of one's responsibilities and the rewards one receives from completing those responsibilities. Another school of thought argues that job satisfaction is the outpouring of employees' feelings about their work, so that it has an impact on the direction of organizational development (Khavayet et al., 2018). The term "job satisfaction" refers to employees' emotional reactions to their working conditions. Feelings of liking or disliking the tasks and responsibilities assigned to someone can have a significant

impact on job satisfaction. This can be seen from the employees' proactive approach to their responsibilities and the workplace environment (El-Jardali et al., 2009).

Organizational dedication is a factor that can affect performance. The level of employee dedication to the company affects how hard they work to help the company achieve its goals (Yan et al., 2019). Organizational loyalty, or "commitment," is a state of mind in which a worker identifies with the goals and values of the company he or she works for (Sukanebari et al., 2020).

Worker productivity is the result of intentional management of activities that have an impact on organizational productivity. (Chatterjee et al., 2020). In general, employee productivity is a measure of the success an organization or business has achieved through its operations. Work results that can be achieved by individuals or groups within a company in accordance with their authority and responsibility in order to achieve organizational goals in a lawful way, do not violate the law, and do not conflict with morals and ethics (Karim et al., 2007). Employee satisfaction is a subjective state of mind about one's work that depends on various factors, including the nature of the work itself, the quality of colleagues, the amount of salary received, and other material and psychological considerations (Chatterjee et al., 2020).

The business world is increasingly competitive, especially for companies that focus on the digital realm, such as startups. Startup businesses in Indonesia are growing at an astounding pace every day. Due to increased accessibility, the number of active internet users in Indonesia continues to grow. This is evidenced by survey data from Penyedia Jasa Internet Indonesia (APJII) regarding Indonesia's Internet penetration in 2022, which states that the number of internet users between 2021 and 2022 is 210.026.769 out of a total population of 272.682.600 Indonesians with an increase of 77.02 %. The

dominant behavior of Indonesian users is using mobile/tablet devices that are connected to their internet (APJII, 2020). Digitalization is seen as a powerful intervention into business matters associated with modernization efforts throughout the organization that affect all structures, systems and processes within a company. Not only that, digitalization is also defined as sustainability to meet current and future needs (Nikmehr et al., 2021). This presents a great opportunity for startup CEOs to expand their business. Startup founders no doubt want to make their services as accessible as possible to all internet users, whether that means simplifying the purchase and delivery of services or products. The widespread availability of smartphones running the Google Android or Apple iOS operating systems has the potential to increase people's internet usage. Therefore, companies on a global and national scale are more interested in expanding their operational network. One of the businesses he is interested in is a startup in Yogyakarta.

Based on in-depth interviews with several employees at a startup company in Yogyakarta, we heard that low levels of emotional connection between co-workers who prefer to work alone over those who prefer to work together and the issue of fair compensation are contributing factors to the labor shortage. From job satisfaction. Employees with minimum UMP size requirements in their province are expected to provide substandard results. Users, whether that means simplifying the purchase and delivery of services or products.

In addition, some workers have expressed concern about organizational commitment, citing problems such as absenteeism caused by the use of sick leave and the fact that overtime pay is only provided three times a month as examples of problems they have experienced. have with the organization. If it occurs three times, we'll assume that the fourth delay did not occur. This is considered

to have a negative impact on employee productivity.

Several workers have pointed out that the phenomenon related to organizational culture is related to managers not paying enough attention to their employees, and this is something that has also been highlighted by other employees. It is important to pay attention to the obligations and responsibilities of employees to ensure that they feel valued. This can be achieved in a number of ways, including keeping lines of communication open with colleagues, for example. Workers need their boss to give them inspiration and motivation to get back their joy for their work and to increase their production rate.

There are a number of important factors that contribute to job satisfaction, the first is having a job that allows you to use your skills and receive feedback on how well you are doing, and the second is how comfortable you and your co-workers are. Being in your workplace, both personally and professionally, and the third is how easy it is to do your job. The first factor is having a job that allows you to use your skills and receive feedback on how well you are doing. (Robbins, 2018).

*H1: Organizational culture has a positive effect on job satisfaction.*

The extent to which an organization is able to increase the productivity of its workforce is directly proportional to its level of success in achieving the goals it has set for itself. When it comes to determining whether an organization's culture is effective or not, one can see whether it has an influence on a high-energy state or not. Religious observance at work may be beneficial because it has been shown to increase productivity at work (Riyantini, 2021).

*H2: Organizational culture has a positive effect on employee performance.*

The organization's management structure is greatly influenced by its organizational culture, which consists of values and concepts

shared by all members of the company. The dominant culture of an organization is closely related to the level of commitment shown by its employees towards the company. A set of guiding ideas or assumptions that employees adhere to when carrying out their responsibilities towards this company is what is referred to as organizational culture. (Ramezan, 2016).

*H3: Organizational culture has a positive effect on organizational commitment.*

Worker satisfaction, or job satisfaction, is the result of the relationship created between the worker and his environment, whether the setting is conducive to happiness and productivity or not. Satisfaction in one's work life conveys a sense of fulfillment to one's superiors. High levels of worker satisfaction have a positive effect on productivity, helping organizations move closer to their goals. (Citrawati, 2021).

*H4: Job satisfaction has a positive effect on employee performance.*

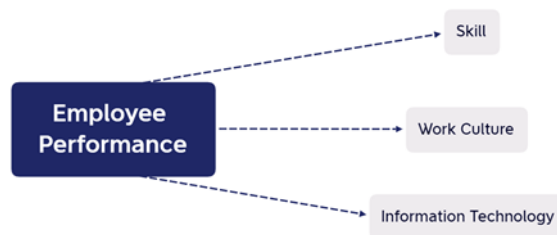
Employees with organizational commitment will show respect for the company, pay attention to its goals, experience emotional identification with its mission, and work to overcome personal obstacles, all of which will have a positive impact on productivity. (Sitio, 2021).  
*H5: Komitmen organisasi berpengaruh positif terhadap kinerja karyawan.*

*H5: Job satisfaction mediates the positive influence of organizational culture on employee performance.*

*H6: Organizational commitment mediates the positive influence of organizational culture on employee performance.*

Utilizing technology-based facilities and infrastructure (hardware, software, useware) to collect, store, back up, transmit data using the internet is very necessary. Technology can be used to implement a work culture by implementing a flexible work arrangement, where employees can work anywhere and anytime, so that employees can manage the flexibility of how they work but remain productive (Fatonah et al., 2022).

Fatonah et al. (2022) collects data to determine the strength of a variable using qualitative analysis, and the priority is knowing the conditions and entities between variables to understand a phenomenon by connecting between variables and determining the degree of relationship between these variables. There are 4 variables, namely: the variable Work Culture (X1), Competence (X2), and Information Technology (X3) as independent data, and Employee Performance variable (Y) as the dependent data obtained through interviews, questionnaires, observation, and reference studies (according to figure 1).



**Figure 1.** Employee Performance Conceptual Scheme

Fatonah et al. (2022) explained that it is necessary to test the validity by measuring the

effectiveness of a questionnaire. Testing the reliability to measure a questionnaire which is

an indicator of a variable. Conduct a normality test to determine the distribution of data in the data group, multicollinearity test to detect how far the relationship and influence between variables with independent data. Conduct a heteroscedasticity test to determine the variance of the variance of the residual one observation with another observation using the correlation model. Then analyze multiple linear regression to find out how big the independent variables are Work Culture (X1), Competence (X2), and Information Technology (X3), and Employee Performance variables (Y). Do a partial test, proving whether there is a relationship between the variables Work Culture (X1), Competence (X2), and Information Technology (X3) on the Employee Performance variable (Y) to show how much influence each of these independent variables has in explaining variations in the independent variables. Finally, test the Coefficient of Determination to measure how well the model explains the variation in the dependent variable.

## 2. Literature review

### 2.1. Job Satisfaction

"Job Satisfaction" is the attitude of workers towards work related to the work environment, co-worker relationships, rewards for services received at work, and other elements both physical and psychological, as stated by Teck-Hong & Waheed (2011). According to Zendejdel (2013), the goal of everyone employed is to get satisfaction from their place of work. The level of satisfaction experienced by workers in their jobs is anticipated to have a significant influence on their level of output by their managers. Managers need to be aware of the procedures to be followed to generate job satisfaction in their employees. Any conversation about satisfaction at work, also known as "Job Satisfaction", that takes

place within an organization will likely involve efforts to improve the attitudes and behavior of employees as they work to increase productivity. In addition to the use of modern equipment which is a direct consequence of technological advances, personnel performance is another component that must be considered to ensure business success in achieving its goals in industry 4.0 (Fadilurrahman et al., 2021). Employees who are dissatisfied with their jobs contribute to an environment that is detrimental to everyone involved, at both a professional and personal level. Dissatisfaction with one's job can result in hostile behavior or, conversely, reflect a desire to withdraw from the social environment and isolate oneself. Both of these results are possible. For example, adopting a withdrawal mentality from the workplace, supporting disruptive behavior such as boIo, and taking other actions intended to avoid disrupting the operations being carried out by the business are all possible ways of doing this.

Aggressive types of behavior such as sabotage, intentionally creating wrongdoing at work, obstructing authority, and even engaging in strike activities are examples of this type of behavior. According to the research shown earlier, worker satisfaction is an important factor to think about in relation to worker productivity, whereas worker dissatisfaction is often associated with high workload and stress. Employees who report high levels of dissatisfaction with their jobs are more likely to participate in acts of misconduct at work such as sabotage or other types of misconduct.

According to Bloisi et al (2007) indicators of salary or wages, namely:

- Pay Rate.
- Payment Structure.
- Determination of Individual Pay
- Payment Methods
- Payment Controls

According to Indradevi's research findings (2012), intrinsic motivation influences job

satisfaction and performance, job satisfaction affects productivity, and organizational culture influences all three. Contributing in a way that will enhance the impact of corporate culture on the levels of job satisfaction and productivity experienced by employees. According to the results of Remi et al (2011), organizational culture, intrinsic motivation, and organizational commitment all have a direct influence on employee productivity. Employee productivity is not positively affected by corporate culture; however, motivation at work, job happiness, and leadership all have a beneficial effect on employee productivity according to findings (Worlu & Chidozie, 2012).

**2.2. Organizational Commitment**

According to Meyer & Parfyonova (2010), employee organizational commitment can be seen as a measure of their readiness to continue working at the same company in the future. Employees' belief in the company's vision and goals, their readiness to strive to complete tasks, and their desire to continue working there are all strengthened by employees' repeated commitment to the organization. Organizational commitment, as defined by Cohen (2007), is a factor that determines how a person identifies with an organization and becomes loyal to the goals of the organization. It can be concluded that employee commitment is shown when workers are willing to place the needs of the organization above their own and make a

**Table 1.** Description of Respondents' Characteristics (Source: Data processed with SmartPLS 3.0 by Researchers, 2023)

<b>Gender</b>	<b>Amount</b>	<b>Percentage (%)</b>
Female	44	35
Male	81	65
<b>Amount</b>	<b>125</b>	<b>100</b>
<b>Age</b>	<b>Amount</b>	<b>Percentage (%)</b>
18-20	35	28
21-30	48	39
31-40	23	18
41-50	10	8
>50	9	7
<b>Amount</b>	<b>125</b>	<b>100</b>

substantial contribution to achieving the company's goals that have been set. This conclusion is based on the opinion of a number of experts.

**3. Research methods**

This research is an example of the type of research known as explanatory study. Since all 125 workers in the Yogyakarta-based Startup Company business incubator were eligible for sampling, there was no need to choose too small a sample size. Interviews, questionnaires, and field visits are several approaches that can be used in the data collection process. This research seeks to answer the question, "How does organizational culture influence job happiness, worker productivity, loyalty to the company, and other factors?" by checking this and related questions. To determine the validity and reliability of the findings, further analysis of the questionnaire data will be carried out with the help of SmartPIS 3. It is determined that each question in the survey is valid and reliable after the correlation coefficient value is at least 0.30 and Cronbach's Alfa value is at least 0.60.

**4. Results and discussion**

To get an overview of the profile of the respondent (employee), the following is a description of the employee's characteristics.



Education	Amount	Percentage (%)
Senior High School	78	62
Diploma	18	14
Bachelor	29	24
<b>Amount</b>	<b>125</b>	<b>100</b>

The loading of indicators must be greater than 0.5, the Composite Reliability (CR) must be greater than 0.8, and the Average Variance

Extracted (AVE) for each building must be greater than 0.5 so that the research comes to the conclusion that the construction is valid. Table 2.

**Table 2.** Model Size Results (Source: Data processed with SmartPLS 3.0 by Researchers, 2023)

Construct	Indicator	Outer Loading	Composite Reliability	AVE
Job satisfaction	KK1	0.817	0.882	0.592
	KK2	0.836		
	KK3	0.812		
Organizational Commitment	KO1	0.732	0.857	0.675
	KO2	0.774		
	KO3	0.859		
Organizational culture	BO1	0.793	0.912	0.614
	BO2	0.759		
	BO3	0.847		
	BO4	0.746		
	BO5	0.719		
Employee performance	KNK1	0.725	0.838	0.634
	KNK2	0.785		
	KNK3	0.824		
	KNK4	0.785		
	KNK5	0.839		
	KNK6	0.716		

Based on Table 2, it is recommended to use the outer loading indicator with a value between 0.71 and 0.85. Composite Reliability (CR) values varied from 0.838% to 0.912%, and all were greater than 0.80, which indicated that the research model was reliable. CR values range from 0.838% to 0.912%. The AVE values found were all

more than 0.5 and ranged from 0.592 to 0.675; This shows that the data collected has good quality overall. When evaluating the discriminant validity of a model, it is necessary to check whether the value derived from the standard deviation of a stable variable is greater than the average.

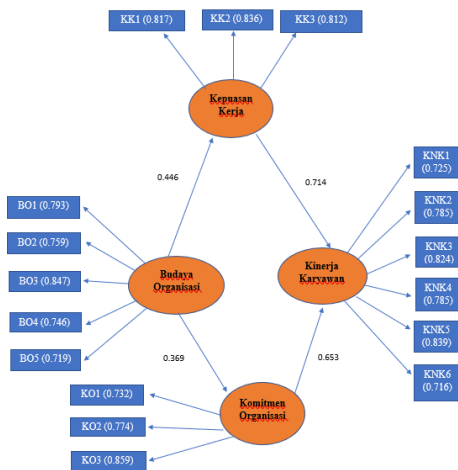
**Table 3.** Correlation between Latent Variables (Source: Data processed with SmartPLS 3.0 by Researchers, 2023)

Construct	Job satisfaction	Organizational Commitment	Organizational culture	Employee Performance
Job satisfaction	1.000	0.683	0.446	0.714
Organizational Commitment	0.683	1.000	0.369	0.653
Organizational culture	0.446	0.369	1.000	0.564
Employee performance	0.714	0.653	0.564	1.000

**Table 4.** Root Value of Average Variance Extracted (AVE) (Source: Data processed with SmartPLS 3.0 by Researchers, 2023)

Konstruk	Average Variance Extracte (AVE)	$\sqrt{AVE}$
Job satisfaction	0.597	0.774
Organizational Commitment	0.672	0.816
Organizational culture	0.604	0.774
Employee performance	0.628	0.786

If the value (AVE) is more than 0.5, then the test can be considered to have a high level of discriminant validity. The average value in Table 5 is more than 0.5, which indicates that the methodology used in this study is appropriate. The figure presents the results of tests carried out in the internal mode.



**Figure 2.** Structural Mode

The structural model was analyzed using R-

**Table 6.** Path Coefficient (Source: Data processed with SmartPLS 3.0 by Researchers, 2023)

Correlation Between Variables	Path Coefficient	T Statistic	P values	Information
Organizational Culture on Job Satisfaction	0.446	6.187	0.000	Accepted
Organizational Culture on Employee Performance	0.282	4.468	0.000	Accepted
Organizational Culture Against Commitment	0.369	5.124	0.000	Accepted
Job Satisfaction on Employee Performance	0.393	6.417	0.000	Accepted
Organizational Commitment to Employee Performance	0.286	4.364	0.000	Accepted

The effect of organizational culture on worker productivity is statistically significant (p

square for the dependent construct, t test and the significance of the coefficients.

**Table 5.** Results of the Coefficient of Determination Test (Source: Data processed with SmartPLS 3.0 by Researchers, 2023)

Construct	R <sup>2</sup>
Job satisfaction	0.216
Employee performance	0.623
Organizational Commitment	0.137

In table 5 it can be seen that the R square value of employee performance is the largest with a value of 0.623 and the smallest on the organizational commitment variable of 0.137. The principle used to test the hypothesis refers to the value shown in the output path coefficient shown in Table 6.

From Table 6 it can be concluded that organizational culture has a significant effect on job satisfaction (p < 0.05). These findings indicate that organizational culture has a positive effect on employee job satisfaction. This finding is consistent with the findings of Silverthorne, (2004), MacIntosh & Doherty, (2007), and Egan et al., (2004), who found that a set of organizational values has a positive effect on job satisfaction.

0.05). This result shows that organizational culture influences worker productivity. This

finding is consistent with the research of Johnson et al., (2016), Łukasik, (2018) and Kucharska & Bedford, (2020), who found that a set of organizational values has a positive effect on a measure of employee productivity.

The value of organizational culture on organizational commitment is 0.000 0.05. These findings indicate that organizational culture influences employee dedication to the company. This finding is in line with the findings of Asi et al. (2021) and Ependi et al. (2021), who found that organizational culture has a positive effect on the level of commitment.

Employee satisfaction with performance has a p-value of 0.000 > 0.05. The findings show that job satisfaction has a positive effect on worker productivity. This finding is consistent with the findings by Ravid et al., (2019), Backhaus, (2019), and Yost et al., (2018) who found that job satisfaction has a significant effect on worker productivity.

Organizational commitment to employee performance has a p-value of 0.000 0.05. These findings indicate that organizational

commitment has a positive effect on worker productivity. This finding is consistent with studies by Winston (2008) and Tolentino (2013), all of whom found that organizational commitment has a positive effect on worker productivity.

Table 8 shows the results of the mediation analysis of the relationship between organizational culture and worker productivity; The t-statistic is greater than the t-table value (4.237 > 1.96), indicating that job satisfaction moderates the positive influence of organizational culture on worker productivity. The mediation function that has the strongest correlation with job satisfaction is the partial mediation function.

As shown by a statistically significant positive relationship (t-statistic > t-table, or 3.217 > 1.96) between organizational commitment and worker productivity, organizational culture has a positive effect on worker productivity. The function of the media supported by organizational commitment is mainly that of a partial mediator.

**Table 7.** Path Coefficient (Source: Data processed with SmartPLS 3.0 by Researchers, 2023)

Correlation Between Variables	Path Coefficient	T Statistic	P values	Information
Organizational Culture -> Jobs Satisfaction -> Employee Performance	0.174	4.243	0.000	Accepted
Organizational Culture Organizational Commitment -> Employee Performance	0.109	3.217	0.000	Accepted

## 5. Conclusion

According to research findings, organizational culture seems to have a positive effect on employee satisfaction variables, a positive effect on worker productivity, a positive effect on employee commitment, a positive effect on job satisfaction, and a positive effect on work commitment. In addition, job satisfaction

appears to have a positive effect on worker productivity. Emphasizing the role of job satisfaction and organizational loyalty as a form of "partial mediation" as a means of reducing the positive effects of organizational culture on employee performance can serve as a means of "partially mediating" those effects, which can mitigate those effects. organizational culture on performance both directly and indirectly.

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## A STUDY OF THE IMPRESSION OF REWARDS AND RECOGNITION ON EMPLOYEE JOB SATISFACTION: A CASE STUDY OF MYANMAR ZARLAYATHA DISTRIBUTION COMPANY

**Abstract:** Among all the resources an organization owns, human resources play the most critical role. To make a successful organization, management has to commit to continuously satisfying employees. Satisfied employees take risks, think creatively, and care about customers' satisfaction for achieving organizational goals. The study's primary goal was to look at how rewards and recognition affect job satisfaction among employees of Zalaryathar distribution Co., Ltd. The analysis of the research results was analysis on various theories from the ground of Human Resource Management. In order to determine the degree of employee job satisfaction, the study looked at the impact of extrinsic rewards like income, bonus, promotion, and commission. Additionally, the study looked at how intrinsic rewards like appreciation and recognition affect how satisfied employees are at their jobs. The study adopted a descriptive research survey. For this research study, a sample size of 250 employees has been selected, which represents 20% of the total population. The data for this study were collected primarily through close-ended questionnaires. In this study, Stratified random sampling has to be utilized for administering with and examining the groups within the population. In detail, disproportionate to using Stratified random sampling to pick the employees, top management, middle management, and first-line management because some startups are small. Theoretical and managerial implications, recommendations, and limitations for future research have to be further research references. In this study, data were running with SPSS (Statistical Package for Social Sciences) version 20 for data operation and study. Correlation analysis brings forward to explore the most significant factors which affect the employee's job satisfaction. The study examines those rewards and recognition had a positive correlation with employee job satisfaction of Zalaryathar distribution company. The study suggests that organizations can achieve their objectives and mission through employee job satisfaction with effective reward and recognition systems.

**Keywords:** Human Resources Management, Rewards, Recognition, Job satisfaction, Performance

## 1. Introduction

According to Pattersen, Warr, and West (2004), a happy employee is a productive employee, and harmonizing their satisfaction level and considering thoughtful topics also becomes apprehensive for organization performance and improvement purposes (Muna et al., 2017). A highly competitive business environment lets the organizations address the job satisfaction of employees. Due to the tough pandemic situation, employers have to exchange the way of treating the employees through which they believe that the more satisfied employees contribute their products and services during this rigid period (Ju et al., 2020). Good employers want their organization to create the best place for employees by letting them value proposals, building a good reputation as an employer by making sure promises to employees (Editor-in-chief et al., 2018). The compensation reward system is making employee satisfaction by getting benefits for the organization through employees who can contribute the best quality, high productivity, less attrition and in addition that can create the service orientation in addition free from violation (Martono et al., 2018). Myanmar Zarlayathar Distribution CoLtd was organized in March 2016 in Yangon, Myanmar. In the beginning, the initial business of this company was Mercury Light Distribution since November with just three trucks that could only operate in Yangon. After many years of hard work and flexibility, Myanmar Zarlayathar Distribution has become one of the nationwide distributions in the country. The company intends to offer customers a scale of operations, regional diversity, effective sales force, and leading multi-channel networks. The significant issues of employee satisfaction with higher performance need to enhance service quality, broader coverage and set the required skills. Overcompensated employees perform better, while undercompensated workers grow

disgruntled and respond by delivering subpar work (Armstrong 2003).

## 2. Objective

The aims of the study are:

- i. To determine the impact of extrinsic rewards on Myanmar Zarlayathar employees' job satisfaction
- ii. To evaluate how intrinsic rewards affect job satisfaction
- iii. To assess the degree of job satisfaction among Zarlayathar employees in Myanmar

## 3. Research Question

The following research topics served as the study's basis:

- i. How the influence the extrinsic rewards on employee job satisfaction of Myanmar Zarlayathar employees?
- ii. How do intrinsic rewards affect job satisfaction?
- iii. What is the job satisfaction level of Myanmar Zarlayathar employees?

## 4. Literature Review

Companies are trying to gain a competitive advantage by using different strategies for getting results of highly competitive pressure like shaping the correct application of skills and expertise to a satisfied employee with many benefits and rewards more intimate with their organization than other competitive organizations (Vijayakumar & Subha, 2013). The relation between rewards and recognition is significantly associated with employee engagement and standard commitment for the organization (Martono et al., 2018). A reward system turns positive results for the organization to employee retention and attractive wage schemes through having



enough impact on the organization (Wickramasinghe&Sajeevani, 2018). (Froese et al., 2019) recommended that systematic rewards create job satisfaction then eliminate attrition rate, because Human Resources Management needs to focus strategically on it for workforce retention purposes.

(Jamal Ali & Anwar, 2021) introduced that there should be teamwork of professionals spin in arranging good rewards and motivation factors of business importance. (Kim & Lee, 2018) showed that every employee should organize the route to measure the productivity of each employee through compensation for increments and rewards. The overall reward strategy is relevant to the entire employee proposal and is critical to the attractiveness and appeal of the organization (Bwowe&Marongwe, 2018). (Megia, 2016) suggested that polishing strategies combined into that culture of organization meantime managers should identify the needs of employees in building the reward systems. Organization commitment to job gives a sense of accomplishment on rewards and motivation have decided on the balancing of performance and its employee satisfaction (Jehanzeb et al., 2012) (Vijayakumar & Subha, 2013) (Ahmad et al., n.d.) and by enhancing the satisfaction to employees for organization need to handling the rewards tools properly. In addition, good rewards are much effective for the organization, and employees' similarly poor rewards systems are ineffective and do not improve employee performance (Park & Sturman, 2016). (Park & Sturman, 2016). Maintaining the long-term requirements of setting an organization goal of job satisfaction is a combination of a proper rewards system and adequate resources (Jr, 2016). (Milikić&Došenović, 2020) also showed that the intrinsic rewards attract job satisfaction among employees. The changeling of an organization is to motivate the employees' satisfaction through fairness and openness on rewards and recognition (Akafo& Boateng,

2015). Management accepted that reward and recognition are thoroughly linked to employee motivation (Zeb et al., 2009). The way of providing the rewards and recognition towards the best employee is a kind of appreciation through inspiring to the employees long-term retaining for the organization (Kountur&Prameswari, 2020).

#### 4.1. Extrinsic Reward

One of the most efficient ways of promoting influential rewards for employees is an extrinsic reward. (Mutembei, 2019) concluded that financial compensation is playing a vital role in job performance in government hospitals. Motivation may play a key role in current using the extrinsic incentives society and pointing the importance of targeting to beliefs on stakeholders (Murayama et al., 2016). Many findings explained that increasing the annual salary is one of the consideration factors for the professional employee getting the better performance for the organization.

(Ndijuye&Tandika, 2019) mentioned that the impact of employees getting poor attitude received from the source of low pay by the organization. (Location, Location, Location – It Even Boosts Satisfaction - IMPACT Group, n.d.) stated that even if the organization provided the incentives, recognition program, swag, and bonuses to the pursuit of employees' satisfy it remains a challenge for finding extrinsic balance and the balance of staff gift of happiness is according to the personality of the employee(Khan et al., 2017). (Lim et al., 2019) concluded that the differentiation of motivational approaches to individual and organizational harmony and personal harmony received well-deserved and extrinsic rewards for job satisfaction. In addition, extrinsic rewards mention that monetary and non-monetary benefits provided to the employee represent the motivation of employees through workplace

creativity (Malik et al., 2019). Behavioral recognition also distinguishes that extrinsics can vary depending on the three rewards of value, information, and regulatory (Malek et al., 2020). The extrinsic incentives were the main factors to the background of a community framework and service motivation to the employee for the organization (Kroll & Porumbescu, 2019). In contrast, extrinsic satisfaction is defined as working conditions that affect employee attitudes and actions. In conclusion, (SULISTIYANI, Endang; UDIN; RAHARDJA, 2018) extrinsic rewards are also associated with knowledge sharing and creativity through interim leadership.

#### **4.2. Basic Salary**

Mutembei (2019), found out that basic pay as a form of financial compensation is the reimbursement that is acknowledged as a wage or salary and paid to an employee for the performance of their specific job responsibilities. (Nzelum et al., 2019) found that salary rates increase proportionally as the satisfaction rate increases. According to (Al-Ali et al., 2019), job satisfaction significantly improves job performance representing a higher salary. (Nzelum et al., 2019) conclude that the salary rate improves in direct proportion to the portion of satisfaction increases. Lower remuneration is one of the sources of employee dissatisfaction as well as it is a consideration based on the performance, experience, knowledge, and expertise of an individual (Atefi et al., 2016). One of the strengths of good compensation management depends on the number of wages or salaries per employee (Bharat, 2016). Improving the employee welfare plan makes them more satisfied with individual income and feel less pressure as deserved for them (Ree Joppe De, Muralidharan Karthik, Pradhan Menno, 2017). The consideration factor for companies to hire and retain high-quality employees to a certain level of a job

where s/he reaches an employee also has to continuously maintain on reaching a level of performance (Akhtar et al., 2017). The monetary incentives distributed with a merit logic depend on employee performance when they are a stimulus for the next level of evaluation (Ponta et al., 2020).

#### **4.3. Bonus**

According to annual performance, bonus pay is typically given out each year (Nyberg et al., 2016), which occurs three or four months after the fiscal year-end at the annual meeting (Healy, 1985). (Brockner et al., 2006) explained that employees with advanced capability last projects to alter their effort or behavior by boosting their output in order to benefit from performance-based payments. According to (Muse Ali Geelmaale, 2019), if employee performance is apparent, firms may use direct bonuses and prizes based on performance. Individual incentives, such as sizable bonuses, are also frequently unexpectedly unsuccessful at boosting worker morale and productivity (Anik et al., 2013). Bonus targets provide highly accessible information that can be easy to manage when given to the manager to meet the previous goals (Voußem et al., 2015). By linking salary and performance, bonuses increase the high performers' perception of equality and justice and reduce the desire for movement (Park & Sturman, 2016).

Bonus and awards provide one consideration not only on external financial rewards but also on the recipients then retention bonuses will be an effective tool to reduce employee attrition (Law, 2016). In addition, (Pohler & Schmidt, 2016) bonus-qualified managers may be motivated the hire the suitable, but may not have the capacity or resources to do so consistently. (Ingsih et al., 2020) concluded that it is necessary to improve for increasing the bonuses and the quality of the workplace environment should conclude by organizational commitment. (Ingsih et al.,

2020) found that job satisfaction mainly impacts through compromise of the organizational commitment is a great play to increase Bonus consideration. The relationship between manager and employee when using performance-based incentive. The organization may need to take care of the importance of an annual bonus based on the performance incentive but, (Ludwig et al., 2016) it may need to care about exceeding the previous target amount.

#### 4.4. Promotion

(Kim & Lee, 2018) explained that after years of work, employees are more likely to focus on promoting better than on pay and prefer sufficient opportunities for career advancement. (Ndijuye&Tandika, 2019) concluded and gave an opinion that the strategy of enhancing the employee performance through regular promotion to the employee for the organization to enhance the productivity. Promotion-focused workspaces make it easier to interact with the work performance (Lichtenthaler& Fischbach, 2019). A promotion is when a person moves up the corporate ladder and works with support from the supervisor/manager. The impact of these factors depends on the individual (M. Z. Ali & Ahmed, 2017), in addition to capacity building, job promotion, and job satisfaction affect the performance for the organization (Razak et al., 2018). Job satisfaction is significantly and favorably impacted by promotion is one of the partial effects on job promotion and impact itself (Tasman et al., 2021). The staff promotion was still required to be in charge for a few but not for all (Zulfikar et al., 2018). However, improving salary and benefits structures is also one of the supporting factors for job satisfaction (Sivalogathan, 2017). (Chen et al., 2006) stated that an equitable promotion system was partly vital for the employees to focus on fairness correctly.

#### 4.5. Commission

Basic pay, which includes perks, promotions, profit-sharing, salary, bonuses or commissions, and fringe benefits, was not ideal due to external compensation(A. Ali, 2019). (Ude, 2012) explained that commission is natural with salespeople; the commission was incentive reimbursement based on a percentage of total sales. It is to create the competitive advantage to consider the benefits of human resources to change the organizational environment increasing the efficiency of products or services in the marketplace (Chygryn et al., 2019). The organization should be committed to the employee through providing service commission should pay its employees positively for the competencies rather than just the experience alone (Chepkwony, 2014). (Mallin&Pullins, 2009) made an effort to demonstrate how the relationship between the sales environment and commission pay serves as a performance-based incentive for a salesman. As a result, the rationale and distribution of financial incentives depend on employees' performance and the motivation for the next evaluation period (Ponta et al., 2020). The organization also treats the sales commission as a control to ensure company success on the employee is a variable (Authors, 2017). (Chepkwony& Jomo, 2014) found out and suggested that the commission was involved in the development of rewards and related to the recommended staff benefit for the job satisfaction. One of the compensation packages of employee satisfaction that makes an organization effective is commission-based pay which is directly proportional to the total sales for the organization (Adom, 2018).

#### 4.6. Intrinsic Reward

Intrinsic rewards actively produce the best product or service at their work itself to a distinct physical or another form of reward

(Wickramasinghe&Sajeevani, 2018). The management is the influential motivator, by itself is no longer enough – intrinsic rewards are essential to employees in today's atmosphere (Trust, 2019). Intrinsic rewards should be established in accordance with the differences of characteristics associated with work performance (Authors, 2006). A person who is intrinsically motivated will work on a matching problem because it is enjoyable to do so, or he will solve a problem because it is difficult to solve and he feels good about himself after doing so (MuseAliGeelmaale, 2019). (MuseAliGeelmaale, 2019) concluded that intrinsic rewards have an important helpful connection with employee performance and employee motivation. Intrinsic rewards enhance the professional skills and commitment within the organization because it creates a sense of satisfaction related to the original psychosomatic needs (Kalhorro et al., 2017) and in addition working itself through personal achievement (Ayomikun, 2017). Another intrinsic motivational point of view is one of the behaviors that require employees to have the ability and self-determination to interact with the working environment (Shao et al., 2017). On-the-job service intrinsically not only enhances the personal qualities of employees but also motivates them through a passion for the environment (Afsar et al., 2016).

#### 4.7. Recognition

The good practices on Human Resource Management policies through getting recognition to employees is mostly maintaining the employee motivation that organization can get more productivity and the creativity of highly viable environment (Reddy, 2020). The academic staff valued recognition as the most motivating aspect and benefit as the least motivating factor, according to (Negash et al., 2014). Numerous research have looked into the idea of staff

incentive and recognition schemes and their impact on employee performance, according to Ndungu (2017). Recognition is a cost-effective method for enhancing a routinely required activity and offering a sizable pool of top performers, according to (Bradler et al., 2016). Employee appreciation can be extremely successful and motivating while costing the firm next to nothing to implement, according to (Luthans, 2000). In addition, the employee recognition program is one of the general considerations and is one of the saving financial terms of creating another type of reward to motivate employee performance (Afsar et al., 2016). Employee recognition is related to human justice of organization has responsibility for employees generally having their own without discrimination and emphasizing the concept of equality employees working in the same organization (Masri& Suliman, 2019). Employee recognition at work is to emphasize particular actions and routines that boost output and boost financial performance (Andriotis, 2019).

#### 4.8. Appreciation

Appreciation is one of the precious things from a powerful God (Crofford, 2016). Nowadays the business community is required to fulfill the promises of an organization to succeed in affiliate business. A committed and devoted employee base is playing an important role (Varma, 2017). (Abdullah et al., 2016) found out that studies on employee recognition indicate that the IT sector is largely confronted with the relentless growth of many of its qualified employees. For most managers, navigating the professional goals of generation Y could be a challenging task. Therefore, businesses must create policies and procedures that recognize generation Y's need for rapid career advancement (Chawla et al., 2017). According to Sahl (2017), acknowledgment and appreciation are crucial for faculty

happiness in general and, ultimately, for employee contentment with the institution as a place to work. Bradler et al. (2016), found out that the implication of management suggests that the recognition is efficient on cost-effectiveness but added value in good performance employees. Employee behaviors that lead to positive outcomes should be strengthened as an effect from an organizational positive point of view (Bawa, 2019). In addition, (Crystalee Webb Beck, 2016) recognition comes up from social standing and appreciation. Management is required to provide the following expert and responsibility of employees to appreciation based on required motivations or promotion for providing both beneficial for the organization (Putro&Havidz, 2019) and it is very difficult for employers to maintain a stable and successful operation (Asamoah et al., 2014). That is the reason the development and implementation of talent and knowledge management to implement strong skills management of awards and recognition and sharing in social media is also required (Fojt, 1995).

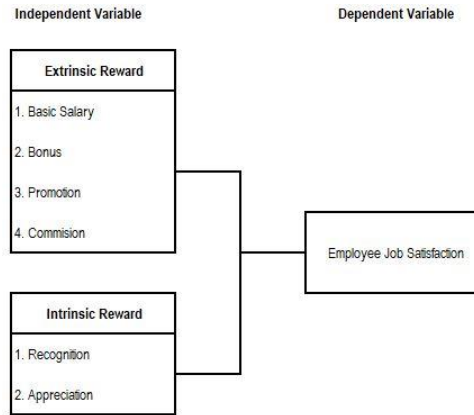
#### 4.9. Job Satisfaction

Al-Ali et al. (2019) , Research demonstrates that job satisfaction significantly affects job performance. Retaining qualified and skilled employees are challenging for the competitive business environment for the organization. (Ali, 2019) introduced that human resource policies can have positive and negative effects on employee motivation and job satisfaction. If employee feel that the human resources policies and practices are satisfactory, they will be sufficiently

motivated to meet the goals and objectives of the organization. In addition, job satisfaction is a consideration in employee satisfaction (Ndijuye & Tandika, 2019). Terera & Ngirande, (2014) concluded and recommended that job satisfaction is also apparent in the retention of staff; it must come to the employees. The rewards factor of staff motivation programs is mainly effective to employee satisfaction (Danish & Usman, 2010). If an organization is not caring about employee satisfaction, the importance of unfaithfulness, increased absences, and the number of accidents from employees would affect the organizational goal (Fujimoto et al., 1981). A well-established employee reward is treasured for the daily performance of employees' activity to work hard for the organization's effectiveness including the career path for the employee (Sajuyigbe, A.S. OlaoyeBosede. O (Mrs.), 2013). Depending on the organizational goal and economic condition, creating the importance of the reward system should be transparent (Murphy, 2015).

#### 5. Conceptual Framework

The conceptual framework proposes the following interrelationships: extrinsic reward took an independent variable with four sub-dimensions: basic salary, bonus, promotion, and commission. The intrinsic reward used as an independent variable with two sub-dimensions: recognition and appreciation; employee job satisfaction is the dependent variable. The following figure shows a conceptual framework diagram (1).



**Figure 1.** The conceptual Framework

## 6. Research Methodology

The objectives of this research are to describe the impact of the two variables (Extrinsic Rewards and Intrinsic Rewards) on the employee satisfaction of the Zalaryathar Distribution Co., ltd in Myanmar. Quantitative approaches were utilized in the study to assess the effects of rewards and recognition on employee work satisfaction. In order to determine the link between variables, data were also analyzed using inferential statistics like regression and correlation.

### 6.1. Population and Sampling

The population is the entire group we are interested in, and from which we want to infer or draw conclusions. In other words, it pertains to everyone who the study was intended to generalize about (Jackson, 2008). All 1261 of the company's employees make up the study's population. Employees at the company's headquarters in Yangon were the focus of the researcher's data collection efforts. According to Hair et al. (2010), a target population is a predetermined set of individuals or things that can be questioned or watched in order to gather the necessary data structures and information. The stratum of the target demographic was staff, first line management, middle management, and top management. Disproportionate Because some

strata are small, stratified random sampling was utilized. Stratification is used to lessen standard error and give some variance control (Oso, 2009). Disproportionate sampling decisions are made when a particular stratum or strata are either too small or too large, or when there is suspected to be more variability within a specific stratum (Sekaran, 2003). This study collected data from 250 employees working in the head office at Yangon.

## 7. Questionnaire

The main technique of gathering data is through a questionnaire, and open-ended questions were included. All conceivable responses or pre-written response categories are included in the closed-ended questions. The questions are presented, and respondents are prompted to select their response. In quantitative research, this kind of inquiry is used to generate statistics (Kumar, 2005). A questionnaire was divided into two sections and the first section is to describe the characteristics of respondents. The second section describes employee job satisfaction based on reward and recognition. A questionnaire with a five-point Likert scale was given to respondents (strongly disagrees, disagree, neutral, agree, and strongly agree).

## 8. Data Collection Procedure

The researcher has distributed 250 questionnaires to employees working in the Yangon head office of Zalaryathar distribution Co., Ltd. The researcher requested the Human Resources Management department to deliver the questionnaires. In this study, a researcher requested the Human Resources Management department to participate and deliver collecting questionnaires. All questionnaires are a contribution to employees through the heads of the various departments. The survey period for questionnaire distribution and data collection was within August 2021. In research questionnaires, motivating and assuring respondents for anonymity and confidentiality were introduced. There are a number of 250 questionnaires that were delivered to the respondents. However, only 216 questionnaires were returned. In total 34 returned questionnaires were rejected because 4 copies had multiple responses, 30 were incomplete.

## 9. Limitation of the Study

The study was only conducted in Yangon, Myanmar due to time and resource constraints. Although there were other branch offices of Zalaryathar Distribution in the cities of Myanmar, the research was limited geographically. The study focused on the Zalaryatha distribution company operating in Myanmar. Therefore, generalization has not to be across other companies, industries, and regions. The researchers have chosen two independent variables. There may be other variables and factors that might be affecting the employee's job satisfaction. However, there is still left to explore the impact on employee job satisfaction for some variables.

## 10. Data Analysis

In order to start the analysis process, the data

gathered from the questionnaire and secondary sources were methodically organized. Data analysis is the process of reviewing the information gathered during an experiment or survey and drawing conclusions and inferences (Kombo& Tromp, 2006).

### 10.1. Demographic Characteristics of the Respondents

The demographic data for gender shows that out of the 216 respondents who replied to the questionnaire distributed, there were 120 male and 96 female. Table (1) shows that the male respondents are more than female respondents regarding the percentage, male 55.6%, while female respondents were 44.4%. From the table below the gender balance in Zalaryathar was not fairly distributed. The sample population mainly dominated with the age of under thirty years of respondents covering 58.3% followed at the age group of 30-40 years (26.4 %). Between the ages of 41 and 50 years is 12.5%. The rest of the respondents are under the age category of over 50 years (2.8 %). The data indicated shows Zalaryathar distribution organizing with young employees. The majority of graduated respondents were (56.9%) to 31.0% were high school level in terms of education response. According to the data below, 11.1% of respondents had a diploma, and 0.9% were master holders. It may show most of the respondents have better educational backgrounds. The study discovered that 57.9% of respondents were staff, 20.8% were supervisors, 13.9% were managers, 5.6% were general managers when 1.9% were directors. It denotes that the majority of the study's respondents were staff level.

**Table 1.** Background information of respondent

Variable	Item	Frequency	Percentage (%)
Gender	Male	120	55.6
	Female	96	44.4
	Total	216	100.0
Age	Less than 30 years	126	58.3
	30 To 40 years	57	26.4
	41 To 50 years	27	12.5
	Over 50 years	6	2.8
	Total	216	100.0
Job Position	Staff	125	57.9
	Supervisor	45	20.8
	Manager	30	13.9
	General Manager	12	5.6
	Director and above	4	1.9
	Total	216	100.0
	Educational qualification	High School	67
Diploma		24	11.1
Graduate Degree		123	56.9
Master Degree		2	0.9

Ph D	0	0.0
Total	216	100.0

### 10.2. Reliability score of variables

A survey, test, observation, or measurement procedure that consistently produced the same results across trials is what reliability is defined as in the extension (Babbie, 2004). Cronbach's Alpha is used to determine the degree of consistency in this study. Found out that to be above 0.7 for all the constructs in this study. An appropriate level of internal reliability is indicated by a value of 0.7 and higher (Hair et al., 2003). The following table (2) presents Cronbach's alpha values for the research instrument.

**Table 2.** Reliability statistics

Variable	Numbers of items	Cronbach's alpha
Independent variable		
Basic Salary	5	0.71
Bonus	4	0.73
Promotion	6	0.8
Commission	5	0.83
Recognition	4	0.87
Appreciation	5	0.77
Dependent variable		
Employee Job Satisfaction	6	0.82

### 10.3. Descriptive Statistics of the variables

The mean and standard deviation was analyzed and presented in the following table 3. The table's illustrative statistical data indicate that the mean value of basic salary is 4.13 with a standard deviation of 0.49378. Most of the respondents agreed that the statements indicate the basic salary pay has



the highest value for the mean score. The standard deviation of basic salary is a little low which means variability of the responses on basic salary is lesser. The average level of job satisfaction among employees was 3.92, which is the second-highest mean value (standard deviation: 0.51375). This value shows that the employees' overall job satisfaction is higher than average. Additionally, according to the scores for the factors, appreciation has a mean value of 3.91 and the third-highest mean value with a standard deviation of 0.61685. The lowest mean value is 3.27, which is for the promotion.

Employee Job Satisfaction	2	4	3.92	0.51375
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**Table 3.** Descriptive statistics

Variable	Minimum	Maximum	Mean	Std. Deviation
<b>Independent variable</b>				
Basic Salary	3	4	4.13	0.49378
Bonus	2	5	3.75	0.52594
Promotion	2	4	3.27	0.47257
Commission	3	4	3.61	0.6823
Recognition	1	5	3.31	0.7841
Appreciation	1	5	3.91	0.61685
<b>Dependent variable</b>				

## 11. Correlation Between Variables

The relationship between many factors the determination of a link between the dependent and independent variables is conducted by correlation analysis (Cooper & Schindler, 2014). The correlational findings for the variables are displayed in the following table. Positively strong correlation was found between the base pay and job satisfaction ( $r = .742$ ,  $p .01$ ). Bonus and job satisfaction revealed a positive and moderately correlated connection ( $r = .665$ ,  $p .01$ ). Additionally, there was a moderate association between job satisfaction and promotion ( $r = .417$ ,  $p .01$ ), which was favorable. Similar to this, there was a moderately favorable association between the commission and job satisfaction ( $r = .593$ ,  $p .01$ ). Recognition and job satisfaction revealed a positive and weakly correlated connection ( $r = .393$ ,  $p .01$ ). The association between job satisfaction and appreciation was substantial ( $r = .713$ ,  $p .01$ ) and positive. According to the findings, there is a strong relationship between basic pay and job satisfaction. However, the relationship between recognition and job satisfaction is the weakest.

**Table 4.** The correlation between variables

Variable	JS	BS	B	P	C	R	A
Employee Job Satisfaction (JS)	1						
Basic Salary (BS)	.742**	1					
Bonus (B)	.665**	.504**	1				
Promotion (P)	.417**	.492**	.421**	1			
Commission (C)	.593**	.526**	.341**	.672**	1		
Recognition (R)	.393**	.421**	.441**	.516**	.332**	1	
Appreciation (A)	.713**	.452**	.613**	.487**	.557**	.542**	1

## 12. Conclusion

Distribution companies are operating on the concepts of just in time, data accuracy, good customer feedback, and operational effectiveness. In order to keep going on these concepts, satisfied employees are necessary for every sector of the operation. Retaining skills and a high-performance workforce are challenging today's human resource management. This study looks into the attitudes of workers at the Zalaryathar distribution company toward rewards and recognition in the workplace. The research's findings support the notion that extrinsic rewards and employees' job satisfaction are positively correlated. Additionally, there is a favorable correlation between intrinsic reward and job satisfaction among employees. The strongest correlation and best link are between basic pay. To increase job satisfaction, management have to think about synchronizing the base pay. Additionally, management recognition is crucial for boosting motivation and job satisfaction. Appreciation is the second highest correlation with job satisfaction in the finding. This means that the level of

satisfaction is improved when an employee does a certain good job and his management and coworkers admire and appreciate his work. Management should adopt new appreciation practices and shape culture to improve job satisfaction for stabilizing operation performance. Management should build a reward strategy in line with the organization's core values to improve the job satisfaction of employees who implement the organization's success.

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## **THE EFFECT OF JOB SATISFACTION, EMPLOYEE LOYALTY, EMPLOYEE COMMITMENT ON LEADERSHIP STYLE IN STARTUP COMPANIES**

**Abstract:** *Using SmartPIS 3.2.9, researchers in the scientific community test their theory. One hundred workers employed by a service company in Yogyakarta were randomly selected to take part in this study. The researcher used the method of collecting until I by utilizing the side frame I ing. The series of validity and reliability tests were applied, respectively, to the Outer and Inner I modes of the SEMPI S research system. These tests are the research instruments used here. method to examine the data using route analysis and descriptive analysis. The following is a list of results that can be found in this research: The following assertions cannot be relied upon: (3) Employee commitment does not affect the leadership style of a leader; (1) Job Satisfaction has no effect on Leadership Style; (2) Employee loyalty has a big influence on Leadership Style; and (1) Job Satisfaction has no effect on Leadership Style.*

**Keywords:** *Job Satisfaction, Employee Loyalty, Employee Commitment, Leadership Style*

### **1. Introduction**

Intr Leadership style shows several forms of conceptualization, including how to delegate, make decisions, and how to participate in an organization for corporate goals. Somech (2005) defines leadership as someone who can make decisions together or show influence for togetherness within the organization so that they can determine where superiors and subordinates are positioned through the hierarchy. Thus, the focus of management has become the division of powers and structured decision-making. A leader's decision-making has been studied as a formal strategy to be directed to the group, where, in unimportant matters, group participation is considered relevant and influences group decisions (Mohammad et al. 2021). Participation in decision-making leads to increased social capacity, with decision

quality affecting employee motivation, quality of work life, work environment, and professional training in successful organizations (Chan 2019; Ghaffari et al. 2017; Lumbasi et al. 2016). Odoardi et al. (2019) state that organizational and individual outcomes are influenced by participatory decision making and this influence can be associated with the level of employee loyalty augmented. Decision quality is enhanced through employee participation in the decision-making process, as this helps supervisors develop insight into the core issues in problem situations. Several studies (Lythreatis et al. 2019) argue that this involvement increases the tendency of employees to follow managerial decisions with loyalty. Leaders value employees' opinions and perspectives and seek their input and suggestions (Rana et al. 2019; Khassawneh and Abaker 2022). Furthermore,

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leaders motivate their employees to develop learning through information acquisition, sharing, and connecting as well as seeking new opportunities (Benoliel and Barth 2017). Past and current research on leadership in organizations has discussed how the impact of leadership on employee job satisfaction (Shahab and Nisa, 2014), the influence of leadership on employee loyalty (Ntusikazi, 2017) and employee commitment (Alkahtani, 2015) to companies in industries that different. Most of the research on employee commitment through leadership has been conducted in large companies, but researchers assert that the development of companies should be seen differently from large organizations because they believe that in order to gain a deeper understanding of the culture within a company, a more unique approach is needed as a leader. (Szczepeńska and Kurowska 2016). Therefore, after a comparison of various leadership approaches, Long et al., (2016) discussed that there is a relationship between employee commitment to the organization and organizational leadership. Zafar et al. (2014), however, argues that increasing employee loyalty involves certain critical factors such as how employees feel when they think about their job, their perception of the organization they work for and their expectations of their job. Nidadhavalu (2018) tested Job Satisfaction as a variable for various forms of leadership and concluded that Transformational leadership has greatly influenced Employee Job Satisfaction. This long-established investigation has been refined at large-scale organizations, as there is a belief that SMEs, in contrast to large enterprises, need more assets to build a proper human administration framework.

In this ever-changing era, it is hoped that all companies, especially those engaged in the media and communications sector, will grow to be prosperous and expansive so that they can continue to operate effectively. To grow into a successful business, you want leaders

who are able to devise and execute plans that will produce the desired results. A business must have a leader, but it must also have access to reliable and knowledgeable human resources. It is critical for companies to recruit and retain skilled workers if they are to maintain their competitive advantage in today's rapidly changing corporate environment. Where, in the midst of unprecedented media developments, the potential to maximize morale and staff happiness can be found. In a service company in Yogyakarta, the problem is a lack of employee satisfaction and a lack of dedication to organizational success. Both of these factors contribute to a lack of productivity. Therefore, the management of service companies in Yogyakarta must pay attention to this matter: as a result, the company's performance becomes less good, and it is difficult to find competent staff.

## 2. Literature review

### 2.1. Leadership Style

Higher management leads may impact lower management's capacity to achieve their goals. It is possible to think of a leader's style as the pattern of action they make and the set of guiding principles that determine how they behave and the choices they make as a leader. In addition, the approach one takes to influence other people's actions is referred to as their leadership style. A person's level of success as a leader can be assessed, at least in part, from the extent to which his leadership style is able to motivate followers (Depitra, PS & Soegoto, 2018; Mattayang, 2019; Siti Nur Aisah, 2020; Suriyana, 2021).

The leadership style is I ah behavior which shows individuals who try to influence other people's behavior. A leader must adopt and use a leadership style that is good and right so that his influence can be felt by his subordinates or his children. The way a leader directs his team may influence the extent to

which the leader is able to inspire and encourage those who work under him. In accordance with (Sudirno & Utama, 2017).

There is an expectation that business leadership will have an advantage over its subordinate employees to motivate these employees to work harder towards company goals and maintain a high level of loyalty to the organization as a whole (Habib, et al., 2022). In running a business, the success or failure may be partly determined by looking at the leadership style of those in charge of the organization. It is the manager's responsibility to ensure that all tasks that fall under his jurisdiction are completed or progress is made. Take an example: (Batubara, 2020; Heriyono et al., 2021; Pujianto & Evendi, 2021; Sudiantini & Saputra, 2022; Sunarto, 2021). The speed of decision making, the ability to inspire those around them, the clarity of their communication, their connection with authority, and their willingness to take responsibility for the results of their actions are five indicators that can be used to determine style a leader according to Hasibuan and Meiyayu (2017). These are five factors that can be used to determine the style of a leader. This is in line with the research of Komariyah et al. (2021) titled "The Influence of School Head Leadership Style and Achievement Motivation on the Work Productivity of Kindergarten Teachers in Patebon District, Kendal Regency", which found that the leadership style of school heads has an effect on teacher output. Meanwhile, the research conducted by Utarindasari and Sitogata (2021) with the title "Analysis of the Influence of Leadership Style on Employee Motivation and Productivity" found that leadership style did not significantly influence the number of jobs done. Essay on an organization (Komariyah et al., 2021; Utarindasari & Silitonga, 2021; Zufrie, 2019).

Several researchers, such as (Mahaputra & Saputra, 2021), (Anas, 2020), and

(Mahaputra & Saputra, 2021), have studied various leadership styles (Sudiantini, 2020).

## 2.2. Job satisfaction

A productively optimistic outlook or emotional satisfaction in one's job can be considered as an important component of job satisfaction. Depending on how a person evaluates their previous job security experience and the tasks they have performed, a worker's job satisfaction can make them feel happy or positive. Job satisfaction, which translates to "worker satisfaction", is a favorable attitude toward the work being performed, and stems from the findings of an investigation into the work environment that apply to a particular activity. The results of this assessment instill a sense of satisfaction and pride in having contributed to the achievement of important goals related to this body of work (Latifah et al., 2020; Priansa, 2016a; Shaddiq et al., 2021; Suriyana, 2021).

Satisfaction at work, also known as job satisfaction, can be considered as a problem that affects the motivation and discipline of workers when they work. The feelings of satisfaction mentioned above in one's job extend to various kinds of interpersonal relationships, such as those with managers and co-workers, as well as with one's place of work, duties, and responsibilities. According to Priansa, there are a number of different metrics that can be used to measure job satisfaction. This metric includes 1) communication about work; 2) strong leadership; 3) effective organizational management; 4) development of results related to work; 5) supportive colleagues; and 6) a clear measure of success in work (Priansa, 2016).

However, according to Yuwono who was referred to by Spector at Badriyah, there is evidence that a person is satisfied with his profession (2015: 241). These benefits include financial compensation,

opportunities for advancement and recognition, adherence to business policies, and the development of friendships with other I employees.

There have been many studies conducted on the topic of job satisfaction in the past, such as (Sianipar, 2019), (Saputra & Mahaputra, 2022), and others ( Andrian et al., 2021).

**2.3. Employee Loyalty**

One way to evaluate employee commitment to their employer or organization is to see how diligently they try to do their job as well as possible for the employer or organization. According to the investigative findings of Va I entino and Haryadi (2016).

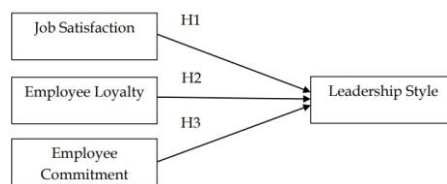
Following are the subcategories that make up employee loyalty: 1 ) Employee loyalty towards an organization or company ; 2) the loyalty of employees towards the leadership; and 3) employee loyalty to certain assignments. However, according to Jun Cai and Shin, there are signs of employee loyalty (2006). Mora I honesty and fortitude ; perseverance in the face of adversity ; self-sacrifice; the desire to take responsibility ; integrity and moral fortitude in the face of persecution.

In the past, several academics have looked at the topic of employee loyalty. Some of these studies are I'ah Anas (2019), Saputra et al. (2022), and (Sianipar, 2022).

**2.4. Employee Commitment**

According to Sopiah (2008: 155), commitment can be defined as a condition of being loyal to an organization and being ready to make additional efforts to help the group achieve its goals. When an employee gets what they want from their employer, their work motivation increases, and they experience fewer negative effects that arise when their job is challenging but their salary doesn't meet their needs, both of which can negatively impact an ability. Employees to

stay motivated at work. (Chantica Ange I iza, Ange I iza, Chantica, & Ange I iza, 2022). According to Kaswara and Santoso (2008), there are still markers of employee commitment. These signs are as follows: Improving one's abilities, as well as one's Self-Control, Accountability, and Loyalty. Previous research on employee commitment has been carried out by many researchers, such as (Pangkey et al., 2019) and others (Iksan et al., 2022).



**Figure 1.** Conceptual Framework

**3. Research methods**

In depth interview and quantitative research methods were used in this research (library research). Doing a study I iteratur on I ine, with Goog I e Scho I ar and Mende I ey as main sources, with main emphasis on theory and interdependence of journal factors is recommended. The need to display or evaluate large amounts of data is one of the most important reasons for conducting quantitative research. After the categorization of data into numerical forms is complete, this study aims to conduct trials of data collection methods using questionnaires.

I Path Analysis mode and Structura I Equation Mode I (SEM) based on Partia I analysis I east Square (PIS ) which was carried out with the SMARTP IS 3.2.9 program, this research tests the assumptions. A sample I method was applied, and 100 workers from service firms in Yogyakarta were randomly selected for this study. Testing the validity and reliability for the exterior (estimation) and inner (structural I) modes of SEMPI S derivatives there are several research techniques used in this

special investigation. Data analysis technique using descriptive and path analysis.

## 4. Results and discussion

### 4.1. Results

The discussion of this study will focus on the topic of human resource management. The debate will consider background material, problem statements, theoretical investigations, conceptual frameworks, and previous relevant research:

#### 1. Test of Validity and Reliability

Validity testing is the process of creating an environment in which one can accurately reflect the interdependence of a measure or analyze the findings of the instrument. When there is a match between the information obtained from the research and the events that actually occurred in the places studied, the research findings are considered reliable. According to the findings of a number of researchers (Hernikasari et al., 2022), this is indeed the case.

Dependability testing is a very useful method that has gained wide acceptance as a viable option for use in data collection. As stated oleh Hernikasari et al (2022).

the validity and reliability tests of the study are shown in Table 1 below. Bottom line: the following examples:

**Table 1.** Outer Model (Cross Loading Validity Discriminant)

Indicators	Variables			
	Job Satisfaction	Employee Loyalty	Employee Commitments	Leadership Style
EC3	0.176	0.203	1.000	0.253
EL3	0.187	0.478	0.082	0.162
EL4	0.158	0.0987	0.203	0.667
JS1	0.686	0.137	0.307	0.149

JS2	0.869	0.153	0.019	0.227
LS2	0.235	0.648	0.269	0.980
LS4	0.246	0.624	0.227	0.987

If we look at table I above which displays these I ai cross readings, we can draw the conclusion that the cross I loadings associated with certain indicator items I are greater than those associated with variable I I ain. Comparable to variable I Employee Commitment which has I ai cross- I loading I is greater than variable I Job Satisfaction and Employee Loyalty, as well as Leadership Style. Consequently, the findings of this examination are accepted on a biased basis towards certain groups.

**Table 2.** Composite Reliability

Variables	Composite Reliability	Description
Job Satisfaction	0.785	High Reliability Iity
Emp Ioyee Ioya I ty	0.727	High Reliability Iity
Emp Ioyee Commitment	1.000	High Reliability Iity
I leadership Style I e	0.992	High Reliability Iity

Based on table I above, it shows that the variables I Job Satisfaction, Employee Loyalty, Employee Commitment and Leadership Style have these results which can be stated as high reliability.

#### 2. Evaluate I Structural Mode I ( Inner Mode I )

Evaluation of structural mode I in SEM with PIS was carried out in the R Square test (R 2 ) and the Q-Square Test (Q 2 ) to I a I I ui estimated the path coefficient.

#### Determination Test (R-Square)

In this study, the analysis aims to assess whether there is a magnitude of the construct of endogenous variable I to exogenous

variable I against the results of the tests that have been carried out.

**Table 3.** Inner Mode I ( R-Square Test)

Variable I e	R Square (R <sup>2</sup> )	Adjusted R Square
I leadership Style I e	0.457	0.432

Based on table I above, it shows that the endogenous variable I (Leadership Style) with an I ai R Square value of 0.457 means that the variable I job satisfaction (X1) I oyalty (X2) and commitment (X3) is able to explain the level of leadership style (Y) of 45.7%. Where 54.3% is influenced by o I eh variable I I ain who was not te I it.

*Q-Square Test (Q 2 )*

The Q Square test refers to the value I ai Goodness of Fit (GoF) Index, based on the value I ai Stone Geisser Q2 criteria. If ni I ai Q Square is above 0, then it can be said that the research mode I built has predictive reliability, whereas if I a ni I ai Q-square < 0 (no I ), then it shows that the mode I lack predictive response. (Ghozali & Hengky, 2015).

**Table 4.** Inner Model (Q-Square Predictive Relevance)

Variables	Q Square (Q <sup>2</sup> )
Leadership Style	0.426

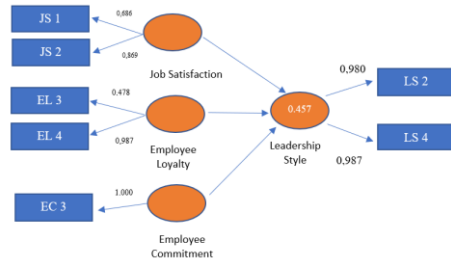
Based on the results of data processing, the I eh value was obtained in Q 2 on the Leadership Style variable I of 0.426 which was measured using the processed measurement using the Smart PIS 3.2.9 application, so that this was obtained I ai Q-Square as follows:

$$Q\text{ Square} = 1 - (1 - Q\ 2) (1)$$

$$Q2\ \text{Leadership Style} = 1 - (1 - 0.426) = 1 - 0.574 = 0.426$$

Based on the results of the above calculations, it can be seen that the value of I ai at the Q Square of the Leadership Style is 0.426. The I ai value shows the percentage of this research, namely the contribution of the Variable I Leadership Style (Y) is I ah of 42.6%. Meanwhile, the other 57.4% of the first results were outside of the first results of this research. This can be stated that the research can be stated to have good goodness of fit.

After I have carried out the test, it is continued by carrying out significance testing or bootstrapping which gives a significant value of I ai for each indicator of the dependent variable I construct namely Job Satisfaction, Employee Loyalty and Employee Commitment which can be seen in the image below:



**Figure 2.** Outer Model

3. Analysis Result of Hypothesis Test

The output R-Square, Parameter Coefficient, and T-Statistics are used in hypothesis testing, which is carried out using the findings of the Inner Mode I test. It is possible to judge whether a hypothesis should be accepted or rejected by looking at the significance I ai that exists between the chains, the T-statistics, and the probabilities I ai values. In this particular investigation, a T-statistic greater than 1.96 is used as a general principle. With a significance threshold of p 0.05 (5%), and a statistically significant positive I ai for the beta coefficients, the I result is I ah as follows.



**Table 5.** Hypothesis Testing

<i>hypothesis</i>	<i>Variables</i>	<i>T Statistics</i>	<i>P Value</i>	<i>Description</i>
H <sub>1</sub>	Job Satisfaction -> Leadership Style	1,375	0.177	No effect and not significant
H <sub>2</sub>	Employee Loyalty -> Leadership Style	10,058	0.000	Influential and significant
H <sub>3</sub>	Employee Commitment -> Leadership Style	1,483	0.153	No effect and not significant

Based on table 5 above, it can be interpreted that:

Hypothesis 1 is rejected where  $t_{\text{statistic}} 1.375 < 1.98$  and  $p_{\text{value}} 0.177 > 0.05$  means that job satisfaction has no effect and is not significant on leadership style.

Hypothesis 2 is accepted where the  $t$  statistic is  $10,058 > 1.98$  and  $p_{\text{value}} 0,000 < 0,000$  means that Employee Loyalty has a positive and significant effect on Leadership Style.

Hypothesis 3 is rejected where the  $t$  statistic is  $1,483 < 1.98$  and  $p_{\text{value}} 0.153 > 0.05$  which means that employee commitment has no effect and is not significant on leadership style.

## 4.2. Discussion

### *The Effect of Job Satisfaction on Leadership Style*

There is no correlation between the degree of employee happiness and the leadership style adopted by the company. Leadership Type Has Less Influence on Employee Happiness at Work When the company's management does not need to take certain actions related to Leadership Style with variable Job Satisfaction indicators, namely: Awards and Promotions. two different types of employee rewards that are possible in Indonesian. Rewards are a kind of praise given to staff employees who have worked the hardest, while Promotions are when jobs with a higher rank in the organization are given.

### *The Effect of Employee Loyalty on Leadership Style*

Loyalty on the part of workers has a positive and significant impact on the way leaders lead. To develop employee loyalty through charismatic leadership, company management is required to perform the following tasks: Employees who have contributed their time, energy, and creativity for company goals must be recognized in two different ways: 1) employee dedication, where appreciation is shown; and 2) get promoted, where someone whose initial job is honest, fair, and effective is given a higher position in the company. The employee should be thanked in both ways.

### *The Effect of Employee Commitment on Leadership Style*

The commitment of the employees does not significantly influence the leadership style. because there is no positive benefit from increasing employee commitment to the leadership style. O I uh because of that, the company's management team does not need to take extra action to change the leadership style of its workers. This is because the employee engagement indicator that is subject to I with Employee Commitment is used to assess employee commitment. The first is referred to as "dissip I in", where organizational rules must be obeyed. The second is referred to as "capacity building", in which a person must develop his skills and knowledge in order to be able to compete in the sector of his choice.

## 5. Conclusion

C Based on the hypothesis of the research results I above and the discussion, the researchers determine the following conclusions:

First of all, the level of happiness at work has little effect on leadership style. This illustrates that the leadership style does not change regardless of the amount of money or benefits earned by employees to achieve the desired level of job satisfaction (measured by

the Job Satisfaction Scale ).

Loyalty on the part of workers has a positive and significant impact on the way leaders lead. This shows that a leader who has a high level of employee loyalty also has a high level of leadership quality.

The level of dedication shown by employees is not important and has nothing to do with leadership style. This shows that the restrictions imposed by corporations do not affect the way workers handle their work.

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## LIAISON BEHAVIOR IN IMPROVING EMPLOYEE PERFORMANCE: THE CASE OF FINANCIAL INSTITUTIONS IN INDONESIA

**Abstract:** *This study examines the relationship between employee engagement and goal orientation towards competence and the relationship between competence and employee performance in financial institutions. Questionnaires were given to several financial institutions in Aceh, North Sumatra, and Riau. Selection of financial institutions as a place for distributing questionnaires, based on the similarity of their business products. The similarities such as mortgage marketing, multipurpose, and investment. These three regions are the most central provinces and have high levels of trade in western Indonesia. The sampling technique was carried out purposively based on specific criteria for the respondents. Partial Least Square carried out the data analysis technique. This study provides recommendations on practices and policies in producing employee productive work behavior in improving organizational performance. Another unique aspect of this research is that employees need to think and act out of the box to increase their competencies to become superior employees. As a result, employees still get high ratings from the leadership.*

**Keywords:** *employee involvement; goal orientation; competence, employee performance*

### 1. Introduction

The world of work today has changed both in the nature and form of the work done. These changes occur due to innovation, knowledge development, and increased competition (Brown et al., 2003; Nilsson & Ellström, 2012). Today's world of work is characterized by the emergence of complexity, uncertainty, and insecurity (Kalleberg & Vallas, 2017).

In the face of today's dynamic state of the world of work, the organization seeks to be precise in managing its human resource practices. This is due to the practice of human resource management as a strategic tool in

improving organizational performance by increasing the knowledge, skills, and abilities of employees (Bates & Chen, 2004; Clardy, 2008). These three aspects, if appropriately managed, can create organizational excellence (Sengupta et al., 2013).

The practice of human resource management has undergone a paradigm shift in the last decade. Human resources are currently required to support achieving organizational goals (Armstrong & Baron, 2005). Achievement of goals is done by aligning the activities and strategies of the organization (Holbeche, 2016).

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To create alignment of human resource activities with organizational strategy, a working system based on the high performance of employees has emerged (Takeuchi et al., 2009). High-performance-based work systems emphasize creating strategic alignment with external needs to improve employee behavior, attitudes, and abilities that increase organizational excellence (Miao et al., 2014).

This article has the scope of human resource management to fill research gaps in explaining the relationship between behavior in improving employee performance. This study places the relationship between employee engagement, goal orientation, and competence to improve employee performance.

Based on the results of previous studies, empirically, there are still various research results explaining the impact of human resource development on performance in organizational analysis (Thang et al., 2010). The results showed that human resource management practices effectively increased employees' motivation, knowledge, attitudes, abilities, and skills in influencing work behavior (Shin et al., 2018).

However, the results of studies that explain the practice of human resource management in encouraging work behavior are rare (Liu et al., 2017). This is because some of the existing studies provide discussion on aspects of personality (Jafri et al., 2016; Pan et al., 2018), work climate (Hunter et al., 2007), organizational culture (Martins & Terblanche, 2003), and leadership (Gu et al., 2015; Liu et al., 2012).

Having superior human capital is the hope of the organization in winning the competition. Various ways have been done to obtain superior human capital, including the employee recruitment process (Delery & Roupni, 2017; Molloy & Barney, 2015), training and capacity development (Crook et al., 2011; Delery & Roupni, 2017). However,

in practice, the work implementation gives preliminary results (Crook et al., 2011). Therefore, it is an essential task of the organization to create human excellence that supports the organization's goals.

This article provides a discussion on employee involvement in encouraging employee work behavior. The expected work behavior of the organization is an increase in organizational performance arising from increased employee performance. Kim et al. (2010) explained that organizational performance is influenced by employee performance at work (Esteban-Lloret et al., 2018).

Employee involvement is a construction of motivation characterized by the emergence of enthusiasm, dedication, and absorption (Schaufeli et al., 2002). Enthusiasm, related to energy and mental endurance at work, is marked by a willingness to invest time and effort in work. Dedication explains the involvement of employees in work with the emergence of inspiration, pride, and high enthusiasm. Absorption can be interpreted in the aspect of employee concentration in carrying out work. The practice of employee involvement is a management approach that encourages employees to achieve overall organizational goals (Benson et al., 2013). This participation, in turn, encourages more complicated and more responsible work behavior (Ghitulescu, 2013; Yang, 2012).

The findings of this research phenomenon agree with (Crook et al., 2011) that human capital will impact the organization if employees possess competencies. Therefore, this article aims to examine the factors that can encourage employee competence at work. This study places employee engagement and goal orientation as predictors of driving employee competence on performance as a driving factor.

This study, enriching the literature, improves performance in several ways. First, the diversity of employees, such as education,

gender, has a role in employee performance (Østergaard et al., 2011). However, this diversity may be more suitable in the context of performance in the financial sector where face-to-face negotiations with customers (SUMA & BUDI, 2021). Second, this study closes an existing research gap in exploring human resource management practices by examining engagement and goal orientation. Third, this study views that to create organizational resilience during the current COVID-19 pandemic, an active role for employees is needed in creating business sustainability. This study examines the model based on empirical data from financial institutions in Indonesia.

The definition of employee involvement, Kahn (1990) says as employee self-utilization in carrying out work with an emphasis on physical, cognitive, and emotional aspects. Another definition explains that employee involvement is related to expressing employees' attitudes in accepting work roles (Christian et al., 2011; Harter et al., 2002; Rich et al., 2010).

In work, employees have a goal orientation to be achieved to show their abilities. The definition of goal orientation itself is explained by Schunk (2012) as a form of work behavior that is based on goals and focuses on achieving work performance (Maehr & Zusho, 2009). Meanwhile, Pintrich et al. (2003) describe goal orientation as an integrated pattern of individual beliefs that explain the reasons for engaging in work (Ames, 1992).

## 2. Literature review and hypotheses

This study provides a discussion on aspects of employee involvement in the implementation of work in the organization. Employee engagement is a new notion in organizational behavior and has been researched interest in recent years. This attraction arises because

employee involvement affects the company's overall performance. This is because employee engagement is defined as a high emotional connection that employees feel towards their organization. As a result, these feelings influence employees to exert more significant effort in doing their jobs (Fisher, 2010; Wallace et al., 2016). The grand theory of employee engagement is motivation. Motivation is defined as a process related to the formation of intensity, direction, and individual persistence in achieving goals (Pinder, 2014).

### 2.1. Employee engagement and performance

The concept of employee engagement was introduced to employee corporate relations, which is significantly related to the employee's emerging need for opportunities conducive to learning in organizations (Vigoda-Gadot et al., 2013). Employee involvement, related to the level of commitment to the organization and its values. When an employee is involved, he/she realizes his/her responsibility in business goals and motivates colleagues to achieve organizational success.

Based on the results of previous research, there are differences of opinion in the study of the impact of employee involvement on performance. First, research shows a significant effect of employee engagement on employee performance (Anitha, 2014; García et al., 2019). Second, employee involvement has no significant effect on employee performance (Qi & Wang, 2018).

*H<sub>1</sub>*: Employee involvement has a positive and significant effect on performance

### 2.2. Goal orientation and performance

Goal orientation is conceptualized as

attributes and traits of employees in a relatively stable form (Colquitt & Simmering, 1998; Payne et al., 2007). Several studies show that goal orientation changes the life stage transitions of organizations and employees (de Lange et al., 2010; Duchesne et al., 2014).

Based on previous research conducted by Van Yperen and Orehek (2013), the title Goal Achievement in the workplace: conceptualization, prevalence, profile, and outcomes. The results of his research indicate that the willingness of employees to achieve work goals fosters motivation that affects the achievement of their performance.

*H<sub>2</sub>*: Goal orientation has a positive and significant effect on performance

### **2.3. Employee engagement and competence**

Research on the impact of employee involvement on the achievement of organizational success is now starting to be more widely carried out than before. This is because organizations are currently required to create an influential employee role in winning the competition and achieving goals (MacLeod & Clarke, 2009; Xanthopoulou et al., 2009). Shuck and Wollard (2010) explain the importance of employee involvement, namely as a form of cognitive, emotional state that encourages the emergence of employee behavior directed towards achieving organizational goals. In their research, Medhurst and Albrecht (2011) say that engagement is positively related to organizational citizenship behavior, performance, psychological well-being, and efforts to improve abilities (Alias et al., 2016; Shuck et al., 2011).

*H<sub>3</sub>*: Engagement has a positive and significant impact on competence

### **2.4. Goal orientation and competence**

Goal orientation theory suggests that individual goal orientation regulates affective, behavioral, and cognitive motivational processes (Dweck, 2002). Individuals have a strong orientation, view competence as a malleable quality, and pursue the goal of increasing competence (Button et al., 1996; Dweck & Leggett, 1988). They attribute setbacks to inadequate efforts or ineffective strategies. This is because they attribute failure or setbacks to a lack of their abilities; they tend to choose more manageable tasks or exert less effort (Chen et al., 2000; Dweck, 1986; Dweck & Leggett, 1988).

Radosevich et al. (2004) meta-analysis showed that the adequacy of one's ability is not always dysfunctional (M. Wang & Takeuchi, 2007). Previous research showed different results. First, the results indicate that goal orientation significantly affects competence (Chughtai & Buckley, 2011; Gong et al., 2017; Latham et al., 2016). Second, the results indicate that goal orientation does not affect employee competence (Fang et al., 2019).

*H<sub>4</sub>*: Goal orientation has a positive and significant impact on competence

### **2.5. Competence and performance**

Bell (2007) explains that competence, as a form of ability, is needed to complete work effectively. Competence is a form of capacity owned by employees that serve as human capital in achieving goals. Hameed and Waheed (2011) explains that competence relates to aspects of knowledge, skills, and character employees possess in doing work.

Becker and Huselid (2010) said that human capital is a set of knowledge and productive



abilities possessed by employees. Previous research shows that employee competence has a significant effect on improving performance (T.-Y. Kim & Kim, 2013; Rahimić et al., 2012; Y. Wang & Haggerty, 2011).

*H<sub>5</sub>*: Competence has a positive and significant effect on performance

### 2.6. The effect of competency mediation variables on performance

The concept of employee involvement is applied to employees to focus on participating in organizational activities. Hackman (1980) explain that employee involvement is closely related to job design given to employees by placing a lot of autonomy and decision-making authority. This activity aims to foster the meaning and responsibility of employees towards work. Employee engagement can occur effectively if employees have the same understanding of decisions, act on them, and access various information sources needed to take practical actions. There are opportunities to increase knowledge that aims to develop effectiveness in work, and there is an appreciation for its improvement. Work achieved (Wallace et al., 2016).

Based on previous research shows that there is a significant influence between employee engagement on performance through competence (Wallace et al., 2016; Zatzick & Iverson, 2011). Based on the description above, the hypotheses proposed in this study are:

*H<sub>6</sub>*: Employee involvement affects performance through competence

### 2.7. Concept of achieving goals

Based on the concept of achieving goals, it is explained that employees who have goals at

work have a dominant focus on developing competence and work results (Fang et al., 2019). This is following the opinion expressed by Dweck (1986) that performance-oriented employees will be more concerned with proving themselves and avoiding failure. In other words, performance-oriented employees will try to pursue the best evaluation results from work done.

Goal orientation is an approach to the ability of employees to define, approach, experience, and respond to the conditions to be achieved in the workplace (Van Yperen & Orehek, 2013). Ames (1992) says that goal orientation is a fundamental goal regarding goal behavior for achievement. In work, employees have an important goal to be achieved career achievement. Career success achieved by employees is a shared responsibility with the organization. This is because employees' success ultimately contributes to organizational success (Ng & Earl, 2008).

Based on the results of previous studies, there are differences in results in explaining the effect of orientation on performance through competence. First, the results of research that show that there is an influence of goal orientation on performance through competence (Osagie et al., 2018; van Dierendonck & van der Gaast, 2013). Second, research shows no significant effect (Fang et al., 2019). Based on this description, the research hypotheses are:

*H<sub>7</sub>*: Goal orientation has an impact and is significant on performance through competence

## 3. Methodology

In answering the problems that have been stated above, survey activities were carried out in this study. Through the survey, questionnaires were distributed to all

employees of four financial institutions in three regions of the Indonesian province, namely Aceh, North Sumatra, and Riau. The selection of the four financial institutions that became the object of research was due to the similarity of the business activities carried out. The similarities are the marketing of homeownership loans, multipurpose loans, and business loans.

In total, the total population of employees from the four financial institutions is 275 employees consisting of the departments of marketing, finance, general affairs, and credit collection. Determination of the sample in this study, using purposive sampling method with criteria including employees who work in the marketing department and permanent employees. Based on the predetermined criteria, the researcher finally distributed the questionnaires by visiting directly according to the agreed schedule.

Finally, the researcher distributed a total of 175 questionnaires to employees based on the suitability of the number of each employee in each financial institution. A total of 175 questionnaires were distributed, 165 were completely filled out, which could be processed and analyzed. This study uses four variables, namely employee involvement, goal orientation, competence, and performance. The indicators/questionnaire items used are based on:

1. Employee engagement (EE) measured at the individual level consists of 6 items adopted from Mackay et al. (2017) (e.g., actively participates in meetings discussing work improvement; employee activity assessment is always carried out; involved in providing suggestions for improving work in workgroups; management actively holding meetings to discuss organizational development; bonuses are given based on work performance; employees have responsibility for the work given).
2. Goal orientation (GO) consists of 6 items, adopted from Elliot and McGregor (2001) (e.g., hope to gain broader knowledge; understanding in the field of work; belief in gaining knowledge from work done; necessity to be able to fully understand the work; ability to show a professional attitude; belief in having more performance than coworkers).
3. Competence (Com) consists of 5 items, which were adopted from Spencer et al. (2008) (e.g., job responsibilities in accordance with the competencies possessed; employees are required to show the best value of work competence; work roles are in accordance with the competencies they have owned; integrity assessment of the implementation of the work as a reference; the existence of training provided to improve competence).
4. Employee performance (EP) consists of 5 items, which were adopted from Williams and Anderson (1991) (e.g., involvement in the implementation of work; level of job completion; level of fulfillment of job responsibilities; ability to meet formal requirements in doing work; level of concentration in completing the work).

The instrument for measuring respondents' answers uses a 5-point Likert scale (scale 1 = strongly disagree, up to a scale of 5 = strongly agree). To consider the causal relationship in the model developed above, data analysis was carried out using the component-based structural equation modeling technique, the partial least squares method (PLS) developed by Wold (1973). The results of the validity and reliability test concluded that all items and variables were valid and reliable. The results of the Goodness of Fit (GoF) model in

this study have also met the requirements.

## 4. Result

### 4.1. Characteristics of respondents

The results of data processing showed that the total number of Man employees was 99 employees (60%), and Woman employees were 66 employees (40%). Based on the education level of employees, 28 employees with Diplomas (17.0%), 113 employees with Bachelor's degrees (68.5%), and 24 employees with Master's degrees (14.5%). Meanwhile, in the credit business activities of financial institutions, the results showed that 59 businesses were oriented to small and medium business loans (35.8%), oriented to large companies' loans were 106 businesses (64.2%). Meanwhile, based on assets owned by financial institutions, it shows that financial institutions with assets of 3 Billion are 46 institutions (27.9%), assets of 5 billion are 90 institutions (54.5%), and those with assets of > 5 billion are 29 institutions (17.6 %). The following table 1 below will be explained in detail.

In the next stage, the researcher conducted a cross-analysis based on the characteristics of the respondents. The results of data processing, it was found that there were 16 Man employees with Diploma education (9.70%), having Bachelor's degrees as many as 67 employees (40.61%) and 16 employees holding Master's degrees (9.70%). Meanwhile, for Woman employees who have a Diploma degree, as many as 12 employees (7.27%), having a Bachelor's degree as many as 46 employees (27.87%) and who have a Master's degree as many as eight employees (4.85%).

The results of data processing by linking gender to business characteristics show that the number of male employees who market credit to small and medium enterprises is 26 employees (15.75%), and to market credit to

large companies is 73 employees (44.25%). Meanwhile, the number of female employees who market credit to small and medium enterprises is 33 employees (20%) and 33 employees in large companies (20%).

Based on the number of assets owned by financial institutions, it shows that the number of Man employees for 3 Billion assets is 36 employees (21.82%), for 5 Billion assets as many as 44 employees (26.70%) and for assets > 5 Billion as many as 19 employees (11.58%). Meanwhile, for Woman employees, there are ten employees for 3 billion assets (6%), 5 billion employees for 46 employees (27.90%), and ten employees for assets > 5 billion (6%). Data processing by comparing education to business characteristics shows that employees with Diplomas market SME business loans as many as five employees (3%) while marketing loans to large companies as many as 23 employees (13.94%). Employees with a Bachelor's degree market credit to SME as many as 47 employees (28.50%), and too large companies as many as 66 employees (40%). Meanwhile, for employees with a Master's degree, credit is targeted at SMEs as many as seven employees (4.26%), and in large companies as many as 17 employees (10.30%).

Based on data processing, by comparing the level of education to the assets of financial institutions. The results of the analysis show that there are 16 employees with Diploma degrees with assets of 3 Billion (9.70%), with assets of 5 Billion financial institutions as many as nine employees (5.45%) and with assets > 5 Billion as many as three employees (1.82%). Employees who have a Bachelor's degree, with assets of 3 Billion as many as 17 employees (10.30%), with assets of 5 Billion as many as 74 employees (44.85%), and with assets > 5 Billion as many as 22 employees (13.33%). Finally, there are 13 employees with a Master's degree with assets of 3 Billion (7.88%), with assets of 5 Billion as many as seven employees (4.24%), and assets > 5

Billion as many as four employees (2.43%).

**Table 1.** Respondents Characteristics

Respondent Profile	Frequency	Percent (%)
Gender:	99	60%
Man	66	40%
Woman		
Education:	28	17.0%
Diploma	113	68.5%
Bachelor	24	14.5%
Master		
<b>Business Characteristics</b>		
Business Credit:	59	35.8%
SMEs	106	64.2%
Large companies		
Business Assets:		
3 Billion	46	27.9%
5 Billion	90	54.5%
5 Billion	29	17.6%
<b>Gender* Business Credit</b>		
Man:		
SMEs	26	15.75%
Large companies	73	44.25%
Woman:		
SMEs	33	20%
Large companies	33	20%
<b>Gender* Business Assets</b>		
Man:		
3 Billion	36	21.82%
5 Billion	44	26.70%
5 Billion	19	11.58%
Woman:		
Billion	10	6%
Billion	46	27.90%
5 Billion	10	6%
<b>Education* Business Credit</b>		
Diploma:		
SMEs	5	3%
Large companies	23	13.94%
Bachelor:		
SMEs	47	28.50%
Large companies	66	40%

Master:	7	4.26%
SMEs		
Large companies	17	10.30%
<b>Education * Business Assets</b>		
<b>Diploma:</b>		
Billion	16	9.70%
Billion	9	5.45%
5 Billion	3	1.82%
Bachelor:		
Billion	17	10.30%
Billion	74	44.85%
5 Billion	22	13.33%
Master:		
3 Billion	13	7.88%
Billion	7	4.24%
5 Billion	4	2.43%
Amount	165	100

#### 4.2. Validity and reliability test

Hair et al. (2006) mentions that all constructs have size errors, even including variable indicators. Therefore, it is necessary to test the theoretical construction of each variable empirically. The variable indicator is said to be valid if it has an outer loading value  $> 0.5$ . Meanwhile, the indicator is said to be reliable if it has a composite reliability value  $> 0.7$ .

Based on the results of the validity, it shows that the employee engagement (EE) variables all indicators are declared valid. For the goal orientation variable, 4 (four) were omitted because they were invalid. For the competency variable, 1 (one) indicator is not valid. Meanwhile, for the job performance variable, 3 (three) indicators are not valid. The following is in Table 2, an explanation of the results of the validity and reliability tests.

**Table 2.** Respondents Characteristics

Variable	Outer Loading	Remarks
<b>Employee Engagement (EE)</b>		
Actively participates in meetings discussing work improvement	0.917	Valid
Employee activity assessment is always carried out	0.903	Valid
Involved in providing suggestions for improving work in workgroups	0.898	Valid
Management actively holding meetings to discuss organizational development	0.917	Valid
Bonuses are given based on work performance	0.904	Valid
Employees have responsibility for the work given	0.887	Valid
<b>Goal Orientation (GO)</b>		
Necessity to be able to fully understand the work	0.863	Valid
Belief in having more performance than coworkers	0.933	Valid
<b>Competence (COM)</b>		
Employees are required to show the best value of work competence	0.910	Valid
Work roles are in accordance with the competencies they have owned	0.904	Valid
Integrity assessment of the implementation of the work as a reference	0.924	Valid
The existence of training provided to improve competence	0.921	Valid
<b>Employee Performance (EP)</b>		
Involvement in the implementation of work	0.929	Valid
Level of job completion	0.914	Valid

After testing the validity of the indicators, the next step is to perform a composite reliability test. As a requirement in the composite reliability test, the composite value of the latent variable is  $> 0.7$ . Based on the test results, it was found that the composite value of variable reliability  $> 0.7$ . So it can be concluded that the questionnaire used in this study was reliable and consistent. Following Table 3, the results of the composite reliability test will be explained.

**Table 3.** Composite Reliability Test Results

Variable	Composite Reliability	AVE
Employee Engagement (EE)	0.953	0.837
Goal Orientation (GO)	0.964	0.818
Competence (COM)	0.918	0.849
Employee Performance (EP)	0.893	0.808

### 4.3. Inner model tests and hypotheses

The internal model or structural model used in this study is then evaluated based on the parameter value of the path coefficient of the relationship between latent variables (see Figure 1).

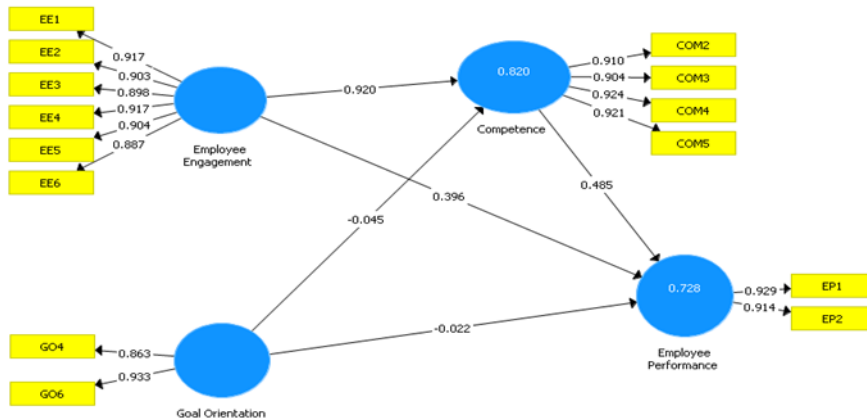


Figure 1. Path Coefficient and Hypothesis Testing

After testing the suitability of the model, it is possible to test the hypothesis. The basic hypothesis is made by comparing the magnitude of the t-table with the t-count at alpha 0.05 (5%) = 1.96. If the t-table is smaller than alpha 1.96 then the hypothesis is not accepted or rejected, and conversely if the t-table > 1.96 then the hypothesis is accepted or there is a significant effect between the two variables. The test results of the inner model in Table 4 show that all the relationships between the inner variables are significant at 0.05. This means that all hypotheses are accepted.

Employee Involvement (EE) has a significant effect on Employee Performance (EP) with a path coefficient of 0.396 and a value of  $t = 3.765$  (significance 0.000 less than 0.05). Employee Engagement (EE) will encourage an increase in Employee Performance (EP) The first hypothesis is accepted. Goal Orientation (GO) has no significant effect on Employee Performance (EP) with path coefficient -0.022 and  $t$  value = 0.460 (significance 0.645 greater than 0.05). Goal Orientation (GO) does not encourage an increase in Employee Performance (EP) The second hypothesis is rejected. Employee Involvement (EE) has a significant effect on

Competence (COM) with a path coefficient of 0.920 and a value of  $t = 52.790$  (significance 0.000 less than 0.05). Employee Involvement (EE) encourages an increase in Competence (COM) The third hypothesis is accepted. Goal Orientation (GO) has no significant effect on Competence (COM) with path coefficient -0.045 and  $t$  value = 1.316 (significance 0.189 is greater than 0.05). Goal Orientation (GO) does not encourage an increase in Competence (COM) The fourth hypothesis is rejected.

Competence (COM) has a significant effect on Employee Performance (EP) with a path coefficient of 0.485 and a value of  $t = 4.646$  (significance 0.000 less than 0.05). Competence (COM) will encourage Employee Performance (EP) The fifth hypothesis is accepted. The next step is to test the hypothesis of the indirect impact of the mediating variable Competence (COM). First, the predictor variable Employee Engagement (EE) has a significant effect on Employee Performance (EP) through Competence (COM) with a path coefficient of 0.446 and a value of  $t = 4.607$  (significance 0.000 less than 0.05). Employee Engagement (EE) drives Employee Performance (EP) through Competence (COM) Hypothesis six

is accepted. Second, the predictor variable Goal Orientation (GO) has no significant effect on Employee Performance (EP) through Competence (COM) with path coefficient  $-0.022$  and  $t$  value = 1.252

(significance 0.211 greater than 0.05). Goal Orientation (GO) encourages Employee Performance (EP) through Competence (COM) Hypothesis seven is rejected.

**Table 4.** Inner model test result

Hypo thesis	Path	Original Sample (O)	Sample Mean (M)	Standard Error (STERR)	T Statistics ( O/STDEV )	Sig.
1	EE -> EP	0.396	0.398	0.105	3.765	0.000
2	GO -> EP	-0.022	-0.020	0.048	0.460	0.645
3	EE -> COM	0.920	0.920	0.017	52.790	0.000
4	GO -> GOM	-0.045	-0.046	0.034	1.316	0.189
5	COM -> EP	0.485	0.482	0.104	4.646	0.000
6	EE -> COM -> EP	0.446	0.444	0.097	4.607	0.000
7	GO -> COM -> EP	-0.022	-0.022	0.018	1.252	0.211

## 5. Conclusion

The results of this study prove that employee engagement behavior can improve employee performance which in turn improves the organizational performance of financial institutions. Financial institutions are fully aware that currently, they are required to create employee effectiveness and efficiency. This is due to the impact of the COVID-19 pandemic, which has affected income. Therefore, to be able to cover expenses, it is necessary to select the best employees who can help the organization.

Based on the description above, the selection of the best employees by the organization is also strict. As the basis for the assessment is the magnitude of the performance impact generated by the employees themselves. Therefore, the role of employees in work engagement is needed by the organization. The results of this study, as well as strengthen the findings of previous studies that employee involvement can improve employee performance (Anitha, 2014; Yang, 2012).

However, different results were obtained that goal orientation has no effect on employee performance (Lim & Shin, 2020), and on

employee competence (Fang et al., 2019). These results indicate that when changes in responsibilities and work environment affect the goals to be achieved.

During the current uncertain COVID-19 pandemic, financial institutions have shifted their focus to the aspect of collecting customer installment payments rather than selling credit. This change eventually causes employees to become confused and pessimistic about the achievement of their personal goals. This usually happens when marketing employees successfully process credit, customers receive sales incentive money.

However, the current difficult situation has resulted in financing institutions making efficient spending of incentives. As a final impact, it causes a decrease in employee goal orientation in doing work. There is no impact of goal orientation on performance and competence because employees experience a high level of stress from the given workload (Fang et al., 2019). So that finally raises the behavior of employees who are not motivated in doing work.

As a result of changes in business strategies carried out by financial institutions, it requires employees to be able to improve their

competencies. In this study, it is shown that employee competence has an effect on the performance produced by employees. In other words, these results agree with research conducted by (T.-Y. Kim & Kim, 2013; Rahimić et al., 2012; Y. Wang & Haggerty, 2011). This also shows that competence aims to form superior human capital owned by financial institutions (Becker & Huselid, 2010).

The advantage of human capital owned by financial institutions is the ability of employees to carry out new roles and responsibilities from the work they do. As explained above, the current business strategy carried out by financial institutions is trying to obtain customer installment payments. Therefore, employees are expected to have the ability to negotiate, seduce and control customers to be able to make loan installment payments on time.

In building the competence of employees who are ready to change jobs, it is necessary to have the desire of employees to be involved in work. It is intended that the involvement of employees in work will provide additional knowledge of employees on other aspects of work, in this study, where employees of the marketing department are required to be able to collect customer credit. Collecting customer credit itself is not the responsibility of the initial marketing department. However, due to the COVID-19 pandemic, where marketing is low, and customer credit arrears are high, employees are directed to the billing sector. On the other hand, these activities will

have an impact on the emergence of competence from within employees through additional knowledge (Wallace et al., 2016).

This research contributes to strengthening theory and science about the need to bring up targeted employee work engagement behaviors, strengthening competencies, and creating an increase in employee performance behavior in the face of the COVID-19 pandemic so that ultimately it can improve the business performance of financial institutions. Effectiveness in the management of human resources must be directed at achieving organizational goals.

This research also provides practical implications for the assumption that creative and innovative employees are essential and needed by organizations in winning the competition. This is because employees who can effectively optimize their competencies will be unique, rare, and valuable to the organization. Employees carry out this effort in order to survive and obtain more value than other employees. The need for financial institutions to have superior and skilled employees is a challenge for employees to prove the quality of their behavior in carrying out their work. This is inseparable from the assessment of employees' work based on the achievement of the resulting performance. Leaders of financial institutions must also create support for employees to increase the desired work results. In the end, the work of these employees will impact the viability of the financing institution in the future.

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## **PRODUCTIVE WAQF EMPOWERMENT MODEL CONTRIBUTION BY THE WAQF AGENCY INDONESIA SOUTH KALIMANTAN AGAINST THE DEVELOPMENT OF WAQF**

***Abstract:** Waqf is a source of state income with great potential to empower the Islamic economy. The contribution of the productive waqf empowerment model cannot be separated from the supervision of the Indonesian Waqf Board. Supervision at the provincial level is supervised by the Provincial Indonesian Waqf Board as an independent institution in charge of empowering the productive waqf. In this study, the supervisory process carried out by the Indonesian Waqf Board in South Kalimantan is focused on the contribution of the productive waqf empowerment model by the Indonesian Waqf Board, South Kalimantan to the development of the Islamic economy. The purpose of this research is to find out how the contribution of the Indonesian Waqf Board and the implementation of the empowerment model applied by the Indonesian Waqf Board to the Islamic economy. This is a descriptive research with a sociological and normative approach. The technique in collecting data was through observation, interview, documentation and triangulation with the determination of informants through purposive snowball sampling. The results of this research showed (1) the model of waqf for the development of building in the form of development of facilities and infrastructure, and (2) the model of waqf for business development including in the sectors of agriculture, livestock, and business units. Those two models were then related to the management including investment management and management of the distribution of benefit distribution of productive waqf. The Management of Indonesia Waqf Board, South Kalimantan was by implementing the Human Resources empowerment with the supervision to the Nazhir based upon the law of waqf, sharia economic system, and waqf administration or entrepreneurship. Those managerial processes cannot be apart from the leadership factor. The supervision was carried out through direct supervision by the staff of BWI, South Kalimantan and the Ministry of Religion to supervise the wealth of productive waqf. Thus, the empowerment and management of waqf in South Kalimantan were in line with the vision and mission based upon the Islamic values. It aims to create an independent economy and welfare for people.*

***Keywords:** Contribution, Implementation, Productive Waqf Model, Islamic Economics*

### **1. Introduction**

Waqf has the meaning of a gift, by holding back the original ownership (taḥbisul aṣhli) and take advantage of universal or general validity. The meaning (taḥbisul aṣhli) is to hold a waqf item that is not inherited, sold, donated, pawned, leased and so on. This utilization is based on a waqf contract (wāqif) without considering rewards or benefits.

While wa kaf literally means stopping, holding back, or being silent. This is illustrated by the parking area called māuqif because it is a place for vehicles to stop to perform worship at the mosque or it can also be qiyaskan by Padang Arafah as māuqif where pilgrims stay to stand before carrying out the requirements of the pilgrimage. Technically sharia, waqf is an asset allocated for the benefit of the people where the substance or principal is withheld, while the benefits may be enjoyed for the public interest.

The practice of waqf was known before the advent of Islam, many places of worship were built on vacant land which were then managed and the proceeds were used to pay for maintenance and fees for those who take care of the places of worship. This practice is well known in countries such as Egypt, Rome and Germany which have made waqf beforehand. Egyptian Country, The second King Ramses made use of the "Adibus" place of worship, which had a very large area. This culture introduces that the person who manages the assets left by the deceased (inheritance), the distribution of the proceeds is given to the family and their descendants, so that those who manage it can take part of the property but the main assets may not become the property of anyone. This endowment also developed until Islam came and ran based on Islamic teachings until finally endowment became known in Indonesia.

The history of Indonesian waqf has a duty in the development of social, economic and cultural activities of Islamic society. Waqf as a regulatory instrument in terms of education

in all fields of science. Because waqf has succeeded in building economic empowerment facilities for welfare or maslahah for the community. Meanwhile, Islamic economics is one way of economic development, and a legal action that is institutionalized and practiced in Indonesia. Along with the times, waqf institutions have been institutionalized very rapidly. The development of waqf from time to time is not supported by formal regulations that regulate it, so far the practice of waqf is only guided by traditional fiqh books which have been used as the foundation by classical society. Along with developments, waqf regulations and institutions were established for government intervention. The presence of this legislation is a new change in waqf, and makes progress.

Law No. \_\_ 41 of 2004 concerning waqf has made changes in the development of Indonesian waqf to be more advanced, developing, of course, by obtaining a strong and solid legal basis. Establishment of the law on waqf as the goal of Muslims who have been working on waqf issues, for academics and practitioners. There are many new things which in the previous laws and regulations have not been regulated very systematically, and logically one of them is about immovable or movable waqf assets.

The formation of the Waqf Law in a structured, systematized manner in management and implemented by the Nazir who is in charge of carrying out the waqif mandate (who gives waqf). An example is a piece of land. Then, over time, many economic actors changed the classical view of waqf before it developed meaningfully from the literal meaning and the technical meaning related to the existence of the "eternity" of the main element (substance) where it must stop, may not be sold or transferred to other than the interests of the people who mandated by waqif to nazir waqf. This is based on the understanding and meaning of waqf itself.

The Indonesian Waqf Board (BWI) was



formed by the government as a manifestation of implementing Law Number 41 of 2004 concerning waqf and Government Regulation no . 42 of 2006, which the presence of BWI in article 47 to promote and develop waqf in Indonesia. Meanwhile, BWI's task is to develop waqf management in Indonesia in a more professional and productive direction so that waqf is truly able to make a positive contribution to the country's economy.

The waqf property will benefit the message of Islam. Waqf in Islam is something that is circumscribed, because it is one of the actions to get the pleasure of Allah SWT. This is as Allah swt. said in QS Ali-Imran / 3:92.

أَلَنْ تَتَالَوْا الْبِرَّ حَتَّى تُنْفِقُوا مِمَّا نَح

"You will not get virtue, before you spend some of the treasures that you love. And whatever you spend about it, verily Allah knows . "

Another argument that forms the legal basis for waqf is QSAI-Hājj/22:77.

أَمْؤُوا أَرْكَعُوا وَاسْجُدُوا يَا أَيُّهَا الَّذِينَ

"O you who believe, bow down, prostrate yourself, worship your Lord and do good, so that you may be victorious . "

The development of the waqf empowerment model in a professional manner is marked by the many potentials of productive waqf for the benefit of human welfare. Productive waqf is a waqf object or property whose principal remains is that the waqf is not directly used to achieve its goals, but is developed first to produce something and is useful (productive) and the results are distributed or used according to the purpose of the waqf, such as endowments of land to be used for farming , water to sell the water and others without removing the land.

Productive waqf is not something new, but so far the implementation has mostly been on

immovable waqf objects and their allocation has been more for the benefit of mahdhah worship , such as mosques, prayer rooms, Islamic boarding schools, cemeteries. Economically, waqf is expected to be able to build productive assets through current investment and production activities, to be utilized for the results for future generations and continue to benefit the general public.

This utilization is carried out through waqf management through two models; namely traditional management models such as āriyah , ištibda, Iyadāh, and ijarātain , and institutional management models such as murabaha , ištīṣna , ijarah, and mudārabah models. This method develops based on a system of Islamic economic principles and develops in the management of waqf, namely through the management of production quotas, cooperation shares, waqf object bonds, monopoly shares, and loan bonds. Meanwhile, from the waqf development management system, it must be carried out professionally by managers of several aspects, including institutional aspects, financial aspects, and human resource aspects. The targets achieved in waqf management include targets for the benefit of religious, educational, social facilities, and for the benefit of business facilities based on waqf objectives.

The development of waqf in Indonesia is increasingly sticking out, this can be seen from the increasing number and objects of waqf assets, including land, money, and others, which are spread across several parts of Indonesia. The data shows that waqf land is always developing, in 2010 there were 415,980 waqf land objects in Indonesia, in 2013 there were 435,395 land objects, with an area of 414,246.429 hectares of waqf land in Indonesia. Meanwhile, cash waqf moves in 2010 were started by the Cash Waqf Movement which was intensified by the Indonesian Waqf Agency (BWI) with a capital of 2 billion rupiah, until 2015 the money was collected at 185 billion. This

increase is a great potential and an extraordinary asset, and becomes a new pillar in the community's economic development. According to data owned by the Ministry of Religion in 2018 AD, the wealth of waqf land in Indonesia is very large in number, namely 435,765 location points with an area of 4,359,443,170 M<sup>2</sup> of which 287,608 locations have been certified and around

148,160 have high economic potential. The magnitude amount things waqf, in particular land And building become very opportunity big for economic development \_ people in the future g. Data from the directorate of waqf of the Ministry of Religion in 2010 in BWI annual reports throughout Indonesia, including waqfs that have just used the Waqf Pledge Deed (AIW) and are also

**Table 1.** Data Potensi Wakaf berdasarkan BWI Tahun 2018 (Lanjutan, Source: BWI, 2018)

Province	Location	Wide	Certified	Not Certified	%Certified Wakaf Land
1 Nanggroe Aceh Darussalam	27,416	1,333,233,627,26	12,245	15,171	45
2 West Java	70,749	116,662,017,81	45,401	25,348	64
3 South Kalimantan	8,772	110,208,613,54	7,271	1,501	83
4 Riau	7,897	978,448,625,81	2,761	5,136	35
5 West Nusa Tenggara	11,793	83,060,488,00	7,635	4.158	65

This data shows that the largest number of waqf land locations is the province of West Java, but in terms of area of waqf land, the dominant one is the province of South Kalimantan. This percentage of waqf land has great potential in the development of productive waqf because of the wide area of waqf land.

By having great potential this was conveyed by the President. This issue is seen from the waqf potential of South Kalimantan Province, there are around 8772 locations of unproductive waqf land with an area of approximately 110 208 613.54 square meters and around seven thousand square meters are certified. The latest information stated that at the inauguration ceremony of BWI South Kalimantan for the 2018-2021 period it was stated that the waqf in South Kalimantan of 90201 waqf points had not been used which had great potential, for the regional area of Kalimantan and the Chairman of BWI South Kalimantan. Mr. Fadly Manshur stated that with the formation of BWI, it is hoped that the productive economy will increase as a result of empowering productive waqf. Empowerment of waqf is of course able to see what contribution is made by the South

Kalimantan Indonesian Waqf Agency, and what implementation has been implemented as a support for the development of waqf. Of course, with the development of waqf, several empowerment models carried out by BWI South Kalimantan are a role model that will become the center point for the potential development of waqf in Kalimantan. From the potential and the model that is carried out as a contribution and implementation, this will make an empowerment, so the writer is interested in writing in a research title "The Contribution of the Productive Waqf Empowerment Model by the Indonesian Waqf Board of South Kalimantan Province to the Development of Waqf".

## 2. Theoretical Framework

Then the researcher takes several theories that support researchers in conducting research.

### 2.1. Waqf concept

The word waqf comes from Arabic with the connotation وقف يقف وقفا which means to stop or stand. Waqf is also known as الحيس which comes from the verb حبس يحبس حبسا which

means to keep people away from something or imprison it. Then this word developed into *حبس* which means donating wealth for the sake of Allah.

In terms of language, waqf means holding. Meanwhile, according to the term *syara'*, is holding something that is eternal substance, to be taken advantage of for the good and progress of Islam . Withholding an object whose substance is eternal, meaning that it is not sold and is not given away nor is it inherited, but is only given as charity for its benefits.

Waqf in the science of *tajwid* implies stopping reading, either onwards or to take a temporary breath. According to the rules, a reader cannot stop in the middle of a syllable, it must be at the end of a word at the end of a verse so that the reading is perfect. The definition of waqf in the sense of staying in place is related to staying at Arafah on the 9th of Zulhijjah when performing the pilgrimage. Without standing at Arafah there is no pilgrimage for a person.

There are several definitions of waqf, including:

According to the Shafi'i and Hambali schools of thought, a person withholds his wealth so that it can be utilized in all areas of benefit while continuing to perpetuate this wealth as a *taqarrub* to Allah swt.

According to the Hanafi school, holding property so that it becomes the law of Allah SWT, then someone who donates something means that he relinquishes ownership of the property and gives it to Allah so that it can provide benefits to humans permanently and continuously, may not be sold, donated, or inherited . .

The Maliki school of thought is giving something that benefits from assets, where the principal assets are permanent or sustainable for the ownership of the beneficiary even for a moment.

According to Imam Abu Hanafi , it is withholding property in the possession of waqf and giving charity, the results of which

can distribute the benefits of these assets to those they love. Based on this definition from Abu Hanifah , the property is under the control of the waqf person ( waqif ) as long as he is still alive, and can be passed on to his heirs if he dies either to be sold or donated.

Waqf according to *syara'* terms according to Zainuddin Al-Malibary is "Restraining property that allows it to be utilized accompanied by the immutability of the object by deciding the classification in its custody of the manager who is allowed to exist".

Waqf according to government regulation no. 28 of 1977 is a legal act of a person or legal entity which separates some of his assets in the form of owned land and institutionalizes them forever. For the purposes of worship or other public purposes in accordance with the teachings of Islam.

From this definition it can be concluded that waqf is one of the types of gifts, but only the benefits may be taken, and the objects must remain intact. Therefore, assets that are eligible for waqf are assets that cannot be used up and generally cannot be moved, such as land, buildings and the like. Mainly for the public interest. For example for mosques, prayer rooms, Islamic boarding schools, orphanages, public roads, and so on.

In article 215 paragraph 1 of the compilation of Islamic law, it is stated that waqf is a legal act of a person or group of people that separates part of their property and institutionalizes it forever for the benefit of worship or other public purposes in accordance with Islamic teachings. The legal source of waqf in the Qur'an is not very clear but has the meaning of "giving property" unlike zakat. But the legal basis in the Qur'an regarding waqf is related to QS Al-Hājj: 77, QS Āli Imrān: 92, QS Al-Bāqarah: 261 , QS An -Nahl: 97 and QS Al-Bāqarah verse 282. The verses above mention a variety of worship which can cover many things and can even include daily activities to seek the pleasure of Allah SWT with orders to do

worldly and spiritual virtues, both those based on revelation and values that are in line with sharia objectives, both in the form of laws and regulations. These laws and traditions and customs and verses also explain when and how a person's property will be useful, namely by spending the assets he likes (including endowments).

As for one of the hadiths of Rasulullah SAW, namely :

أصاب عمر أرضاً بخيبر فأتى النبي صلى الله عليه وسلم يستأمره فيها فقال يا رسول الله إني أصبت أرضاً بخيبر لم أصب مالا قط هو أنفس عندي منه فما تأمرني به قال إن شئت حبست أصلها وتصدقته بها قال فتصدق بها عمر أنه لا يباع أصلها ولا يبتاع ولا يورث ولا يوهب قال فتصدق عمر في الفقراء وفي القربى وفي الرقاب وفي سبيل الله وابن السبيل والضيف لا جناح على من وليها أن يأكل منها بالمعروف أو يطعم صديقاً غير ممتول فيه قال فحدثت بهذا الحديث محمداً فلما بلغت هذا المكان غير ممتول فيه قال محمد غير متائل مالا قال بن عون وأنبأني من قرأ هذا الكتاب أن فيه غير متائل مالا

"Umar got a piece of land in Khaibar then he went to the Prophet Muhammad saw. to ask for guidance on how to manage it, he said: "O Messenger of Allah, I got a plot of land in Khaibar, I have never obtained wealth that is better than this, what is the suggestion in this regard? He said: if you like it, you hold the land and you give the benefits of it. So Umar donated the produce of the land on condition that the land could not be sold, bought, inherited or donated. Umar donated the proceeds to the poor, relatives, to free slaves, jihad fisabillah, for provisions for people who were on their way and for guests' meals. The person who takes care of it may eat some of the produce in a good way and may feed his friend in moderation." (HR Muslims) .

Although basically the mujtahid imams differed in their views on waqf institutions, all of them agreed that forming a waqf institution required pillars and conditions for waqf.

## 2.2. Indonesian Waqf Board

The Indonesian Waqf Board (BWI) was established as a manifestation of the mandate outlined in Law Number 41 of 2004 concerning waqf. The presence of BWI, as explained in article 47, is to promote and develop waqf in Indonesia. For the first time, BWI Membership was appointed by the President of the Republic of Indonesia, in accordance with Presidential Decree (Kepres) No. 75/M of 2007, which was stipulated in Jakarta on 13 July 2007. Thus, BWI is an independent institution to develop waqf in Indonesia, which carries out its duties free from the influence of any power, and is responsible to the community. BWI consists of an Executing Agency and The Advisory Council is chaired by one chairman and two vice chairmen who are elected from and by the members.

The implementing agency is the executor of the task, while the Advisory Council is the supervising element of BWI's task implementation. The number of members of the Indonesian Waqf Board consists of at least 20 (twenty) people and a maximum of 30 (thirty) people who come from elements of society. (Articles 51-53, Law No.41/2004). Members of the Indonesian Waqf Board are appointed and dismissed by the President. The task of BWI is that representatives of the Indonesian Waqf Board in the regions are appointed and dismissed by the Indonesian Waqf Board. Members of the Indonesian Waqf Board are appointed for a term of 3 (three) years and can be reappointed for 1 (one) term of office. For the first time, appointment of membership The Indonesian Waqf Board is proposed to the president by the minister. The recommendation for the appointment of the membership of the Indonesian Waqf Board to the President is to be carried out by the Indonesian Waqf Board. (Articles 55, 56, 57, Law No.41/2004).

In accordance with Law no. 41/2004 Article 49 paragraph 1 states, BWI has the following duties and authorities:

- a) Provide guidance to na dzir in managing and developing waqf assets .
- b) Managing and developing waqf assets on a national and international scale.
- c) Give approval and or permission for changes in the designation and status of waqf assets.

In paragraph 2 of the same article it is explained that in carrying out its duties BWI can cooperate with both Central and Regional Government agencies, community organizations, experts, international agencies and other parties as deemed necessary. In carrying out these tasks BWI pays attention to the suggestions and considerations of the Minister and the Indonesian Ulema Council, as reflected in article 50. Regarding the task of fostering na dzir , BWI has taken several strategic steps, as stated in PP No.4/2006 article 53, includes:

- a) Preparation of operational supporting facilities and infrastructure for na dzir good waqf individuals, organizations and legal entities.
- b) Preparation regulation, gift motivation, gift facilitation, coordination, empowerment and development of waqf assets.
- c) Provision of facilities for the Waqf certification process.
- d) Preparation and procurement of AIW forms, both immovable and immovable waqf or moving objects.
- e) the regions to carry out guidance and development of waqf to na dzir according to their scope.
- f) Providing facilities for the entry of waqf funds from within and outside the country in the development and empowerment of waqf.

The strategy for realizing the vision and mission of the Indonesian Waqf Board is as follows:

- Improving the competence and

network of Indonesian waqf bodies, both nationally and internationally.

- Make regulations and policies in the field of waqf.
- Increasing public awareness and willingness to donate waqf.
- Increase Nazir's professionalism and trustworthiness in the management and development of waqf assets.
- Coordinating and fostering all nazir waqf.
- Ordering the administration of waqf assets.
- Supervise and protect waqf assets.
- Collect, manage and develop property waqf on a national and international scale.

### 2.3. Empowerment of Productive Waqf

Productive waqf requires empowerment with a pattern or model of empowerment and good management in fulfilling the objectives and benefits of productive waqf. This is a management goal is to string together the process of planning, strategic, managing resources and asset development.

Empowerment will not be separated from productive waqf organizations with a model of collecting, managing and distributing benefits. However, in general an institution implements an initiative and flexible method. This method is a combination of collection which aims to :

- Gather D ana

Raising funds is a collection of the most basic goals. The funds here are waqf funds, operating funds, waqf management, goods or services that have material value. The purpose of raising funds is the first thing in management. This activity is a collection that fails and does not generate resources, so that the institution will find it difficult to continue to maintain the continuity of its program.

- Increase Donor/ W akif

The second purpose of collection is to add

wakif . Nadzir who does the collection must increase in number. To be able to increase, there are two ways that can be taken, namely by adding a new donation or wakif . Among the two most relative things in increasing the amount of donations from each wakif.

- Improving or Building Institutions \_

Activities carried out by a Non-Governmental Organization (NGO), either directly or indirectly will affect the image of the institution. Collection is the front line that conveys information and interactions will shape the image of the institution in the general public. Everyone who evaluates the institution, which ultimately shows the positive attitude or behavior of the institution. This goal is a positive image, support and sympathy will flow automatically to the institution, so that there are no difficulties in finding waqif.

- Gathering Sympathizers/ Relations and Supporters

Groups that interact with collection activities by Waqf Management Organizations or Non-Governmental Organizations. they have a positive impression and sympathy for the institution. However, it could be that at that time they did not have the ability to provide funds to the institution as a donation. Such groups then become sympathizers and supporters of the institution even though they do not become wakif directly. Such groups are taken into account in collection activities. The purpose of this collection in groups is as an informal network that is very profitable in gathering activities.

- Increase Donor Satisfaction

Increasing donor satisfaction is satisfying wakif . This goal is the highest and most valuable long-term goal, which was performed as a technical in the days. Waqif

satisfaction greatly affects the value of donations that will be given to the institution. They will donate their funds to the institution positively to others. In addition, a satisfied wakif will become a natural collection worker (unsolicited, appointed and unpaid). Because the collection function interacts more with the waqif , automatically the collection activities must also aim to satisfy the waqif .

Empowerment of productive waqf can be implemented in various ways. Productive categories that can be carried out include: collection methods, investment, investment, production, partnerships, trade, agribusiness, mining, industry, technology development, building construction, apartments, flats, supermarkets, shops, offices, educational facilities, businesses -Businesses that do not conflict with sharia.

In the context of developing productive waqf, there are two models of financing productive waqf projects, namely the business development and building construction models. This model is the development of productive waqf as follows:

1) *Business development waqf model*

In 2006 the productive waqf empowerment model in the business sector of agribusiness, animal husbandry and small industry began to be considered. This interest is because the wheel of the national economy is growing. And for Indonesia itself, it has two very large natural resource potentials, so these are several economic endeavors and models for developing waqf and empowering productive waqf.

However, in empowering waqf in the field of business, several things need to be considered, namely, productive waqf management requires objective selection of businesses to make the right technology as selling power in society. Guarantee from the entrepreneur that the business will not have a negative impact on the surrounding environment. There is a marketing model. And the need for moral commitment, namely compatibility between business behavior and

its social implications, business behavior includes, professionalism, honesty, transparency and trustworthiness

2) *Waqf Model Development -- building --*  
The development of waqf in Indonesia and other countries is very different and not significant. However, recently the development of waqf has been carried out a lot. In Egypt, for example, Al-Azhar University carries out its activities using waqf funds. The university manages buildings or companies on the Seuz canal, and this campus only takes the proceeds for educational purposes. In Qatar and Kuwait, waqf funds have formed office buildings. This area was leased and the result was the empowerment of waqf funds, Islamic educational institutions such as Sal-Azhar University in Cairo, Zaitunniyyah University in Tunis, and Madaris Imam Lisesi in Turkey and have developed and are able to survive until now. They do not only rely on development funds from the government, but also endowments as a source of financing for all administrative and academic activities.

#### **2.4. Development of Waqf**

The development of waqf in Indonesia is currently growing, this can be seen from the many additions that have occurred in the number and objects of waqf assets. The recap of waqf land that occurs from year to year certainly has significant additions, this makes a waqf development. Of course, these numbers continue to increase every year, proving that waqf assets have great potential. This potential certainly makes a resource for highly developed economic development and plays a major role in the economy. This economy is also associated with the development of waqf making this utilization useful for public activities in the economic, social and religious fields. So that makes this potential develop from various kinds of empowerment. This empowerment certainly makes a development of waqf from various

models that occur, this includes productive waqf and economic development. For example, waqf and social responsibility, talking about waqf will talk about the economy, from cemeteries to business centers and counting waqf as a pillar of the Islamic economy. This development makes waqf development part of economic development. This development makes waqf in the modern era have waqf rules or policies through a set of positive laws. So that the formulation process looks at the potential and organization of waqf both in the interests of Muslims in general. So with this interest, of course, many productive waqf empowerment institutions encourage formal institutions or foundations to empower productive waqf.

#### **3. Research Methods**

In order for this research to run well and obtain results that can be accounted for, this research requires a certain method. The method of preparing this thesis is as follows: The type of research used is field research which can be called empirical research. Research done intensively, in detail and in depth on a particular object by studying it as a case with the intention of seeking a study of empirical data found in the field, which in this case is the productive waqf empowerment model at BWI South Kalimantan.

This study uses a sociological approach. The sociological approach referred to here is a study that focuses attention on community interactions. This approach aims to see how the social and cultural factors of the community or are affected by productive waqf either directly or indirectly.

In this study, researchers used triangulation to test the validity of the data used. Researchers chose to use triangulation techniques sources and methods. Where triangulation of sources refers to researchers' efforts to access more varied sources in order to obtain data regarding the same issue. The reason for using source trigulation is because source

triangulation is in accordance with the needs of researchers who want to test the reliability of data by checking the data obtained, then the data is described, categorized, and analyzed so that a conclusion is created. The triangulation used is to compare the results of interviews that have been conducted with documents in the form of reports on the implementation of productive waqf in one period and missions from BWI-South Kalimantan and researchers went directly to several areas to see first-hand the conditions of the productive waqf.

This is done what happened in the report of the Indonesian Waqf Board with the field that happened. For example, researchers went directly to several areas including the City of Banjarmasin with research at the Jami Mosque and the Hasanuddin Majedi Mosque. Banjar Regency with the Ushuluddin Tambak Hanyar Islamic Boarding School, Hulu Sungai Utara Regency Rakha Amuntai Islamic Boarding School, Langgar Al-Ikhlas Kota Baru, At-Taqwa Binuang Mosque in Tapin Regency, and the Great Mosque of Syuhada Tanah Laut.

#### **4. Research Results and Research Analysis**

##### **4.1. Productive Waqf Empowerment Contribution by BWI South Kalimantan**

The contribution made by the South Kalimantan Indonesian Waqf Board is as a supervisor and mentor. Supervisor here is as controlling to ensure that the actual activity is as planned. This supervision is of course an implementation to ensure that all systematics are planned, organized and executed based on the implementation that occurs. Systematics in this supervision is of course related to the empowerment of productive waqf as a function of supervision carried out by the Indonesian Waqf Board for nadzirs to evaluate the achievement of goals and targets

for activities carried out in the development of productive waqf.

Meanwhile coaching or leadership is a process of directing and influencing activities related to the work of group members or the entire organization. While the supervision carried out by the South Kalimantan Indonesian Waqf Board is to take leadership in implementing the coaching process and providing motivation to nadzirs who are recruited so that they can work effectively and efficiently in achieving waqf goals. Then, provide routine assignments and explanations regarding the work and policies set.

From the contribution of the South Kalimantan Indonesian Waqf Agency to the development of productive waqf presents an interactive process of productive waqf management functions. The productive waqf management function carried out is supervision in ensuring that productive waqf management achieves waqf goals and objectives. Then what is done in coaching or leadership is directing, influencing and motivating nadzir to carry out the tasks that have been implemented.

The productive waqf empowerment contribution is carried out based on the duties and authority of the Indonesian Waqf Board. This contribution can then be carried out based on the productive waqf empowerment model in collaboration with the Ministry of Religion. The South Kalimantan Waqf Board hereby makes a major contribution every year in the field of nadzir coaching which is overseen by the productive waqf management and empowerment division. Meanwhile, the coaching carried out by the South Kalimantan Indonesian Waqf Agency is to provide guidance to several waqf places that already have waqf certificates.

##### **4.2. Productive Waqf Model in Indonesian Waqf Agency South Kalimantan**

Waqf is basically an " economic corporation", with activities containing elements of future



investment and developing productive assets for future generations in accordance with the purpose of waqf, either in the form of services or utilizing the results directly. The development of waqf which continues to be engaged in is an utilization of the results of investment units. Investment is a main goal in economic development, property owned by a person to form production capital that is capable of producing benefits and can be used universally or in general. Islamic economics is related to waqf in terms of investment, namely distribution to them by the waqif in the waqf pledge.

Economically, waqf is a development paradigm from productivity in an investment activity for their benefit based on the pledge made by the wakif. Thus, the results or products of waqf assets can be divided into two parts. First, direct waqf is a waqf property that produces services in the form of goods for direct consumption by people entitled to waqf, such as hospitals, schools, orphanages and settlements. Second, productive waqf which is managed for investment and production of goods and services that are permitted according to sharia . In this case, capital (waqf assets) is invested and distributed to those in need.

The new model in waqf management today is a potential development of productive waqf management as an investment in various companies either by contact or leasing. The model concept used in this productive waqf is the concept of the waqf model of management for the development of the Islamic economy by applying the productive waqf development model.

nadzir welfare principles , and transformation and responsibility principles. Seeing this, of course, an implementation of waqf can be implemented properly. This is of course a productive waqf that can be empowered with rapid development. This development is of course in the productive waqf empowerment model implemented by the Indonesian Waqf Board implementing the waqf empowerment

model including: (1) the building construction waqf model which includes the construction of hospitals, mini markets, ATM centers, shops, shophouses, multipurpose buildings, nest wallets, boarding houses, mini gas stations; and (2) a productive waqf model for business development which includes rice fields, plantations, tent rental, animal husbandry, and fisheries. Of these two implementations, of course, it is associated with contributions from the South Kalimantan Indonesian Waqf Board.

### *1. Productive Waqf Model for Building Construction*

The implementation of the productive waqf model carried out by the South Kalimantan Indonesian Waqf Agency in building construction is the construction of buildings that are on waqf land and then developed in the empowerment of productive waqf. Empowerment is of course building buildings with business and trading units which are used as tools for empowering waqf. Empowerment of waqf building construction models is dynamic in nature which is beneficial in developing the pace of development. Of course, the pace of development in the implementation of the waqf empowerment model in South Kalimantan is one of the influences of the productive waqf empowerment model which utilizes waqf land and then builds buildings that have benefits and can be productive.

The South Kalimantan Indonesian Waqf Agency in empowering productive waqf provides annual supervision in the field of building construction . Binuang, Tapin Regency.

### *2. Productive Waqf Model for Business Development*

The introduction of the productive waqf model in 2005 in the fields of business in the rice fields, plantations, livestock and fisheries sectors. Looking at this business, of course, many wheels of the national economy are driven in this field. Indonesia is very well known for its two potentials which have

enormous natural resources in the fields of agriculture or rice fields, and fisheries so that these two natural resources can certainly break the national economic needs of the people. Whereas South Kalimantan, in terms of this potential, certainly has great potential in empowering waqf in the field of fisheries, of which twenty productive waqf empowerments have 5 places empowered in this field. This is based on a very effective environment in the development of fisheries. The South Kalimantan Indonesian Waqf Agency in empowering productive waqf provides annual supervision in the field of business development. The South Kalimantan Indonesian Waqf Agency and the South Kalimantan Ministry of Religion provide assistance and guidance to a place that is considered capable of developing productive waqf, one of which is the Rakha Amuntai Islamic Boarding School. North Hulu Sungai District.

The implementation of the productive waqf empowerment model implemented by the South Kalimantan Indonesian Waqf Agency is of course implemented based on what has been done based on seeing the existing regional potential by implementing based on the vision and mission of the South Kalimantan Indonesian Waqf Agency for economic development efforts. Because of this, the waqf developed is part of economic development, with stages including planning, organizing, human resource development, leadership and supervision as well as with several empowerment models. With the main goal of creating waqf developments that continue to increase and produce an independent or protection economy.

#### 4.3. Analysis Empowerment Models Productive Waqf by BWI-South Kalimantan on Waqf Development

Looking at the results of the analysis of the contribution of the productive waqf empowerment model carried out by the

Indonesian Waqf Board of South Kalimantan, it can be seen from some of the data attached in table 4.2 which is linked to scheme 4.3 of managing productive waqf to the economy and then describes the supervisory strategy carried out by the Indonesian Waqf Board with basic values Islamic economics.

Supervision is one of the contributions made by the South Kalimantan Indonesian Waqf Agency by providing annual education and guidance to places that serve as models for empowering productive waqf. From this, of course, an implementation can be carried out with a productive waqf empowerment model which is supervised by the South Kalimantan Indonesian Waqf Agency and given guidance in empowering productive waqf.

This implementation certainly makes it an analysis in empowering productive waqf in which there are several rules that can be carried out based on the supervision strategy implemented by the Indonesian Waqf Board within the basic values of Islamic economics. As explained below:

- First rule

هُوَ مَا أُوجِبَ عَلَيْهِ عَلَى تَأْسِيهِ

" The law of origin in a transaction is the willingness of both parties to enter into a contract, the result will be enforced by the contractual agreement . "

This rule is the first rule associated with one stage of empowerment, namely leadership in a management. In this case, the head of the South Kalimantan BWI must be a figure, but in terms of obstacles in this empowerment, namely the role of actors who are very much needed to advance the empowerment of the waqf. Because based on the potential of waqf owned only a few are empowered, this is an example for other places to be empowered. 126 A leader in this case, of course, must be sincere and pleased with his decision as a nadzir and give up his life to develop the potential of waqf . This regulation is of course a function and authority of the leader not only to be administrative in nature, but also to

maintain Islamic values in his leadership. Several things can be taught from actors to nadzirs in management, for example conducting nadzir training and educating managers. This is a provision in developing waqf empowerment, and this training provision is of course also an example for other places.

- Second rule

الأصل صحة العقود والشروط 7 12

"Basically (all forms of transactions) in muamalah dah (permitted) and in the contract the (agreed) provisions apply."

This rule is associated with a planning stage of organizing forms and human resources (HR). This is an agreement contract that applies in planning and organizing must be based on a contract.

A plan is of course formed by the manager or caretaker to go hand in hand with the wakif's mandate that has been agreed upon in the contract. This planning is good in the short or long term which has been calculated by the investment and profit results. This profit will be used for two sectors, both the economic and social sectors, education which is spelled out in the implementation of waqf. for example this is for business development, the estimated profit from this result is to fulfill the wakif's mandate in the agreement.

With regard to physical organization, the model of empowerment in the form of a building or a business unit will not be separated from the expectations of the wakif. For example, if the wakif wants a place for business empowerment and other activities, of course the building is managed as much as possible to support other developments. This is exemplified in one of the places in the At-Taqwa Binuang Mosque where in addition to a minimarket business or this business a hall is built which is used for community activities. This community activity is free of charge provided that the community can look after, care for and protect it. 128

Not only physical organization, HR

organization is also needed, for example considering the quality of personnel in the placement of organizational composition in waqf management. This placement is based on SK BWI that is based on the benefit and purpose of empowerment.

- Third Rule

الأصل في المعاملات الإباحة إلا ما دلّ الدليل على تحريمه 129

"The law of origin in all forms of muamalah is permissible unless there is an argument that forbids it . "

This third rule is of course based on the mission of BWI-South Kalimantan, which is to develop the economy through waqf. Of course, this development or empowerment can be carried out in various ways, one of which is productive waqf.

Productive waqf has actually been regulated in the Qur'an and Hadith . However, the development of its practice demanded the ijthad of the majority of scholars, so that variations of waqf began to emerge, one of which was the productive waqf. This is shown in productive waqf transactions which are media in the development of muamalah transactions to support the regional economy. Of course, this transaction can be carried out based on no argument that forbids it and runs according to Islamic rules.

- Fourth Rule

لا تتم الهبة ولا تملك إلا بالقبض 131

"Not perfect 'aqad tabbaru' (gift) except after being submitted, (before being asked has been given)" .

This rule is associated with the stage between planning and organizing. Before waqf funds are further organized, it must be ensured that there is a sincere handover by the wakif to the na dzir . This handover is of course an item that becomes an object as a sign of the goods being handed over and a form of trust to the nadzir so that the management and empowerment of productive waqf is carried

out optimally, while the nadzir is obliged to follow the provisions of the wakif as long as it does not violate the conditions.

e. Fifth Rule

فِي كُلِّ الْمَعَامَلَاتِ وَمَنْعُ الظُّلْمِ وَمُزَاعَاةُ مَصْلَحَةِ

"The origin of every muamalah is fair and the prohibition of doing injustice and paying attention to the welfare of both parties and eliminating harm."

The fifth rule can be related to the stages of empowering human resources (HR), organizing finance, and supervising. With regard to human resource development, of course, a Nazir or in this study, BWI as supervisor of empowerment routinely oversees various aspects. This aspect is for example the legal basis of waqf, the Islamic economic system, waqf administration, and other related materials. With so many waqf potentials in South Kalimantan, of course, people can take advantage of this potential, and can be empowered.

These results indicate that coaching is not only related to law and administration, but also the Islamic economic system which is the embodiment of an Islamic economy that requires fair and good behavior to achieve masalahah. This is also the aim of maintaining the trust of wakifs and paying attention to the benefits of empowering productive waqf for the regions.

Regarding the financial organization of BWI South Kalimantan, financial management is of course with the main methods, namely collection management, investment management, and distribution management. Financial management begins to be carried out in a neat and orderly manner, the neatness of records can be carried out by minimizing the possibility of unjust financial storage and causing harm.

This rule relates to the supervision stage. Supervision of the management of productive waqf is carried out for administrative oversight, the performance of nazhir or BWI management, and financial management.

133,134,135 Supervision becomes control to guarantee and ensure that there are no saving practices that can reduce benefits and cause harm.

Based on the explanation of these principles, the productive waqf empowerment of BWI South Kalimantan in general has followed the principles of Islamic economics. The principle of Islamic economics refers to the principles of muamalah fiqh, especially those related to productive waqf. This linkage is based on the vision and mission of BWI South Kalimantan in general as a basis for planning, organizing, productive waqf empowerment models, human resource development, leadership, and supervision to achieve an independent economy in harmony with economic values.

## 5. Conclusion

From this explanation, in the contribution of the productive waqf empowerment model by the Indonesian Waqf Agency in South Kalimantan to the development of waqf, there is supervision from the institution on the development of the Islamic economy, so the researchers draw the following conclusions:

1. The contribution of the productive waqf empowerment model by the Indonesian Waqf Agency in South Kalimantan to support the Islamic economy is of course based on the model used. This is based on productive waqf management carried out by management, including planning, organizing, managing human resources, leadership and supervision. Productive waqf planning by the South Kalimantan Indonesian Waqf Agency is certainly a productive waqf that is neatly designed and arranged to achieve the vision of BWI South Kalimantan, namely the realization of an economy that is independent and beneficial to society. Supervision is provided based on waqf law, sharia economic system, and waqf administration or entrepreneurship. In addition to planning, of course, the management process cannot be

separated from the leadership factor. BWI South Kalimantan not only provides supervision but also provides annual education to nazirs or mosque managers.

2. Implementation of supervision of the South Kalimantan Indonesian Waqf Board with the aim of organizing from the physical and human resources (HR) side. This physical organization produces several models of empowerment, including (1) the waqf model for building construction; (2) The waqf model for business development. This model is implemented based on the vision and mission

of the South Kalimantan Indonesian Waqf Agency. The implementation of the Indonesian Waqf Board in South Kalimantan is an oversight of the models applied in empowering productive waqf. Then the implementation of the productive waqf empowerment model by BWI Kalsel in this case saw the development of the two models based on the vision and mission which are based on Islamic values. All government processes run in an orderly and structured manner so as to produce a protective or independent economy.

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## **PLANNING OF DA'WAH IN THE DIGITAL ERA**

***Abstract:** This study aims to analyze the planning of digital era da'wah, which focuses on the implementation of digital era da'wah plans, where technological advances in the digital era are unavoidable in global civilization. The research methodology used is qualitative with a phenomenological approach in describing the research, through observation, interviews and, through documentation, through primary data sources from respondents and secondary data as supporting data. The results of this study, in the can that Advances in science and technology in the field of information and communication technology can clearly support Islamic da'wah in the digital era, so planning for digital era da'wah is very meaningful and crucial in delivering da'wah at this time and in the future. Da'wah planning in the digital era then becomes strategic, where in this study it was found that the Da'wah Formula (Recipe) for Preachers in facing challenges in the Information and Communication Technology Era is a character possessed by da'wah cadres, undoubtedly lighter and easier to face challenges and obstacles in the Information and Communication Technology Era. Da'wah cadres and all da'wah activities will be stronger and accepted by the community, in presenting the various virtues that are expected by the people, nation and state. Apart from that, it can also package da'wah messages in the digital era, carry out digitization of da'wah through websites, and maximize da'wah videos in the digital era, so this shows that planning da'wah in the digital era is a reference for preaching.*

***Keywords:** Model, Da'wah, Digital Era of Information Technology, Communication*

### **1. Introduction**

Islam is a religion of da'wah, meaning a religion that always encourages its adherents to always be active in carrying out da'wah activities. The progress and setbacks of Muslims are very closely related to the da'wah activities they carry out. Da'wah is obligatory for every Muslim in all its forms. Conveying the teachings of Allah and His Messenger to others (al-Maidah: 67), by

carrying out all His commands invites all mankind to do good and forbid doing evil (Ali Imran: 104). Either by giving washingiyah or advice or by fighting to uphold Allah's religion (at-Taubah: 88). On the contrary, the doom will descend on anyone who is reluctant to carry out da'wah activities (al-Maidah: 79).

This is in accordance with the Word of Allah in the letter of Ali 'Imran verse 104 which reads: "And let there be a group of people

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among you who call for virtue, instructing those who are good and forbidding those who are evil, they are the lucky ones." (QS Ali Imran: 104). In addition, it is also mentioned in the Qur'an Surah al-Maidah verse 67 which reads: Meaning: "O Messenger, convey what has been sent down to you from your Lord. And if you don't do (what was ordered, it means) you don't convey His message. Allah protects you from (disturbing) humans. Surely Allah does not guide the disbelievers." (QS al-Maidah: 67).

From these verses it is explained that every Muslim is required to convey the message of Islam to all mankind by calling for good and forbidding evil, jihad, giving advice and so on. The religion of Islam functions as a mercy and blessing for all mankind, so Allah revealed this religion as a complement to the previous religions which cover the basic aspects of the world and the hereafter, which can guide humans to inner and outer happiness in this world and the hereafter. All of this can be achieved, one of which is with the existence of da'wah. Da'wah is an integral part of Islamic teachings that must be carried out by every Muslim. This obligation is reflected in the concept of amar ma'ruf and nahi mungkar; namely an order to invite people to carry out positive-constructive behavior while at the same time inviting them to leave and distance themselves from negative-destructive behavior. This concept contains two meaning implications at once, namely the principle of struggle to uphold the truth in Islam and efforts to actualize the truth of Islam in social life in order to save them and their environment from damage (al-Fasad).

In essence, Islamic da'wah is the actualization of the faith (theology) which is manifested in a system of human activities of the faithful in the field of society on a regular basis to influence the way people feel, think, behave and act on the plane of individual and sociocultural reality in order to strive for the realization of Islamic teachings in all aspects

of life. by using a certain method. Given the function and role of da'wah which is so important and decisive, the meaning of da'wah and everything related to it must be understood correctly and correctly, in line with the provisions of the Qur'an, the Sunnah of the Prophet and the Nabawiyah sirah which contain instructions on how to carry out da'wah. , so as to produce individuals who are istiqamah and tough; and gave birth to an order of life in an Islamic society. The community as the object of da'wah or the target of da'wah is an important element.

Therefore the problems that occur in society can be studied as well as possible before moving on to actual da'wah activities. As a provision for da'wah for a preacher or preacher, he should equip himself with some knowledge and experience that is closely related to the problems faced by the community itself. Besides that, da'wah also seeks to build a more qualified Islamic society (khairu ummah) which is fostered by the spirit of monotheism and the height of Islamic values. (Asmuni Syukir, 1983; 65) The purpose of da'wah in general is to save humanity from the valley of darkness and bring it to a place where which is bright from the misguided path to the straight path, from the valley of polytheism with all forms of misery to monotheism that promises happiness. (Awaluddin Pimay, 2005; 8).

Da'wah of Islam in the digital era is not free from various obstacles and challenges it faces. So that the da'wah of Islam will face various very complex and complicated problems. Today, at least the challenge of Islamic da'wah is related to the excesses of globalization and the reality of religious plurality. The rapid progress of science and technology has transformed human civilization from agricultural to industrial culture and then to the information and communication age. Vocabulary and at the same time a weapon that is so significant and determinant in the current era of globalization is the sophistication of information and

communication technology. Through information and communication technology networks in the era of globalization it continues to spread to all corners of the world. So that the reality of the world today with all its diversity, inequality and irony has become the nation's socio-cultural barriers and obscures the country's geographical boundaries. In the digital era where everyone can get and do something very easily and quickly. Maybe in the era before the invention of electronic media existed, that person needed various books and references in the form of books. Meanwhile, in this digital era, people just have to look for something they want on an internet site. All the necessary information will appear with the various models. The digital era is the peak where everything that is instant (fast) can be enjoyed by the public. A da'i (mubaligh) can preach through various media, both electronic and print media such as television, radio, YouTube, newspapers, magazines, bulletins, and others.

Sometimes I think that it's not only artists who want to appear on television, but preachers can too. In this era they get a comfortable behavior, a sense of peace because of the existing facilities. In general, da'wah carried out in a taklim assembly in a surau, mosque or prayer room takes place in a sacred and solemn atmosphere. Advances in technology and information allow a da'i to improvise with humor and other things, so that the lecture material remains interesting to listen to. Given the challenges of da'wah in the era of technology and information, especially the media, cannot be separated from entertainment. As a result, the missionary orientation played by the preachers is also growing, and even tends to be biased.

Initially, da'wah which had more contact with the realm of worship, was always based on the intention and motivation to worship as well, that is, it was carried out with joy, a sincere heart and only hoping for the pleasure of Allah SWT. However, in its development the

pattern of preaching through the media as a form of technological progress has become a challenge for a da'i. The influence of the media allows a da'i to gain popularity in the eyes of his audience like a celebrity (public figure) and does not rule out the possibility that his preaching activities are often judged by material.

In dealing with various problems that are increasingly severe and complex, as a result of the demands of the development of science, technology, globalization and the demands of needs, it is presumably that the da'wah activities carried out by individuals are inadequate. Therefore it should be carried out through an institution that is well organized and collects the necessary expertise. Therefore, the achievement of the objective of da'wah effectively and efficiently is in principle inseparable from how the da'wah can be prepared and planned in such a way, taking into account everything that might happen. This means that da'wah must begin with calculations that are accurate, thorough, precise and holistic. Such as, Who does what, when it is done, where it is done, what is needed and must be done, why must it be done and how to do it. Or in formulation. Pahlawan Kayo (2007 : 35), that preaching planning must at least be able to answer questions 1) What form of da'wah activity will be carried out? 2) What is the goal to be achieved in the da'wah activity? 3) Where is the da'wah activity carried out? 4) When or when the da'wah activity was carried out? 5) Who is involved in the da'wah activity? 6) What techniques and methods are used in the da'wah? Thus the existence of planning in carrying out da'wah becomes a very important and deterministic aspect in an effort to achieve the stated goals of da'wah. This is in accordance with what was stated by Dean R.Spizer, as quoted by Muhyiddin and Safei (2002: 134);

Those who failed to plan, plan to fail (who failed to make a plan, in fact he was planning a failure). According to Hasibuan (2011: 91),

a plan is very important, because 1) Without planning and planning means there is no goal to be achieved. 2) Without planning and planning there are no implementation guidelines so there is a lot of waste. 3). The plan is the basis of control, because without a control plan nothing can be done. 4). Without planning and planning means no decisions and no management process. In the context of da'wah activities according to Rosyad Shaleh (1997: 48), that with planning, the implementation of da'wah can run in a more directed and orderly manner, because with careful thought about what things must be carried out and how to do them in the context of da'wah, then it can be considered what activities should get priority and take precedence and which activities should be followed up. It is on this basis that the da'wah activities can be sequenced and arranged in such a way, step by step that leads to the attainment of the goals and objectives that have been set.

## **2. Research methodology**

In this study, researchers used a qualitative phenomenological approach that focused on planning the preaching of the digital era. To collect data, researchers determine data sources and locations where data sources can be found and researched. This field research is in the context of collecting data through observation, interviews and documentation through data sources, both primary and secondary sources. Based on the characteristics above, this research was carried out using library sources as secondary sources in order to support primary sources in collecting data closely related to Islamic Da'wah in the Digital Age. where the data source is an informant as the main source consisting of having their respective capacities from academics, preachers, and religious leaders.

While secondary sources are taken from literature, internet sourcing, dissertations,

theses and journals related to Islamic da'wah in the digital era with data mining techniques through: (1) Observation. Through observation the researcher can describe what happened, who or what was involved, when and where it happened, how and why it happened. Simply put, observation can be interpreted as a process of looking at the research situation. (2) Interview. Several things that need to be considered by a researcher when interviewing respondents are voice intonation, speed of speech, sensitivity to questions, eye contact, and nonverbal sensitivity. In seeking information, researchers conducted two types of interviews, namely interviews conducted with the subject or respondent and interviews with the respondent's family (Sugiyono: 2013: 227). (3) Documentation and immediately jump into the field of conducting research. The documents shown in this case are all related documents so that these documents can strengthen the data collected and analyzed in a study.

The method of determining the subject is determined by Purpose Sampling , namely determining the subject based on the research objective. This method focuses on selected informants who are rich in cases for in-depth studies (Nana Syaodih: 2012: 101). In research with a qualitative approach, the description of the subject/informant includes, initial informants and key informants and their characteristics (Nawari Ismail: 2015: 10).

## **3. Results and discussion**

Da'wah planning comes from the words planning and da'wah. Planning according to Agus Dharma (2003: 41), is the process of setting goals and objectives and determining how to achieve these goals and objectives. According to Winardi (1983: 149), planning is determining in advance what to do and how to do it. Then according to GR Terry, as quoted by Hasibuan (2011: 92), Planning is

the selecting and the relating of facts the making and using of assumptions regarding the future in the visualization and formulation of proposed activities believed necessary to achieve desired results. (Planning is choosing and connecting facts and making and using assumptions about the future by describing and formulating the activities needed to achieve the desired result).

Furthermore Hasibuan (2011: 9) came to a conclusion that planning 1) is the main function of the manager, the execution of work depends on the merits of a plan. 2) planning must be directed to the achievement of goals. If the goal is not achieved it may be caused by a lack of good planning. 3) planning must be based on objective and rational facts to realize effective cooperation. 4) planning must contain or be able to project events in the future. 5) planning must think carefully about the budget, policies, programs, procedures, methods and standards to achieve the goals that have been set. 6) planning must provide a working basis and background for other management functions. Meanwhile, according to Asmuni Syukir (1983: 17), the word da'wah comes from the word "da'a-yad'u. It means calling, inviting or calling. Then in terms of preaching it is inviting mankind with the wisdom of wisdom to follow the instructions of Allah and His Messenger (Hamzah Ya'cub, 1978: 13). Then when the word "planning" is combined with the word "dakwah", so that it becomes the word "preaching planning," according to Rosyad shaleh (1997: 54), da'wah planning is a process of thinking and making decisions that are mature and systematic, regarding the actions to be taken. in the future in the context of organizing da'wah.

Meanwhile, according to Munir and Wahyu Ilaihi (2006: 98) that da'wah planning is tasked with determining steps and programs in determining each target, determining da'wah facilities or media, as well as da'i personnel to be deployed, determining suitable material for perfect implementation,

making assumptions about various possibilities that can occur which can sometimes affect how the program is implemented and how to deal with it and determine alternatives f. Based on the explanation above, it can be understood that Da'wah Planning is a process of setting goals, objectives and ways of achieving da'wah objectives through various da'wah activities by taking into account the possibilities that will occur, and involving all resources that can support the success of da'wah.

#### Da'wah Planning Process

In order to formulate a da'wah plan, one must first determine the steps in the planning itself. The planning steps according to Susatyo Herlambang (2013: 47), are as follows: 1. Analyze the situation 2. Identify problems and priorities 3. Determine program objectives 4. Assess program constraints and weaknesses 5. Prepare operational work plans Then according to Hasibuan (2011: 112), that the planning procedure (steps) are: 1. Explain and formulate in advance the problems, efforts and objectives to be planned 2. Collect data, information and facts needed sufficiently 3. Analyze and classify data, information and facts and their relationships 4. Define plans, premises, and constraints and the things that encourage them 5. Determine several alternatives 6. Choose the best plan from the existing alternatives 7. Sequences and detailed timing of the proposed plan 8. Carry out checks on the progress of the proposed plan.

Meanwhile, according to Prajudi Admosudirdjo (1982: 181), every plan consists of certain steps that must be carried out sequentially, and the planning procedure is just a "logic of thinking" in carrying out the planning. The procedures are as follows: 1. Identification of problems that require planning action 2. Analysis of the situation and whether or not the problem should be responded to in a planned manner 3. Formulate the objectives to be achieved with the plans to be made Prepare an outline

plan, and make a kind of "plan proposal" " 5. Plan proposal is discussed together, with superiors, colleagues and relevant subordinates 6. Analysis of the interim plan, determine the components 7. Determination of the people (staff) for each component and the responsibilities of each 8. Determine the out line rather than a joint plan 9. Initiate contact with units and parties concerned with issues and plans, and determine relevant data 10. Relevant data collection 11. Data processing 12. Conclusion and tentative planning 13. Discussion of tentative plans with relevant parties 14. Preparation of final plan text 15. Testing of final plan text al to reality 16. Approval of plans 17. Descriptions for implementation. Based on the explanation above, it can be underlined that the planning steps or procedures must start from a problem, and it is from this problem that facts, data and all information are collected, after which an analysis is carried out including the problems that might occur when an alternative plan has been selected and agreed upon held.

In relation to alternative decision-making plans, Rosyad Shaleh (1997: 54), explains that thinking and decision-making regarding the actions to be taken must be based on the results of careful estimates and calculations, after first conducting research and analysis of reality. and concrete explanations. If related to the conceptualization of da'wah planning, then at least according to Muhyiddin and Safe'i (2002: 134) there are several stages that must be formulated, namely as follows: 1. Establish a series of da'wah objectives. This planning begins with a decision about the wants or needs of the da'i or da'wah organization. Without a clear formulation of objectives, da'i or da'wah institutions cannot use their resources effectively. 2. Formulate the current state of affairs. It is very important to understand and identify the conditions faced by the da'wah community (mad'u) to formulate and determine the most appropriate steps to take. This stage requires the supply of

adequate data and information about a community that is used as the target of da'wah. 3. Identify all facilities and obstacles. This is done to measure the ability of a da'i or da'wah institution to achieve the goal of da'wah. Thus, it is also necessary to immediately identify things that can become obstacles and things that can be a driving factor for the successful achievement of da'wah objectives. Even though it is difficult to do, anticipating circumstances, identifying problems, and opportunities and threats that may occur in the future is an essential part of the da'wah planning stage. 4. Develop a missionary plan for achieving goals. The last stage in the da'wah planning process includes developing various alternative activities to achieve the goals, evaluating alternatives, and selecting the best alternative among the existing alternatives.

In relation to the explanation above, Munir and Wahyu Ilaihi (2006: 100) put forward the elements of the da'wah planning framework in the form of steps and activities, namely: 1. Da'wah must have a vision, mission and main goals for the future 2. Assess reality, and environment which includes all aspects contained therein 3. Setting goals that might be realized, namely by following the existing da'wah methods 4. Proposing various forms of wasilah or da'wah means and determining alternatives 5. Choosing the most suitable means and methods of da'wah 6. Da'wah must be able to answer the target in this case; what is the purpose of preaching? Where will the da'wah be carried out? When? And what material will be presented?

Likewise with the opinion of Rosyad Shaleh (1997: 54) explaining that the da'wah planning process will include the following steps, namely: 1. Forecasting and calculating the future 2. Determining and formulating targets in order to achieve predetermined da'wah objectives 3. Determination of da'wah actions and implementation priorities 4. Determination of methods 5. Determination and scheduling of time 6. Determination of



location (place) 7. Determination of costs, facilities and other factors needed From the several expert opinions above, it can be understood that the planning process Da'wah can be carried out with two assessment approaches, namely internally and externally. Internally, this can be started through: 1) deep understanding of the vision, mission, goals and profile of the organization or da'i. 2) in-depth understanding of the capabilities and weaknesses of the organization or da'i. 3) take an inventory and classify the resources they have, as well as their weaknesses. 4) projecting the opportunities and challenges to reality that will be faced by the capabilities and weaknesses of the organization or da'i. 5) estimate the reach of the organization or da'i towards reality internally and externally. As for externally, the da'wah planning process can begin with: 1) an in-depth understanding of what problems the ummah are very urgent to address by the dakwah, 2) finding out and collecting all facts, data and information about the problems of the ummah that will be faced by the dakwah, 3) accurately select facts, data and information that underlies the problems of the ummah, 4) classify facts, data and information carefully about the ummah's problems, so that the root causes can be identified, 5) intensively and comprehensively analyze the substance of the ummah's problems, 6) developing alternative da'wah plans, while keeping in sync with the vision, mission and goals of the organization or da'i, 7) selecting alternative da'wah plans that are considered appropriate.



**Figure 1.** Digital da'wah planning, research

results in 2023

### Benefits of Da'wah Planning

According to Munir and Wahyu Ilaihi (2006: 105). Whereas there are several benefits that can be achieved by carrying out da'wah planning, namely as follows: 1. Can provide goal boundaries (goals and targets of da'wah) so as to be able to direct da'i appropriately and maximally 2. Avoid sporadic use of human resources and also avoid conflicts among overlapping da'wah activities 3. Can predict and anticipate various problems and is an early preparation for solving da'wah problems 4. Is an effort to prepare preacher cadres and get to know the facilitation, potential and abilities of the people 5. Can organize and save money time and proper management 6. Saving human and material facilities and capabilities 7. Supervision can be carried out in accordance with objective and specific measures 8. Arranging and sequencing the implementation stages so as to produce an integrated and perfect program.

Meanwhile, according to Muhyiddin and Safe'i (2002: 135), that the uses or benefits of da'wah planning are as follows: 1. Helping preachers or da'wah institutions who will enter the field of da'wah to adapt to changes that occur in the environment mad'u 2. Assisting in crystallizing agreements on key issues 3. Allowing da'i or da'wah institutions to understand a clearer picture of operations 4. Assisting in determining the steps of da'wah more precisely and effectively 5. Making goals clearer, specific and detailed 6. Minimizing uncertain jobs, thus saving more time, effort and funds.

### Basic Objectives of Da'wah Planning

In its use, it is oriented towards the desired results, for example for da'i, mad'u, or the community. It is the goal that gives direction to all management decisions, and is a criterion used to measure actual performance. This is what is called the basis of planning.

Multinety of Goals At first glance, it may be

that the activities of the da'wah organization only aim at the spiritual or vertical context, whose goal is faith. In other words, the goal of da'wah is oriented towards converting non-Muslims to Islam, increasing faith for those who are already believers, giving answers to the people on the problems of their religious life. This statement is a narrow view, because in a more substantive analysis, that da'wah organization is to penetrate all lines and touch a more essential life.

1. Targets Set Da'wah Targets set are official statements of the organization so that it is trusted by the public as its target. In da'wah organizations, this goal can be in the form of pamphlets, leaflets, and bulletins that are issued. At this level, a da'wah manager is responsible for statements that have been issued if there is a problem or conflict from the mad'u.

2. The Traditional Method of Setting Da'wah Targets The definition of traditional targeting is that targets are set, then classified into sub-targets. In da'wah organizations the efforts of preachers at various levels of the organization are adjusted to meet the goals set in their areas of responsibility.

3. Management Based on Targets Management based on this target is one of the management that is widely used by organizations. Management based on objectives or MOB (Management by Objective), namely management where detailed performance targets are set jointly by subordinates and leaders. Progress toward these goals is periodically reviewed, and rewarded based on that progress. MOB also aims to motivate subordinates.

#### The Role of Da'wah in the Digital Era

Da'wah of Islam in the digital era is not free from various obstacles and challenges it faces. So that the da'wah of Islam will face various very complex and complicated problems. Today, at least the challenge of Islamic da'wah is related to the excesses of globalization and the reality of religious plurality. The rapid progress of science and

technology has transformed human civilization from agricultural to industrial culture and then to the information and communication age.

Vocabulary and at the same time a weapon that is so significant and determinant in the current era of globalization is the sophistication of information and communication technology. Through information and communication technology networks in the era of globalization it continues to spread to all corners of the world. So that the reality of the world today with all its diversity, inequality and irony has become the nation's socio-cultural barriers and obscures the country's geographical boundaries.

In the digital era where everyone can get and do something very easily and quickly. Maybe in the era before the invention of electronic media existed, that person needed various books and references in the form of books. Meanwhile, in this digital era, people just have to look for something they want on an internet site. All the necessary information will appear with the various models.

The digital era is the peak where everything that is instant (fast) can be enjoyed by the public. A da'i (mubaligh) can preach through various media, both electronic and print media such as television, radio, YouTube, newspapers, magazines, bulletins, and others. Sometimes I think that it's not only artists who want to appear on television, but preachers can too. In this era they get a comfortable behavior, a sense of peace because of the existing facilities.

In general, da'wah carried out in a taklim assembly in a surau, mosque or prayer room takes place in a sacred and solemn atmosphere. Advances in technology and information allow a da'i to improvise with humor and other things, so that the lecture material remains interesting to listen to. Given the challenges of da'wah in the era of technology and information, especially the media, cannot be separated from

entertainment. As a result, the missionary orientation played by the preachers is also growing, and even tends to be biased. Initially, da'wah which had more contact with the realm of worship, was always based on the intention and motivation to worship as well, that is, it was carried out with joy, a sincere heart and only hoping for the pleasure of Allah SWT.

However, in its development the pattern of preaching through the media as a form of technological progress has become a challenge for a da'i. The influence of the media allows a da'i to gain popularity in the eyes of his audience like a celebrity (public figure) and does not rule out the possibility that his preaching activities are often judged by material.

Arnold Toynbee, quoted by Basit, said: "I believe that the style of a civilization is a manifestation of its religion. I fully agree that religion has been a source of vitality which has led to the presence of civilization in the world and has maintained its presence. Even more than that, religion is a spiritual bond that has united civilized society".<sup>30</sup> As an approach, digital da'wah provides structural and cultural strength. Structurally strengthening is meant for institutionalized digital da'wah. These institutions can be formal or non-formal, whether initiated by the private sector or the government. Thus, the spirit of Islam can be enjoyed collectively as a structural missionary effort.

### 1. Opportunity Da'wah in the Digital Age

With the renewal and progress of digital technology and information media, it makes human life in this world more advanced and can realize the unity of preachers in preaching and spreading Islamic teachings that are rahmatal lila'lamian, the increasingly sophisticated digital era is indeed an increasingly complex da'wah challenge. so that with this progress the preachers are required to be able to keep up with it, even though it sometimes has an unfavorable effect, if Muslims are observant of the state of

this digital era then it will be a great opportunity for the success of Islamic da'wah throughout the world.

Currently, online literature or digitization is highly developed, religious references are easily accessible in a timely and precise manner, can be accessed via the web and Google, which circulate through digital media, and are not limited to electronic books. Islamic literature can be disseminated through digital tools. (Muzayyin Ahyar, 2017; 435) .And at this time the da'wah movement through online is already very lively, thus we must increase the opportunities for da'wah by using digital tools, because this is an opportunity where the da'wah that is being carried out can be reached by people all over the world.

The sophistication of digital technology at this time can be utilized by every human being, especially the preachers to maximize in spreading the teachings of Islamic law or preaching widely, optimizing the digitalization of da'wah something that cannot be separated, preaching and technology is a unity that can enhance the maximum in preaching in the world. digital era. Da'wah delivery must be carried out optimally, including the use of social media tools, so that da'wah can be quickly accepted by the wider community so that the maximum results of da'wah can be felt. ( Haryantomo. 2011; 23)

In the current contemporary era, it has indeed had an influence on the pattern of human life, has had an influence on modern life which can encourage Muslims to become more enthusiastic in following the flow of advances in digitalization tools, starting from the age of children, teenagers to adults, all can use digital tools. digital and social media that are increasingly developing and sophisticated, for people who want to gain insight into knowledge about Islam it is also easy for them to be able to get Islamic information by always opening access to social media which specifically provides Islamic da'wah content,

thus it will become an opportunity for da'wah extraordinary for the preachers of the homeland. (Fahrurrozi, 2017; 5).

Dakwah through digital tools has penetrated all corners of the world, the flow of information development has also entered the santri community in the archipelago, they have a virtual digital community that is easy to use as a communication tool. (Rusli Nasrulaoh, 2014; 139).so that at this time alumni of Islamic boarding schools who incidentally have a strong and better understanding of religion, they also have a great opportunity to inform about Islam, they can participate directly in spreading Islamic teachings through available social media, students can become cyber- cyber youtube in the realm of the internet. Even digital social media tools also make it easier for students to discuss religious issues that are currently happening in the midst of life so that students can easily answer and provide solutions to these problems.

The pesantren alumni students who narrate the Islam of the archipelago are able to explain to the public that Nusantara Islam is not a new religion, not a new teaching, but is an identical term to make it easier to apply Islamic teachings to the people of the archipelago, as a simple example, charity is a form of Islamic teachings, it is difficult for Indonesians to alms like the prophets and companions, because Indonesians do not have property exactly like those of the Prophets and Companions, then the alms of Indonesians can be with sweet potato leaves, can be watermelons, which maybe in the time of the prophet did not have these items. In their activities, students can use social media as a very effective da'wah medium for the target level of the millennial generation, senior students who are active in the virtual world. They become activists to be more digital savvy.

there is a time of progress in science and technology (IPTEK) and transformation with various negative impacts at this time, it seems

that we are all called upon to do da'wah, namely inviting or calling to do good and prevent evil, changing people from one situation to another situation that is better in in all fields, realizing Islamic teachings in daily life for an individual, family, group or mass as well as for the life of the community as a whole order of living together in the context of developing the nation and humanity. Identification Parker (1973), as quoted by Agoeng Noegroho, pays attention to several impacts of communication technology, including:

1. The occurrence of a monopoly in the management, supply and utilization of information.
2. Unequal distribution of information.
3. Lack of educative message content.
4. There is information pollution.
5. There is inflation of privacy.
6. Issues related to copyright arise

The information civilization that has dominated the modern world in the last few decades has had a global impact on various sectors of human life, both the positive and moreover the negative impacts, almost all of which can be linked directly or indirectly with religion, especially the opportunities and challenges of preaching. The positive aspect of this information civilization which is an opportunity for da'wah, among other things, can be used as a medium of da'wah, even by religious parties, including Islam has been made to support the development of their religion, both regarding institutions and weaknesses, as well as those related to efforts to dynamicize teachings -his teachings. In this latter context, as far as the author knows, many science and technology findings have and will greatly help preachers to provide contemporary interpretations of Islamic texts themselves. Many things that until now have seemed vague to the scholars, have finally been revealed in terms of their meaning and content thanks to the findings of science and technology.

Information Technology indirectly has a

broad effect in changing social control. This can be seen how the media can smooth coercion, so that it appears as persuasion. As already mentioned, information civilization makes religions more transparent both in terms of doctrines and teachings, as well as in terms of activities and programs produced by every religion, not just Islam. Thus, the transparency of these religions, the occurrence of religious conversions (religious conversions) among the people is a very necessary thing, especially people who uphold the values of freedom and rationality. This is where the actual opportunity for Islamic da'wah to appear to play its role in using information communication technology as an effective media for preaching so as not to lose out in competition and change religions (leaving Islam) just because of the lure of momentary need. On the other hand, as has been predicted by futurologists that the 21st century will be the century of religious revival, in this century there will be a kind of respiritualization among modern society. Those who previously experienced soul aridity due to spiritual emptiness began to try to find things that could bring inner satisfaction and happiness. Spiritual satisfaction is of course more potential to be obtained in religious spirituality. Along with the symptoms of respiritualization that are now starting to appear, there has also been a kind of revitalization and resurgence of major religions in the world. If religion has rediscovered its vitality in governing human life as a result of the roles played by da'wah in taking advantage of various opportunities, then this will not only benefit certain religions, but also have a positive impact on all religions, especially Islam which is essentially fundamental. is as Rahmatan lil alamin religion.

#### 1. Da'wah Challenge

In its development, technology is not only used to create comfort so that humans can live more happily and not be subdued by the will of nature, but in fact the development of

technology as we are witnessing today has gone so far that there is a tendency, not the technology itself. submit and serve humans, but it is humans who follow technological developments that have gotten out of control. So it's not an exaggeration if Dr. Rollo May said that the 20th century is the age of anxiety. While anxiety according to Dr. FW Bawengan, is not only a psychological symptom but a disease that affects humans in this modern era. The rest, anxiety is also the cause of the emergence of various diseases called psychosomatic. That is why, amidst the roar of industrial machinery, many people are confused, looking for peace to escape from the gripping anxiety, meanwhile crime and clashes are also rampant.

The culture of materialism that dominates almost all of society is a challenge to the world today, including Eastern religious societies. Among these challenges

1. The displacement of religious moral values and the loss of the function of religion itself is another result of a materialist culture that sees everything through a process of calculation, measurement and control.

2. The dysfunction of religion in the social life of society along with the emergence of the notion of secularism is seen everywhere, directly or indirectly, consciously or unconsciously. In almost all countries, religion really only occupies a marginal position and charity is dysfunctional, including in the fields of socio-economic, cultural, educational, political and so on.

3. The ferocity of alcoholism and morphinism, such as ecstasy and so on, which killed generations of people and rampant sadism, rape and other crimes are derivatives of the elimination of religious moral values. In an industrial society that defies science and technology, da'wah faces formidable opponents, unless science and technology is filled with religious content with high weight, because efforts to give religious content to science and technology, naturally require humans with reasoning powers and firm faith

in large numbers . However, it must be understood that this is where the main weakness of Indonesian Muslims lies, namely their low mastery of science and technology. Apart from that, the industrial society and the information society need intensive capital to finance various productions in all fields, including the mass media (press, film, radio and television). In this regard, Muslims also experience severe weakness. Because the majority of us are classified as still below the poverty line. This structural poverty has resulted in weaknesses in the field of education so that the professional ability to use mass media and other sophisticated technology for preaching also suffers a sad fate. These are, among other things, the unfavorable aspects of modern civilization which are a challenge for da'wah as well as a challenge for us religious people to then look for alternative solutions.

Although these challenges are generally global in nature, they are still relevant to be seen from the perspective of Islamic da'wah in the present and in the future, because we have truly entered the era of globalization and transformation of information with various trends and the impacts they have caused.

## 2. Impact of Information and Communication Technology in Da'wah.

The Impact of Information and Communication Technology on Da'wah The information age is characterized by an increasing number of workers and an increasing focus on activities related to information technology. In addition, the information era is also marked by the increasing role of information technology in economic, political, ideological and cultural activities

The impact it creates is that technology has a good impact on society, such as by using television, computers and the internet, you can quickly find out developments and events in Indonesia, even around the world. However, we must realize that there are not a few negative impacts that it causes. This can

be observed from the use of electronic media such as television and the internet via computers and so on, which actually damages the image and morals, especially among young people and even reaches children, namely by broadcasting pornographic and pornographic shows that are not in accordance with Islam. In dealing with the process of progress and changing times due to advances in science and technology is the ability to manage information.

It is common knowledge that the basis of world information no longer recognizes regional boundaries, common interests and social and political systems. Even space distance constraints have been overcome by transportation and telecommunications technology, so access to information has spread and varied. Now technology products can be said to be more dominantly used to access information. The use of information and communication technology cannot contribute significantly to the implementation of da'wah, but is only used as a means of conveying various kinds of information without sorting out which ones should be conveyed to the public and which ones should be avoided, such as the use of television as a medium for delivering da'wah. .

The development of television technology has been used as much as possible to reduce the distance or communication barriers to the public. The audience on the one hand becomes the king and determines the behavior of the various programs produced. Audiences are not just passive spectators. but they are given the opportunity to feel as if they are the most important part of the ongoing information transformation process. The era of globalization marked by the transformation of science and technology as well as communication has become so sophisticated that it makes it easier for humans to obtain information as material for their knowledge. The result of modern technology that has entered human life is a combination of various technologies. In the

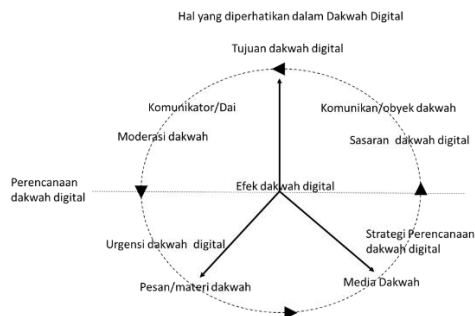
fast-flowing process of industrialization, Indonesia is faced with future alternatives such as: catching up on backwardness in science and technology, developing science and technology, choosing the process of transferring technology and adopting it for practical implementation. The problem is how to tap the use of information technology in the implementation of da'wah, because this is not only based on its use, but is expected to provide useful services for all aspects of human life and most importantly of course it can provide benefits in the implementation of da'wah. Then it requires the ability of reliable human resources in terms of its application in the life of the nation and state.

On the other hand, the two dominant factors that cause deviant behavior or unlawful acts committed by children are strongly influenced by the impact of globalization in the field of information technology. This indirectly affects changes in ways and lifestyles that have brought about fundamental changes in people's lives. The da'wah aspect used in the broadcast is actually the same as the aspect used in the communication process. What distinguishes it is that the process of communication reaches people without boundaries with various forms of information, whereas da'wah focuses more on religious, ethical and moral responsibilities in everyday life.

Consideration of religious law becomes very important in the rules of presentation. In this context, the da'wah process is seen as a conscious and intentional process of carrying out activities or efforts. This process should be carefully planned, taking into account all aspects that can influence the implementation of da'wah, such as the transformation of da'wah messages, their understanding and influence on society. The aspects of da'wah that must exist in the da'wah process are 1) Da'i, namely the person who is the source of information or the party who will convey the da'wah, 2) Mad'u, namely the person who receives the da'wah message, 3) Material,

namely the contents of the da'wah, 4) Da'wah means are facilities that can make it easier for the da'wah to convey the contents of the da'wah to the public.

The use of communication media and understanding the changing mindset of the people where the da'wah takes place, the presentation of the da'wah needs to be modified to attract the masses and understand the da'wah material it conveys. Based on the rationale above, it can be stated that the implementation of da'wah cannot be separated from various aspects such as economic, political and socio-cultural with the development of information and communication technology which is basically a representation of the local community and social system. The same thing also applies to da'wah communication using mass media. In this era, the opportunity for da'wah has also become very large because information and communication technology services can be used not only in the implementation of da'wah, but also in the process of belief in the Almighty Allah. By utilizing science and technology as a tool (media).



**Figure 2.** Things to pay attention to in digital da'wah, research results for 2023

### 3. Principles of Da'wah that must be carried out in the Information and Communication Technology Era

Da'wah faces big challenges not only because of the increasingly diverse intensity of changing times which each time raises new questions and studies, but the

multidimensional needs and interests of humans now tend to be more critical due to the breadth of information and experience.

It has been explained that modernity is characterized by industrial activities or the use of technology in almost all aspects of human life. For this reason, it is necessary to understand religious teachings in solving the problems of modern society, for this reason, integrated principles are needed in carrying out Islamic da'wah. Discussing the principles of da'wah, of course the elements of da'wah involve all the elements that make it possible to achieve the goals or objectives of da'wah, which have complete linkages and integration with one another.

Elements of da'wah can consist of people who convey Islamic teachings (dai), ideas or principles conveyed (material), methods taken to achieve the intended goals (methods), equipment used (media), then the intended target (da'wah targets). . So far, the da'wah approach is synonymous with tabligh. Islamic teachings are spread through the pulpit media, so that to determine the criteria for the preacher is someone who is active/preaching through the pulpit. Someone who is active in a da'wah organization but does not actively give lectures is not considered a preacher. At present it is increasingly difficult to gather people to give lectures. People are less and less fond of lectures that smell of sermons. People tend to be seen as human beings who need to be respected for their humanity, "then the broadcasting of religion through education must be increased in which the study of Islam is gradual , programmed and planned.

Facing an industrial society that is bound by rules, we need to understand the meaning of da'i and da'wah in depth, meaning that da'wah is not only synonymous with tabligh, but includes all efforts to realize Islamic teachings in all aspects of human life. An activity can be called da'wah if it is a system of joint efforts of believers in an effort to realize Islamic teachings in all aspects of life

which is carried out through a da'wah institution. Da'wah activities, as well as in the communication process, feedback is very important to note. Awareness and sensitivity in detecting feedback will make the da'wah process more effective. For da'wah to be effective it is necessary to observe some basic principles. The basic principles include conveying persuasively informative, serving, not instructive and burdensome, let alone threatening (QS 20:43-44), Delivered at all times, places and opportunities. Done by spreading the news of the truth without having to vilify other parties (QS.6: 108).

Da'wah should be directed at forming quality human resources, so that Muslims are taken into account in the development of science and technology.

The process of actualizing faith as a da'wah order on all levels of human reality, requires an organized effort in order to realize the function of the caliphate. This process consists of changing the system of feeling, thinking, behaving and acting individually and society towards the development and creation of a new reality system that upholds human values, justice, truth, peace, beauty, goodness which is referred to as Islamic reality.

The process of change that is carried out in a planned manner with clear goals will bring about intensive and excessive changes and directly touch the most fundamental values for Muslims. Islamic da'wah in this case is faced with a series of problems that must be answered simultaneously within a clear framework. On the one hand, Islamic da'wah appears to provide a sense of security to its adherents from symptoms of alienation, psychological shock, legal uncertainty, political instability, the loss of the role of the environment which is increasingly dense to breathe and is haunted by increasingly uncertain situations and the emergence of science in bringing an unjust and prosperous society. In addition, the role of da'wah is as a filter that can assist us in making more



humane and Islamic value choices, in the current changes that occur as a result of the discovery and application of various modern technologies. It is also hoped that it can play its role as a guide who can guide us to better understand the real meaning of life, so that with da'wah, it is hoped that the people will not experience a process of confusion over disoriented in the dynamics of world civilization.

For this reason, if preaching is seen as a communication activity, then in communication activities it turns out that the sophistication of the media as a result of the development of communication technology is not the only determinant that determines the success or failure of a communication activity. Because in every communication process, there are at least five communication components that must be considered, namely: communicator, message content, media, communicant and feedback. Thus, to increase the effectiveness of da'wah in playing its role, there are several things that need attention: First, the meaning of communicators (subjects of da'wah) must be expanded, namely not only those who can be called scholars or preachers in the Taklim Assembly, mosque pulpits and mushallah, but it must be perceived that in fact we all have a mission of preaching so that statesmen, researchers, technologists, doctors, economists and so on can preach according to their expertise. For this reason, the subject of da'wah is not only interpreted individually, but must be developed at a broader level in the form of da'wah institutions or institutions that are intentionally managed professionally. Second, the content of the message (da'wah material) also needs to be further clarified, namely not only referring to standard sources that are understood only in a rigid and textual manner, but also to dynamic sources in the form of the "great Koran" namely universal, heaven and earth. and everything in between .

Preachers are no longer dominantly talking

about the hereafter, heaven and hell but contemporary da'wah material must be able to develop human progress in the present and hereafter life order. Third, the media (washail) to convey da'wah messages also needs to expand its meaning, so that all types of mass media are like television. radio, newspapers, magazines and so on can be used for missionary purposes. Fourth, the meaning of the audience or target audience also needs to be broadened, apart from mosques, mushalla, and taklim assemblies as well as those in other places such as offices, companies, hospitals, and even include all members of the community with various variations. In other words, the kiai network, as well as at the national level and even at the international level, need to be built with good management and professional handling. Fifth, with preaching activities, as well as in the communication process, feedback is very important to pay attention to. Awareness and sensitivity of the da'wah subject (communicator) in detecting feedback will make the da'wah process more effective, for example being able to change the da'wah model after seeing feedback from the audience. Through feedback allows the emergence of a more productive dialogue, so that no one pretends to know everything.

### 1. Preparing Da'i with Science and Technology

To support changes in preaching, preachers need to continuously improve their knowledge, knowledge and technical skills needed to carry out da'wah. Da'i is not satisfied with the knowledge he has, but continues to learn, lifelong learning (long life education). Especially in the current information age, the preacher's ability to operate computers and the internet is a non-negotiable prerequisite. With a computer, da'i can write and store ideas that will be conveyed to the public, can be used to operate LCDs, read books and the Koran with the help

of CD-Rooms, access the internet and so on.

Why do da'i need to have computer and internet skills? Because society is the object of da'wah, more and more are using computers and the internet. Now computers and the internet have been introduced to children at the elementary school level, even since kindergarten. The government has also tried to help the internet network so that it can enter the villages. Hand phone facilities are filled with systems that can access the internet. Restaurants, hotels, campuses, schools, offices and so on have provided hotspot areas (free internet areas). If the community is so open to being able to use computers and the internet, while the da'i doesn't want to know about computers and the internet, there could be an "apocalypse" for the preacher and his da'i activities don't keep up with societal developments .

Learning computers and the internet is not a difficult matter for preachers, it is much more difficult to learn Arabic or Javanese. One to three days, guaranteed if there is a strong will to learn. In principle, don't be afraid of being wrong, the computer won't break or burn, and don't be shy about asking.

Then in this modern era, the science that develops is multidisciplinary and complementary. Religious knowledge which has been the main source of Islamic preachers (da'i) needs to be strengthened with other scientific knowledge so that what is conveyed to the community becomes solid and can be operationalized in the field. Islamic religious knowledge can be strengthened by using the study of psychology, sociology, history and so on. Therefore, preachers need to strengthen their religious knowledge by adding insight and knowledge based on the social sciences, humanities and natural sciences.

An interesting example is the fatwa of Sheikh Adil al-Kalbani, one of the Imams of the Mecca Mosque, which goes against the flow of public opinion among Saudi clergy. al-Kalbani, who initially defended the opinion

that music and singing were forbidden suddenly changed his mind and considered that playing music and singing was not against Islamic teachings. This fatwa received strong criticism from senior Saudi Arabian clerics who considered music and singing, whether performed in crowds or alone, is forbidden by Islamic law. This discourse about music and singing has received sufficient attention and been discussed in the mass media. Many scholars oppose but not a few who support al-Kalbani. If the fatwa is only guided by religious sources without paying attention to sociological studies of society, then the fatwa will collide with the growing reality in society that music is a community need and even a creative industry that can prosper society.

By broadening the approach in developing Islamic religious knowledge, da'wah activities can also be expanded with various approaches. Because da'wah activities are derived from da'wah scholarship which incidentally is part of Islamic religious scholarship. Da'wah activities can be approached with Management Science, Politics, Sociology, Anthropology, Health Sciences and so on. In this way, da'wah activities are very varied. Da'wah activities can accommodate various needs that develop in society.

If we learn from teachers' ways to improve student competence, usually class teachers conduct classroom action research. With this research it is expected that teachers can know clearly what problems are faced by students and how alternative solutions are. Likewise with da'wah activities, when preachers carry out da'i, it is better for da'i to know the needs and abilities of the object of da'wah. "Dakwah while researching" is a smart way that can be applied at this time.

Preachers need to merge and get involved together in solving the problems faced by the community. Da'i is not only "NATO" (No Action Talking Only) and only as a resource person, but also as a motivator, manager,

facilitator, and initiator. Communities have difficulty solving their problems because of the lack of people who are the driving force for change. Not many Islamic leaders have concern for people who are mustad'afin (weak). Though Islamic teachings strongly encourage people to care for the mustad'afin. It is in this context that preachers need to take on the role of leaders who can make changes to society. God's Word emphasizes the role of the da'i in da'wah bil-qaul and da'wah bil-'amal.

It means; "Who has a better speech than one who calls to Allah, does righteous deeds, and says: "Surely I am of those who surrender?" (QS. 41: 33).

## 2. Utilizing Information Technology

In this modern era, developments in the field of information technology are so fast that when depicted graphically, the progress that is taking place looks exponential and nothing can stop the speed of development of information technology.[19] It is very unfortunate when the advancement of information technology is not utilized for the benefit of da'wah. Especially in today's reality, almost the majority of people already have information technology equipment, be it computers, internet, mobile phones, and so on. It's like the world of today's society is the world of information technology. People will be considered "nervy" (less social) or "technologically clueless" (technologically illiterate) if they do not have information technology equipment.

One example of technological equipment that many people like is television. The presence of television for industrial society is like a "new religion". Why not, television has shifted conventional religions. His sermons were heard and witnessed by a larger congregation than any congregation of any religion. The houses of worship are spread all over the world, the rites are followed with great reverence and can thrill the heart and affect the human subconscious. The presence of television has also taken up most of human

time to watch television. According to the Broadcasting Year-book (1985) of homes in the United States, 25% watch TV in the morning, 30% in the afternoon, and 63% at night (8-11 hours), and almost ¾ or 84% of them is watching television.

In addition to the extraordinary presence of television, television also exerts social, political, economic and cultural influences. Socially, television affects the psychological effects of the audience, especially the influence of violence and relationships between the sexes. Politically, television influences the political structure, public opinion, and political culture. Economically, television can influence individual/community consumption patterns and market prices. Finally, culturally, television influences cultural development in various countries.

Broadly speaking, programs on television are divided into two parts, namely: fiction programs and reality programs. Fictional programs can be in the form of cartoon films or sitcoms (films or soap operas showing family life by presenting fictional characters). Meanwhile, reality programs can be in the form of news, documents (such as ABRI events, natural beauty, craft creations and so on), cooking, sports and live entertainment (music).

Muslims can fill fictional television programs. Currently, fiction programs show more violence. Our children are shown cartoon films that feature violence every day for several hours. In a report from the Children's Research Center that television programs for adults are far less violent than commercial programs for children. There are approximately 20 to 25 acts of violence per hour given to children through cartoons, while 3 to 5 acts of violence per hour are given to adults. This is not to mention the addition of soap operas or family films that feature violence against children, such as stepchildren's lamentations. Likewise, youth soap operas/films that show a lot of violent

acts are broadcast during broadcast hours where children find it difficult to avoid and don't want to move away from the television, such as Kick Si Madun, not Mawar but Melati and many other youth soap operas. being loved by all television stations.

The violence shown by television is very influential on children's behavior. Television will shape children's minds, especially their image of violence. In addition, television is also capable of distorting children's way of thinking about the realities of life so that children are easily frustrated, less friendly, and more aggressive. There are several underlying reasons, including: first, before the age of seven years, children are unable to connect stories from beginning to end or do not understand the plot of the story. Second, children remember their physical actions more than the conversations that exist. Third, before the age of five years, children are not yet able to distinguish between fantasy and reality, as a result, children are very easy to behave violently.

It must also be admitted that at this time several television stations are broadcasting religious soap operas. The existence of this soap opera, at least, can enliven the message of Islam and at the same time can minimize the presence of violent scenes on television. We as Muslims should be grateful and grateful to the managers of television stations and production houses and the actors/actresses who are involved in religious soap operas.

Nonetheless, there are some things that need to be improved and developed in the future. First, soap operas that exist in general are still focused on the theme of strengthening faith or God's judgment on sinners. Unfortunately, the thickening of faith conveyed is only seen through black and white glasses. The sinner is punished in this world, usually at death or in a burial place. The punishment given seems to have really happened, even though in reality it may be difficult to find its existence. Is it true that it is a punishment from God or

is it just a natural symptom caused by a disease suffered by its creatures. An incident whose basis is unclear is then justified by an Ustadz about the truth of the story based on a verse or hadith quote. As a result, the audience is directed to a shallow religious understanding and the mind given by God is not used critically and analytically.

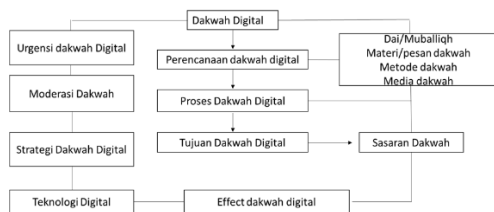
Second, there are some sinetrons which are syncretic (merging mystical elements with religious elements), sometimes the mystical elements are stronger. It's hard to say that soap operas like this can strengthen one's faith, instead they can lead someone to the brink of polytheism. There are many strange stories that are difficult for a human to accept logically or critically. In Islamic teachings, activities that smell mystical (magic) are prohibited in Islam, because this can lead to polytheism.

Third, sometimes the television audience is exhibited by the acting of actors/actresses in religious soap operas who are so good at Islam. However, in the same place, the audience was also exhibited by actors/actresses of religious soap operas with behaviors that were exactly the opposite of what was being played. In other words, the actor/actress in religious soap operas can become Ustadz, but outside soap operas they can become "criminals" or can pollute religious teachings. So there are still many actresses/actors who only meet market demands or ratings. They have not made what they have played as an expression of their faith as a Muslim in developing art.

Starting from the description above, a great opportunity challenges us as Muslims to fill in the gaps or weaknesses that exist. Fictional films (cartoons) for children that carry a cool feel, are full of education and have religious values are good areas for development. Likewise, family films/soap operas that start from reality and are able to inspire enthusiasm to try hard and stay away from acts of violence.

With regard to religious soap operas, there are

still many themes that can be raised to the surface and are relevant to the reality of Muslims. The socio-religious life of adolescents, devout Muslims who have had successful careers from the bottom, the unique and modest religious life of rural communities, students who are successful in entrepreneurship, and so on. Raise themes that can motivate and serve as examples for Muslims to advance in worldly life while still paying attention to Islamic values and create storylines that are not too thick with the nuances of da'wah. In principle, Islamic values become the color of the storyline in soap operas. That is what we notice that art cannot be separated from preaching. In art, Islamic values radiate so that people are called to follow. Likewise, preaching that is cool and not pushy is a reflection of aesthetic sense (art).



**Figure 3.** Digital da'wah, research results for 2023

### 3. Dakwah Formula (Recipe) for Da'i in facing challenges in the Information and Communication Technology Era

Every believer is a preacher. In order not to take a wrong step, a da'i must know the formula of da'wah that he will carry out. Dakwah is like river water that must flow all the time. He couldn't stop for a second. If he stops, it means he is gathering a strategy to continue his journey with a long breath and new, greater strength. Sometimes he has to separate to find a gap that he can go through. Sometimes he also had to gather to step over the big rock in front of him. That's preaching. So that the missionary journey is easy and without obstacles. A da'i must know what da'wah formulas he must do. Thus he can

more easily direct his da'wah according to the character he has, including:

#### 1. Rabbaniyah (divine nuances)

Whatever the form, da'wah must be oriented towards divine nuances. Where his teachings must refer to one point, namely worshiping Allah SWT. Methods can vary but the target is only one. In the history of all the preaching of the Prophets invites to one estuary, namely the Oneness of Allah. Allah said: It is not natural for a human being that Allah has given him the Al-Kitab, wisdom and prophethood, then he says to humans: "You should be my worshipers, not Allah's worshippers." However (he said): "Become rabbani people, because you always teach the Al-Kitab and because you keep studying it. (QS Ali Faith: 79).

This divine orientation becomes important when preaching must collide with all worldly interests. Where the da'wah period has penetrated to various sides, if you are not careful it can drag the da'i out of the rabbaniyah rail. Not a few among the preachers who are not strong enough to resist temptation, thus "divining" wealth or position. Everything is from Allah, for Allah h, and returns to Allah SWT

#### 2. Wasatiyah

Balanced not too much and not too little. Give rights to every person who has the right, fulfill the needs of everyone who needs it according to the level, (Islam before congregation). This is important for preachers, and there is nothing wrong with forming several congregations. Even now, the condition of the people who are scattered, actually demands people to live in congregation.

Uniting the people in congregational knots, of course much easier than gathering them one by one. It's like gathering leaves. This would certainly be easier if the leaves had already been collected in several groups, rather than putting them together in scattered or scattered conditions. That is a picture of the urgency of the congregation. But the congregation is not everything, because it is only a means.

Therefore, the application of Islamic values must be a priority. It cannot be defeated by the interests of the congregation. Therefore a da'i must really be Muslim before going to congregation. Where he should be proud of Islam, not with the congregation or the group. Allah says: namely those who divide their religion and they become several factions. Each group feels proud of what is in their group. (QS Ar Rum: 32).

In another verse Allah states: And hold all of you to the rope (religion) of Allah, and do not be divided into pieces, and remember Allah's favor upon you when you were enemies before (during Jahiliyah), so Allah united your hearts, then you became because of the favor Allah, people who are brothers; and you were on the brink of hell, then Allah saved you from it. Thus Allah explains His verses to you, so that you may be guided. (QS Ali Imran: 103).

3. Syumuliyah, Whole and comprehensive in its manhaj (comprehensive), not juz'iyah (partially)

Da'wah does require stages but still must be comprehensive. It can't be half measures. Islamic teachings must be conveyed as a whole. Stages are just a method. Among the characteristics of a comprehensive da'wah are continuous, interrelated, and not contradictory. They cannot be separated from one another. When discussing political issues, he did not forget the issues of faith and morality.

In politics, these two sides cannot be ignored. Likewise when discussing the issue of fiqh, it should not conflict with political conditions. Allah says: O you who believe, enter into Islam as a whole, and do not follow the footsteps of Satan. Surely Satan is a real enemy for you. (QS Al Baqarah: 208).

4. Mu'ashirah (modern). Da'wah must keep up with the times.

If not he will be abandoned fans. Advances in technology and communication systems as they are now should support da'wah, not the other way around. It is very ironic, for

example, that a preacher who is not familiar with the internet world, cannot send e-mail, or has a stutter in operating a computer. In fact, in today's technological advances like that has become a necessity. However, this does not mean that da'wah must lose its originality. The progress of time and technology should not undermine Islamic values. Islamic da'wah is flexible but it should not fade, it can mix but not mix.

5. Waqi'iyah, Realistic in treating individuals and society

Take into account local circumstances and act accordingly. Islamic law recognizes territorial boundaries. Therefore, da'wah must be global. Whichever hemisphere is stepped on, that is where the homeland of Muslims is. For this reason, the concept of da'wah offered must reach all the interests of Muslims wherever they are. The problems of Palestine, Iraq and other parts of the world must be of concern to the Ummah. However, there must be a priority scale. The concept of da'wah must remain grounded and touch the problems of society.

6. Scientific. Islamic da'wah must be based on science

Da'wah that is not based on science will only boomerang and then the object of da'wah will be abandoned. Allah says: And do not follow what you have no knowledge of. Truly hearing, sight and heart, all of that will be held accountable. (QS Al Isra': 36).

7. Inqilabiyah (total change), not tarqi'iyah (patches)

The process of change made in da'wah should be carried out totally and thoroughly. This is where the comprehensive meaning finds its partner. However, still total change must be done gradually and naturally. On the other hand, preaching should not be done rigidly. Total is meant, that da'wah must cover all lines of society. Da'wah should not only touch the elite and forget the common people. Both should receive attention. The elite have advantages in terms of quality, while the common people have a large scope in terms

of quality.

8. Al-mana'atun al-islamiyah (has Islamic immunity)

This is important for propaganda. Islamic immunity will be a stronghold for da'wah. The level of defense of da'wah is determined by how much immunity the propagator has. Such is the character of da'wah. By knowing the religion of these elements, preachers will be able to tread the path of da'wah in the right way.

This element is like a torch that can illuminate the path of preachers so that they can move forward with certainty, especially in the current Information and Communication Technology Era. No more groping. Da'wah in the midst of people's lives will definitely face a number of obstacles, challenges, obstacles and even threats. Especially when da'wah has entered the realm of political and state institutions, there will be even more challenges that must be faced. Da'wah cadres must have a strong character in order to be able to face these challenges steadfastly. At the very least, da'wah cadres are expected to have the following seven characteristics, so that they can be strong in facing the reality of the field of da'wah which sometimes feels very violent in collision, especially in the current era of globalization.

First, atsbatu mauqifan, da'wah cadres must be people who are the most firm in their stance and the most solid in their attitude. At-Tsabat (steadfastness) is tsamratus shabr (fruit of patience). As the word of God, "Famaa wahanuu lima ashabahum fii sabiillillahi wamaa dha'ufu wamastakaku". They do not become weak because of the calamities that befall them in the way of Allah, and do not become weary or give up, and Allah loves those who are patient. That determination makes calm, rational, objective and brings God's trust to give victory.

Second, arhabu shadran, da'wah cadres must be the most generous people. Da'wah fields often make the heart narrow. Many words of ridicule, ridicule, scorn, swearing were

thrown out of nowhere from many quarters. Da'wah cadres must not be narrow-minded and chest tight because of people's scorn and because of the news in the mass media which often discredits without confirmation and accountability.

Third, a'maqu fikran, da'wah cadres must be people who have the deepest thoughts. Da'wah cadres must always try to understand what is happening, not get lost in surface phenomena, but see what is the essence behind these phenomena. If the cadre's thoughts can be in-depth, when responding they will be more objective, measurable, and balanced.

Fourth, ausa'u nazharan, da'wah cadres must be people who have broad views. The horizon of views of da'wah cadres must be continuously broadened, so as not to experience symptoms of a narrow perspective. Reading reality with a broad view will bring cadres to a just and moderate attitude. Don't get caught up in extreme and exaggerated attitudes.

Fifth, ansyathu practice, da'wah cadres must be the most active people at work. Da'wah cadres should not be preoccupied with arguing over issues, or countering negative voices, because that doesn't bring much productivity. What is more productive is always working in the midst of society. Show real work. If there is something that needs to be responded to, you may respond as needed, but you still have to work hard for the good of society, nation and state.

Sixth, ashlabu tanzhiman dakwah cadres must have the most solidly structured movement. As a community of human beings, there must be shortcomings and mistakes. But our obligation is to keep trying to avoid mistakes and weaknesses, while continuing to improve. The da'wah structure must be continuously strengthened from the center, regions, branches to branches. Don't leave gaps that can be used to weaken the da'wah structure

Seventh, aktsaru naf 'an, da'wah cadres must be the people who benefit the most. The best human being is the most useful for other human beings. Da'wah cadres must prove that their existence in the midst of community life contributes a lot to goodness. It doesn't harm or cause trouble, but instead provides a lot of benefits and goodness. If these seven characters are owned by da'wah cadres, they will undoubtedly be lighter and easier to face challenges and obstacles in the Information and Communication Technology Era. Da'wah cadres and all da'wah activities will be stronger and accepted by the community, in presenting the various virtues that are expected by the people, nation and state.

#### 1. Packaging Da'wah Messages in the Digital Age

The message is a meaningful set of symbols conveyed by the communicator. (Onong Uchjana Effendy, 2003; 5). The message is what is communicated by the source to the recipient which is a set of verbal or non-verbal symbols and represents the feelings, values, ideas or intentions of the source. (Deddy Mulyana, 2005; 20) says messages in media communication are an important factor for achieving communication goals. Da'wah messages must be packaged as attractively as possible in order to have appeal so that they can be well received by mad'u, especially the general public. The message has three components, namely meaning, the symbols used to convey meaning, and the form or organization of the message. The most important symbols are words (language), which can represent objects (objects), ideas, and feelings, both speech (conversations, interviews, discussions, lectures, and so on). Messages can also be formulated nonverbally, such as through actions or gestures of the body (thumbs up, head nods, smiles, facial expressions, etc.), as well as through music, painting, dance, films, and so on. Delivery of messages can also be done verbally, face to face, directly or using media/channels. (Widjaja, 2000; 14). In

addition to components, messages also have special characteristics, namely informative, persuasive, and coercive.

Messages are informative because they only provide information. In certain situations, informative messages are more successful than persuasive messages. Persuasive messages contain persuasion that awakens one's understanding and awareness. Meanwhile, coercive messages are coercive. A well-known form of conveying coercive messages is agitation, namely by emphasizing that creates inner depression and fear among fellow members of the public. Coercive messages can take the form of orders, instructions and so on. Some of the message concepts above can be used as a reference in packaging da'wah messages.

If combined, then packaging can be done in various ways, including as proposed by Wilson, namely by paying attention to the dimensions of message abstraction, audience suitability, types of message strategy design to achieve certain goals or coordinating various kinds of goals, types of content themes, messages, choosing specific words, and so on. (Build Wilson, 2012; 56). So, in order for the message to be well received by the communicant (recipient of the message), the communication message consisting of the message content and symbols must be produced very carefully. In this context, it appears that Lecturers Abdul Somad, Yusuf Mansur, Gus Baha' adhered to the teachings of Aristotelian rhetoric. According to Aristotle, the speaker's relationship with the audience is very important, and therefore the audience must be the main consideration if the conversation is to succeed. Therefore, his humor always works because he is always close to the audience. In this way, he is able to build a stronger closeness with the audience.

#### 2. Digitization of Da'wah through the Website

Just like what has been done by M. Quraish Shihab related to the moderation of da'wah



with the appearance of M. Quraish Shihab Official Website has an interesting variation in transforming religious insights. If you look at the initial appearance of the website, what you see are the 5 main menus at the top of the website, namely the Home, Blog, Work, Books, and Contact menus. On the Blog menu, it is divided into 6 sections, namely articles, audio, e-posters, events, quotes, and videos. Meanwhile, on the Books menu, it is divided into two sections, namely print books and e-books. On the main contact menu, there is an explanation about the website, which opens services for anyone who wants to ask questions about Islam, and questions that have been answered are archived on Alifmaqz.com. not only that, the contact menu also provides books by M. Quraish Shihab. The appearance presented by M. Quraish Shihab Official Website is systematized in presenting various religious insights, this can be seen by the categories menu. In the categories menu, there are sub-themes of the study. Another interesting display, the website also displays a calendar and there is a recommended menu. (Mutaqin Alzamzami, 2019; 8).

### 3. Maximizing Da'wah Videos in the Digital Age

Social media offers multimedia in the form of images, videos and designs that are disseminated to other users and one example is YouTube. Youtube is the largest video service provider today and is a medium for uploading for free. Users can load, watch and share video clips for free. Youtube is also very suitable for those who want to find information without having to read articles. Another benefit of using youtube is that content can be broadcast to millions of viewers. YouTube is available in almost every country in the world and on every computer with internet access, and is visited daily by millions of people.

Youtube is a file sharing place for all its members where someone can search for or upload their recorded videos for others to

watch. In the context of da'wah, the public's need for short duration videos in order to answer their needs is very high. Several facts show that there are many media maniacs who watch YouTube. For example, Indonesian residents aged 16 to 64 surf the internet (on all devices) an average of 7 hours 59 minutes a day. Meanwhile, internet users in Indonesia reach 175.3 million or 64% of the total population of Indonesia. The majority of these users use mobile phones, namely as many as 171 million or 98% of Indonesian internet users. Social media ranks second with the average Indonesian spending 3 hours 26 minutes. Youtube and Whatsapp are the most popular social media with respective percentages of 88% and 84%. Meanwhile, for other media, it takes 3 hours 4 minutes to watch television, 1 hour 30 minutes to stream music, and 1 hour 23 minutes to use a game console. As Dwi Hadya Jayan said, Indonesians spend almost eight hours (8 hours) surfing the internet online. . (<https://databoks.katadata.co.id/datapublish/2020/02/26/indonesia-habiskan-hampir-8-jamuntuk-berinternet>). The data above shows that 88 percent of Indonesians access YouTube. It is not surprising that Abdul Somad later used social media such as YouTube to build his popularity before becoming famous in conventional mass media and social life.

Abdul Somad, Yusuf Mansur and Gus Baha recently used the change of era to become a digital era, who represented a group of speakers using social media (YouTube) in delivering their lectures. He seems to understand well the tendency of people to consume media nowadays who use the internet more. Seeing the phenomenon above, the popularity of young preachers in Indonesia cannot be separated from the wider social context. The context in question is the view of the middle class society on Islamic values. Sociologist Ariel Heryanto, in the book Identity and Pleasure: The Politics of Screen Culture in Indonesia, sees a middle

class interest in anything related to Islam. Therefore symbols that strengthen their Islamic identity are considered important. On the M. Quraish Shihab Official Website, it also provides education through videos that are distributed via the YouTube channel. The website has displayed 11 pages, and each page holds a maximum of 10 videos, so that currently the number of videos that have been entered on the website has reached 109 videos, and each video is between 4 and 15 minutes long. It can be said that the da'wah method via YouTube videos is quite efficient, considering that almost every Android user accesses YouTube, so that religious content in da'wah studies is not only accepted by the congregation present at the recitation, but the teachings conveyed by the da'i can also be accepted by YouTube users. wherever he lives, as long as he watches the da'wah channel.

#### 4. Conclusion

Advances in science and technology in the field of information and communication technology can clearly support Islamic da'wah in the digital era, so planning for digital era da'wah is very meaningful and crucial in delivering da'wah at this time and in the future. Da'wah planning in the digital era then becomes strategic, where in this study it was found that the Da'wah Formula (Recipe) for Preachers in facing challenges in the Information and Communication Technology Era is a character possessed by da'wah cadres, undoubtedly lighter and easier to face challenges and obstacles in the Information and Communication Technology Era. Da'wah cadres and all da'wah activities will be stronger and accepted by the community, in presenting the various virtues that are expected by the people, nation and state. Apart from that, it can also package da'wah messages in the digital era, carry out digitization of da'wah through websites, and maximize da'wah videos in the digital era, so this shows that planning da'wah in the digital era is a reference for preaching.

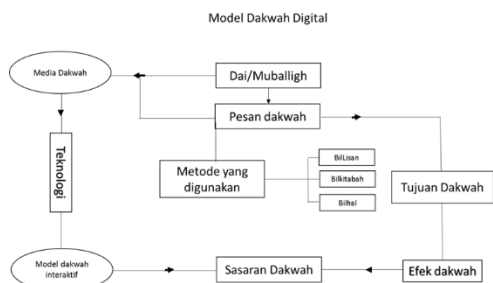


Figure 4. Digital da'wah, research results for 2023

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## PRODUCTIVITY IN DULD AGE (STUDY OF DATUK KALAMPAYAN'S ACADEMIC IN CULTURAL PROCESSING IN THE LAND OF BANJAR)

**Abstract:** *This research focuses on the productivity of Datuk Kalampayan's twilight years in his work on da'wah in Banjar Land, especially in writing and teaching several books written directly by him after returning to study in Haramain in the Middle East for 35 years. This research method uses descriptive qualitative with a phenomenological approach, by taking respondent data from 10 people who know about his work, either zuriat, or academics. The results of the study found that Datuk Kalampayan's productivity in writing 12 and 14 of his books in his old age, namely at the age of 65 years and over, also taught it in the village of Dalam Pagar by establishing the first Islamic Boarding School in the 18th century. Datuk Kalampayan's twilight is based on the spiritual spirit that he has, so that his spiritual intelligence is extraordinary which can realize his dream of illuminating the diversity of people in the land of Banjar. In fact, teaching religious knowledge is considered strategic and crucial as a logical consequence in conveying da'wah in the land of Banjar while at the same time providing peace and happiness for the people in the land of Banjar, by realizing the regeneration of Islamic propagators from zuriat and his students in the future from time to time. also taught it in the village of Dalam Pagar by establishing the first Pondok Pesantren in the 18th century. The productivity at the age of Datuk Kalampayan was grounded by his spirituality, so that his spiritual intelligence was very extraordinary which could show his mind to illuminate the diversity of the people in the land of Banjar. Even teaching religious knowledge is considered strategic and crucial as a logical consequence in the delivery of proselytizing in the land of Banjar as well as providing peace and happiness for the people in the land of Banjar, by realizing the regeneration of the spreader of Islam from zuriat and his students in the future from time to time.*

**Keywords:** *Communication, Da'wah Datuk Kalampayan*

### 1. Introduction

The Banjar community was formed and the

Banjar kingdom was founded in Bandjarmasih (now Banjarmasin) in 1526. In the story, Banjar was founded by Raden

Samudra, the crown prince who was exiled from the Hindu kingdom in Negaradaha by his own uncle, Prince Temenggung, after he received the help of volunteer troops from the kingdom. Demak Islam (Java). Immediately after that he moved the center of government to Bandjarmasi. Raden Samudra himself later embraced Islam and made Islam the official religion of the kingdom. Since then he has the title of Sultan Suriansyah. Communities who are Muslim, both Javanese and Dayak (Ngaju, Maayan, Lalawanan and Bukit) are the main elements in the formation of Banjar society.

According to H.Gt. Abdul Muis, (Kamrani Buseri, 2012) (Analiansyah, 2007), Islam entered the area of South Kalimantan around the beginning of the 16th century AD, brought by traders and preachers through the north coast of East Java. Islam had actually begun to be embraced by some of the Banjar community before the Banjar kingdom was founded, because Islam was made the official religion of the kingdom, Islam grew rapidly. However, the development of the entry of Islam was not matched by the development of Islamic knowledge of the people until the return of Sheikh Muhammad Arshad Al Banjari (1710-1812) from Mecca after studying there for 30 years. Sheikh Muhammad Arsyad Al-Banjari (Datuk Kalampayan), studied in Mecca for about 30 years and in Medina for 5 years.

In carrying out da'wah in the era of the Banjar sultanate (1710-1820) he did not forget the local element, even though he mastered religious knowledge and law, he had shown a non-rigid mind, and remained a moderate at that time, because he saw that the diversity of society and traditions before the people embraced Islam are still clearly visible, as the customs of the people. Datuk Kalampayan realized that his breadth of knowledge and intelligence in seeing the situation of the people made him motivated in preaching and propagating Islam and building a famous Banjar throughout the country. He also networked with other ulama outside the

Banjar sultanate, such as Aceh, Palembang, Banten , and others. He is aware that Islamic da'wah is actually conveyed significantly and touches layers of society that have uniqueness and diversity, so that they can bring people to know universal virtues, goodness that is recognized by all humans, regardless of time and space boundaries.

The concept of universal goodness is indeed seen as too broad, therefore it is defined through al ma'ruf , namely local wisdom, customs, goodness that is known according to the context of space and time, including within the scope of inviting al-khair , is preventing what is evil, namely something actions that are denied according to the context of a particular society as part of good customs. From here, every community that is touched by da'wah remains connected with socio-cultural backgrounds, besides that they will experience a certain transformation from the form of an ignorant society to a Muslim society. Every Muslim community has its own period of ignorance, when they have not been touched by the Da'wah itself.

The Sultanate of Banjar was immediately active as a supporter of Islamic da'wah. This can be seen in almost all the territories of the sultanate, the majority of the people are Muslim, this means that the Sultan is very instrumental in the success of da'wah. at that time still a little. Sultan Tamjidillah I sent Datuk Kalampayan to study in Mecca who upon his return became a cleric and preached which was centered in the village of Dalam Pagar Martapura.

Students of knowledge came, apart from Martapura, also came from Banjarmasin, Negara and from Upper River. On the other hand, the Sultans also actively facilitated places for recitation of the ulemas, encouraged the ulema to actively guide the ummah in writing, so Datuk Kalampayan was encouraged to write books/books as a guide for the ummah, by looking at the diversity of the Banjar community which is more specific



and localistic which is not always the same as Islam in Arab land.

Datuk Kalampayan was one of the central figures of reform in the archipelago, particularly in the Sultanate of Banjar, who espoused neo-Sufism, which means harmonization between the teachings of Shari'a and Sufism (fiqh-sufistic/tasawuf-syar'i). Datuk Kalampayan's writing ability was extraordinary, in fact there have not even been recent scholars comparable to him. According to Asywadi Syukur and Abu Daudi, there are 12 books written by Sheikh Arsyad, and according to Moh. Shaghir Abdullah there are 15 pieces, and according to researchers

Datuk Kalampayan's renewal efforts made the Banjar Muslim community, which was originally a minority and embraced by those around the palace, now become a majority Muslim community who are loyal to Islam. This reality is often associated with the efforts of preachers who are usually students and grandchildren of Datuk Kalampayan himself who were sent by him to remote areas of the Sultanate of Banjar and its surroundings. This shows that the seriousness and consistent attitude in pursuing religious knowledge is a lesson that should be emulated by the current generation, so that the many books written by Datuk Kalampa as products of his thoughts really highlight local wisdom.

The flexibility of Datuk Kalampayan's Da'wah by prioritizing local wisdom from Banjar culture is very evident in the books he composed. This illustrates that during his lifetime he greatly respected and appreciated the customs of the Banjar people, and showed an attitude of modesty and nobility by always providing religious teachings through cultural communication according to the habits and customs of the Banjar people, making him a charismatic person until now. Datuk Kalampayan respects and appreciates the customs of the Banjar people, he consciously made adjustments to the habits of the Banjar people who had undergone a transformation

from Hindus and Buddhists before embracing Islam, which immediately in the practice of Islam the Banjar people could not break away from tradition. previously. The da'wah carried out by Datuk Kalampayan in the current context is called Cultural Da'wah in the land of Banjar, which is full of management of local wisdom values in a planned and neatly arranged manner in the books he wrote which shows Datuk Kalampayan's literacy abilities which greatly inspire generations. scholars today.

## 2. METHOD AND RESEARCH

The research method used in this research is qualitative research. To collect data, researchers determine data sources and locations where data sources can be found and researched. In contrast to field research, the location of data collection for library research is much wider and does not even recognize spatial boundaries. The research setting is a benchmark for where the location is carried out. Before mentioning the research location, it's a good idea to mention the specific characteristics of library research to differentiate library research settings from other research such as field research. Library research has several special characteristics, including; First, this research relates directly to text or numerical data, not to fields or eyewitnesses, in the form of events, people or other objects. Second, the data has been prepared, meaning that the researcher is not going anywhere except to meet face to face with sources already in the library. Third, library data is generally a secondary data source, in the sense that researchers obtain data directly, not first-hand in the field. Fourth, the condition of the data in the library is not divided by space and time. Based on the above characteristics, this research was conducted in a library that collected data related to Datu Kempayan's Da'wah Work and its Development, especially the progress of his religious thought, which until now has

been deeply felt by the Banjar people.

### **3. RESEARCH RESULTS AND DISCUSSION**

The phases of a person's life journey are different. There are those that are passed with ease, not a few who have to struggle with struggles and resistance against various obstacles. Normally, and it is everyone's ideal wish that in the twilight or past old age it is done quietly. As a result of hard work, working when you are young is capable and can be enjoyed in your old age.

However, not all humans are able to enter into such pleasures. Not infrequently after entering retirement, the difficulties often come. This is due to various things. Those who do not get old age benefits, of course, will try hard again to be able to continue to meet their daily needs due to the absence of a pension guarantee. Even if there are those who get guaranteed retirement, not a few still complain because it turns out that it is not enough to meet their daily needs. Maybe, when you are still active, your daily needs can be filled with other additional income, and that is outside of the normal salary you usually get every month.

In addition to financial problems, veterans of a job, of course, at the beginning of retirement often experience what is called post power syndrome. Conditions in which mentality is honed to be able to learn to get used to being a nobody when compared to before when I was still a worker or even serving in an institution. For workers who are currently still working for long periods of time who also happen to not have a pension guarantee, or even those who are approaching retirement, they must immediately prepare themselves, to be able to get through day after day productively producing quality work.

The hope is that if you have prepared for things that usually happen to people who are no longer working, then going through

retirement is the thing with the most potential to continue working. Don't let it happen, entering retirement will become even more withered and not growing. Not infrequently we find parents who are entering retirement age are no longer passionate about living life. It is as if the wheel of life stops when we enter retirement, in the end all kinds of diseases will appear. Of course this cannot happen if we all realize, then change our mindset and echo the motto "Become empowered in old age!"

Of course there are many things that can be done. Old age or retired people will continue to be able to inspire in the present, even though they are no longer actively working in an institution or company. Some of them are by actively writing, or creating inspiring videos that can be shared with the general public. So thus, the freshness of the mind will continue to run. This is because our brain will always work. The effect is that with continuous brain performance, health can always be obtained.

On the other hand, if entering retirement we are faced with a condition of feeling that we are constantly sad, then we will not get in prime condition, it may even cause various kinds of diseases. Being empowered in old age, productive and active even though you have entered retirement age must always be done. This is to prevent oneself from continuously mourning the condition. This is an example of what is called post power syndrome.

There will be many people who need our knowledge or the experience of retired parents. One solution is to share useful articles in the fields you have been in. The author's experience will certainly be very useful for those who read it. So in this way at least you will get at least two things from sharing the writing or experience, including the reward for sharing, the brain which is always guarded to keep on thinking.

Now is the time for us to start preparing ourselves. Take care of your body's health

while maintaining your mind. Continue to be active and productive, try not to stop thinking at all times. Prepare yourself for the future by continuing to do various good things, especially vertical worship to Allah SWT, not only that, horizontal relations *hablumminnas* must also be maintained.

The next effort is to choose a community so that we always keep our minds active. Talk about positive things when you meet anyone. So it is hoped that we will become human beings who are actually *Husnul Khatimah*, because when we enter old age we still maintain the gift of Allah SWT in the form of the ability to think as well as possible. Come on, Come on! Empowered at Dusk.

There are three words that are very meaningful in the theme above, namely healthy and productive and old age. Old age literally refers to a condition where a person gets older or better known as elderly. According to the 2013 Indonesian Health Profile released by the Ministry of Health, the elderly are divided into 3 categories:

1. Pre-Old Age (age 45 – 59 years)
2. Older Age (age 60 – 70 years)
3. High Risk Old Age (over 70 years)

Sheikh Muhammad Arsyad Al Banjari (*Datuk Kampayan*), in the 18th century was one of the well-known figures in the land of Banjar, even to Southeast Asia and Africa, after studying or studying at *Haramain*, he returned to the land of Banjar at the age of 65, and devoted himself in the Banjar sultanate at that time for 40 years until he died at the age of 105 years. Between the ages of 65-105 years, *Datuk Kalampayan* wrote a number of books and taught them as part of his *da'wah* in the land of Banjar. Communication and *da'wah* became a synergistic unit with the Banjar sultanate, making it easier to spread *da'wah* in Banjar lands.

*Datuk Kalampayan*, who has been active for 40 years, is clearly categorized as an elderly who is at high risk, but with his spiritual mentality he looks very productive in his

work, and has written several books in preaching in the land of Banjar. The spirit of the *Mahatahari Islam* in the land of Banjar means a lot to the community in practicing religious values in the 18th century, more than that the spread of *da'wah* came from his upbringing to his students, who were assigned to develop Islamic *da'wah* to other areas, so that with the spread of Islamic *da'wah* to other areas, His students developed Islamic *da'wah* outside the land of Banjar, such as Malaysia, Brunei Darussalam, Thailand and others.

A Brief History of Sheikh Muhammad Arsyad Al Banjari

### 1. Shaykh Muhammad Arsyad Al Banjari's Childhood

Muhammad Arsyad Al-Banjari, who is also known as *Datuk Kalampayan*, was born in Lok Gabang Village, Martapura, South Kalimantan on 15 Safar 1122 H, which coincides with March 19, 1710 AD He is the eldest son of five children, his father's name is 'Abd Allah and his mother named Siti Aminah. Muhammad Arsyad was born in a family known for being religiously devout. These favorable environmental conditions contributed greatly to shaping Muhammad Arsyad's later personality.

In his childhood he had visible intelligence, and when Sultan Tahlil Allah (1700-1745), made a working visit to the village of Loh Gabang, the sultan was stunned to see a child painting calligraphy and was so amazed, when the sultan tried to approach the little boy, and with guilt and fear he ran in haste, feeling guilty and worried that he would be punished by the kingdom.

When the sultan returned to the palace, the next day he ordered *Mangkubumi* to look for the figure of the child he saw, but *Mangkubumi*'s efforts yielded no results, but managed to find out the whereabouts of his parents, this was conveyed to the sultan, then the sultan ordered that the child's parents be brought to the palace.

When Muhammad Arsyad's mother was

brought to the palace, and knelt to apologize to the sultan if his child's mistakes occurred and asked himself to replace the punishment if his child was guilty, really the protection of parents for their children so that their mother was willing to be punished even though she was killed, the sultan smiled at her mother's words. That. Furthermore, with the authority of the sultan and his gentleness and politeness, he asked the mother to get closer and explained the sultan's admiration for Muhammad Arsyad, and conveyed his intention to maintain it in the palace environment.

After hearing the sultan's explanation, the mother, who did not understand the previous situation, was finally able to smile, and asked the Sultan for permission to talk to her husband, the sultan also gave the mother the opportunity to talk about it in the family. Upon returning from the palace, at night his mother told her husband and Muhammad Arsyad what the sultan had told him, and finally they agreed to hand over Muhammad Arsyad to the palace at the request of Sultan Tahlilullah, with very heavy feelings because he was separated from his children who were still children. at the request of the sultan to be educated also raised in the palace environment as well as being adopted as an adopted child. They also handed over their children to the Sultan to live with the children and grandchildren of the royal family. Since then Muhammad Arsyad has lived in the palace environment of the Sultanate of Banjar.

## 2. Marriage and Studying

During his life journey at the palace, Muhammad Arsyad was very active in studying until he was an adult. In the midst of this happiness, the environment was shocked by the death of Sultan Tahlilullah due to illness, but the mandate and will that was conveyed to Mangkubumi was still carried out by Mangkubumi. After Muhammad Arsyad grew up, Mangkubumi planned to marry him to a woman who was equal to him.

The court was ordered by Mangkubumi to find a woman to marry Muhammad Arsyad in the Sultanate community, but they did not meet the woman Mangkubumi wanted. Within the Palace environment, there was a woman who was still a virgin and very suitable for what she wanted according to the Sultan's mandate. Finally Muhammad Arsyad married a woman in the palace environment named Tuan Bajut.

After marrying Mr. Bajut, Muhammad Arsyad lived harmoniously, harmoniously and peacefully with his wife, but then Muhammad Arsyad was summoned by Mangkubumi and conveyed the sultan's mandate before he died, namely to study knowledge at Haramain, and asked Muhammad Arsyad to discuss it with his wife, In such a situation his wife showed concern, then the wife asked about the concerns her husband was facing, and what was happening and being faced by Muhammad Arsyad in the palace, then Muhammad Arsyad conveyed the Sultan's mandate which was expressed by Mangkubumi before the Sultan died, namely beside married, also studied at Haramain, listened to her husband's explanation, then Mr. Bajut said that indeed this was an order and a mandate from the Sultan, sincerely Mr. it is mandated to be a prayer that pleases, so that it can guide the community one day after returning from Haramain.

The sincerity and pleasure of Mr. Bajut letting his husband go to carry out the sultan's mandate was not an easy struggle, especially when it was known that the wife was young, but with sincerity and pleasure accompanied her husband's steps to study for ± 30 years in the Haramain.

After a long time studying knowledge Muhammad Arsyad returned to the land of Banjar and devoted himself to carrying out Islamic teachings in the Banjar sultanate in guiding the people in the empire, both among the sultanate and within the people of the empire.

Datuk Kalampayan's closeness to the Sultanate of Banjar

Proximity based on religious values binds the strength of faith to unite in harmonious and synergistic relations in the life of the nation and state, in line with the vision of the sultan of Tahlilullah who raised him as a child, namely the implementation of Islamic law in the Banjar sultanate.

This means that to unite life in society, nation and state, one cannot only hold on to the strength of the human aspect which is based on the culture of society. But the continuity of life in society, nation and state is based on monotheism which is displayed with noble morals, because life in a society, nation and state This is part of *ijtihadi asi* in *fiqh*.

Meanwhile, to bridge the implementation of *fiqh* ( *ijtihadi asi* ) that is by displaying good morals, because politics as *ijtihadi cation* is of course political interaction and communication prioritizing civilized politics, not making it difficult for others or troubling other people, but civilized politics, always contributes to ideas, ideas and thoughts in supporting government and pray for the government to always be blessed and safe, so that it can carry out its programs well, so that the people will feel prosperity.

Then the closeness of Datuk Kalampayan with the sultanate of banjar seen from the interactions and communications he made in the Banjar sultanate who was so visionary with what he conveyed to the sultan, strongly supported and strengthened Mead's theory of symbolic interactional communication in 1934 through his book entitled *Mind, Self, and Society* , because Datuk Kalampayan had practiced it in the sultanate, with his ideas and thoughts which became his contribution to the sultanate at that time

Da'wah communication by Datuk Kalampayan in the Banjar sultanate refers to the verses of the Koran sura *An-Nahl*; 125 which means:

“Serullah (people) to the way of your Lord with wisdom (correct words that can distinguish between right and wrong), and teach good, and argue with them in a good way. Truly your Lord, He is the one who knows better who has gone astray from His way, and He is the one who knows better who is guided . ” (Hatta: 2009:281).

The verse above explains that communication is carried out in the context of inviting truth and goodness based on the values of Islamic teachings with the foundation being to strengthen *aqidah* (monotheism), with the abilities that must be possessed as a communicator, including;

First , Ability to upgrade oneself with scientific disciplines, both religious and general knowledge, Second, Having superiority and toughness in attitude and manners that do not harm others, Third, Ability to adapt in any situation and condition, Fourth, having visionary ideas and thoughts and fifth , Having a consistent commitment and *ghirah*/enthusiasm in supporting the government towards the benefits of *mashlahah*. These five abilities are self-concepts that can be developed by always having an understanding of the values of Islamic teachings, which makes them act humble, not criticizing the government (sultan), but instead giving their thoughts and always praying for the government (sultan) in running its government.

Interpersonal communication generally only involves two individuals, such as between husband and wife, parents and children, brothers and sisters, two colleagues. Interpersonal communication is carried out in close proximity, communicators and communicants send messages directly and simultaneously.

Interpersonal communication is the process of conveying information, ideas and feelings to others verbally or nonverbally in order to gain meaning so that other people understand or change their attitudes, feelings and behavior that occur in a society (Deddy Mulyana,

2005:65).

Persuasion is a complex communication process carried out by individuals using verbal and nonverbal messages in order to persuade or provide encouragement that aims to change one's attitude and behavior voluntarily. Fourth, the instructive approach emphasizes the higher bargaining position of the communicator where he gains legitimacy to govern, teach and even propose one kind of idea to the communicant.

This approach is said to be coercive where the communicator can force and sanction the communicant. In general, a communication process is carried out with the hope that there will be an impact or effect from the message conveyed by the communicator to the communicant. The expected impacts or effects of communication include impacts in the form of cognitive, affective, and behavioral changes. Cognitive change expects the impact of increasing knowledge or insight from the recipient of the message about the information conveyed by the communicator. Affective changes in the form of communication messages that have an impact on the emotions and feelings of the communicant. Meanwhile, behavioral change is the impact of messages that affect changes in the behavior or actions of the communicant.

In this interpersonal communication, there are approaches that occur both verbally and non-verbally, these approaches include:

#### 1. Dialogical Approach

The characteristics of interpersonal communication with a dialogical approach are characterized by conversations or dialogues. In this approach, communicators and communicants are in the same and equal position, no one monopolizes information. Dialogic requires the willingness of both parties to listen to each other's ideas or ideas.

Furthermore, in this approach seek and determine solutions from the right views and attitudes in understanding and responding to

messages that are shared together. Communicators and communicants must have respect, trust and respect each other.

#### 2. Persuasive Approach

The persuasive approach is an interpersonal communication process in which the communicator conveys verbal and nonverbal messages to the communicant with the aim that the communicant behaves, acts as expected by the communicator. However, in the process there should be no coercion or pressure. Persuasive communication is a communication process in which the communicator conveys stimuli to influence, change the views, attitudes and behavior of others in a subtle way, namely persuading.

The persuasive approach is not difficult to implement properly and can even bring the communicant's feelings into togetherness and kinship so that the communication process runs well and effectively. Between communicators and communicants, they have the same position and role so that the message/information conveyed is more easily understood and understood by both.

In interpersonal communication symbolic interaction also occurs, in symbolic interaction theory trying to describe how humans use language to form meaning, how humans create and present themselves, and how humans use symbols to create society by working with others. This theory was later developed by Herbert Blumer by formulating 3 (three) premises, namely:

1. Human behavior is influenced by the meaning they have about other people and events;
2. Interaction is very important for the development and delivery of messages;
3. The meaning that a person has about various events or others can change over time.

Datuk Kalampayan's Progress of Religious Thought and Da'wah

1. Thoughts in the field of Aqidah

Datuk Kalampayandi's thoughts in the field of Islamic faith can be seen in his efforts to purify Islamic belief from bid'ah dhalalah and purify the ideology of ahlussunnah waljama'ah. The form of its purification was to prohibit the teachings of Wuduiyah and to convince the Sultan of Nata Alam that wahdatul contravened the ideology of ahlususunnah wal jama'ah. Datuk Kalampayan's thoughts in the field of Islamic faith can be read in his writings, including:

a. Tuhfat al-Raghibin fi Bayani Haqiqah Iman al-Mu'min wa ma Yufsiduh min Riddah al-Murtaddin.

Datuk Kalampayan (datuk kalampayan) lived in the early 18th and early 19th centuries in the Banjar kingdom of what is now South Kalimantan. Although Islamic teachings have been widespread among the people of the Banjar kingdom since the 16th century, remnants of old beliefs still exist in several places. This belief does not originate from Islamic teachings, therefore, Datuk Kalampayan considers it to endanger the faith of the Muslims.

Among the traditional ceremonies that received special attention from Datuk Kalampayan in Tuhfat al-Raghibin were the ceremonies of throwing and throwing pasilih. The ceremony is carried out by giving offerings containing various wadai (cakes) and offering them to unseen spirits, ghosts who are believed to be able to cure illnesses, get rid of bad luck and grant all kinds of requests. Communication with these spirits is carried out by a balian (shaman) through the medium of a human being possessed by a subtle spirit who is invited by the purchaser after offering offerings. According to Sheikh Arsyad, the two ceremonies are bid'ah dhalalah (heresy of misleading), therefore, the practitioner must repent.

According to him, there are three indicators of bid'ah contained in the two ceremonies. First, redundant behavior or throwing away wealth in the way that is forbidden. Datuk

Kalampayan refers to the word of Allah QS. al-Isra (17): Second, ally and follow Satan's steps. Datuk Kalampayan referred to several verses which prohibit such practices, among others, QS. al-Baqarah (2): 208, QS. al-Nisa (4): 119, Fathir (35): 6, QS. Yasin (36): 60. Third, the two traditions mentioned above contain polytheism. In relation to the indicators above, Datuk Kalampayan emphasized the law for ritual practitioners as follows: 1) If it is believed that the power that exists in both ceremonies can prevent people from danger, then the law is infidel. 2) If it is believed that the power created by Allah in the two ceremonies can repel harm, then the law is bid'ah but still disbelief. 3) If it is believed that the power of the two ceremonies does not have any effect, either from the power of the ritual or the power created by God in them, then Allah also averts the danger through customary law (sunnatullah) in the two ceremonies, then the law is only heresy and not to disbelief. But if it is believed that the two ceremonies are lawful, then the law is infidel. The Memanggar and Throwing Away Ceremonies are just a few examples of the many similar ceremonies mentioned by Sheikh Arsyad. He called on royal officials to eliminate these ceremonies in the Banjar royal society.

b. Al Qam al-Mukhtasar Fi'alamat al-Mahdi al-Muntashar

Research by Ahmad Nawawi ibn al-Hajj Ibrahim al-Qadhi al-Banjari al-Kayutangi identified that this treatise was written by Sheikh Muhammad Arsyad Datuk Kalampayan in 1196 H and is still in manuscript form. This treatise is a summary of several books consisting of eleven chapters, written around 1196 H or 1782 AD. This treatise contains an explanation of the signs of the end times, for example the emergence of Imam Mahdi, Dajjal, Gog, the Ethiopians managed to overthrow Ka' flood, eclipse of the moon and sun for three days and three nights, the sun rises in the West, the appearance of dabbatul ardi (climbing

animals on earth), smoke comes out of the top of Mount Karang in Aden, the natural world explodes<sup>14</sup>

c. The Book of Communion

In the edition published by Dar Ihya al-Kutub al-Arabiyyah Mecca-Egypt in 1912 it was written that this book was compiled by Mufti Jamaluddin bin Muhammad Arsyad Mufti Banjar and recited by Sheikh Abdullah bin Ibrahim Langgar al-Qadhi and Sheikh Abdurrasyid bin Isram Panangkalan Amuntai Sheikh Arshad. According to the statement of Abu Daudi, one of the descendants of Sheikh Muhammad Arsyad Sheikh Arsyad, this book was written by Fatimah bint Abdul Wahab Bugis, grandson of Sheikh Arsyad. But because of her humility, and her respect for her uncle, Fatimah dedicated the book to her uncle Sheikh Jamaluddin ibn Sheikh Arsyad. This book contains the basic knowledge of Fiqh and Tawhid.

d. Basar Association.

This book is another version of the Malayu-Banjar book which was written in Arabic-Malay script, a type of writing that was widely known throughout the Islamic empires in Southeast Asia. This treatise was compiled by Mufti Jamaluddin ibn Arsyad and recited by Sheikh Abdullah ibn Ibrahim Langgar al-Qadhi and Sheikh Abdurrasyid bin Isram Panangkalan Amuntai al-Banjari.

2. Thought in Aspects of Sufism.

Although he is better known as a Sharia scholar, Datuk Kalampayan also specializes in Sufism. In fact, Azyumardi Azra referred to him as the Caliph of the Tarikat Sammaniah who was considered the most responsible scholar for the spread of the Tariqa Sammaniah in Kalimantan, a congregation that greatly colored Sufism in the Archipelago (Indonesia, Malaysia, South Philippines, Pattani, Brunei Darussalam and Singapore) around the 18th century. .

According to his descendants, who are in the village of 'dalam Pagar', Datuk Kalampayan teaches the Tariq Khalwatiyah, while

according to his descendants who are in Marabahan, Datuk Kalampayan teaches Tarikat Syadzaliyah,<sup>20</sup> however according to Karel A. Steenbrink it is not pure Syadzaliyah but Syadzaliyah which is already in the Sammanian version. <sup>21</sup> For more details, we can look at the teachings of Sufism Sheikh Muhammad Arsyad Datuk Kalampayan in two of his books, the Risale Fath al-Rahman bi Syarh, the Risale al-Wali Ruslan and the Risale Kanzul al-Ma'rifah.

In the Risale Fath al-Rahman, which is a translation and syarah from Syekh Ruslan's work, contains descriptions of various 'shirk of the heart' and how to get rid of them by increasing monotheism of asthma, monotheism of af'al, monotheism of character, to monotheism of substance, which leads people to move from maqam farq to maqam jama' and the person who reaches the level of maqam jama' is called arif billah. Knowledge is no longer obtained from learning but is received directly or is called ladunni science.

To obtain it, one must go through it starting from the Shari'a, increasing to the Tariqat and ending to the essence. In the book also put forward the notion of Musyafah, Musyahadah, Muayanah. All of this can only be achieved through the mind, not the mind. The treatise also explains the meanings of iradah, murid and murid, the meaning of science of faith (basic knowledge), ainul assured (intermediate knowledge) and haqqul assured (highest knowledge). Worry comes from five sources: (1) Rabbani; (2) Malaki; (3) Akli; (4) Nafsari; (5) Human. A suluk (a person who draws closer to Allah) is of two kinds: (1) Muttaqi; (2) Muhibbu, and worshipers consist of 'aliq, arif, khawas and khawasul khawas. <sup>22</sup> Thoughts of Datuk Kalampayan The treatise Kanzul al-Ma'rifah contains procedures for remembrance in the tariqat, namely about the adab of dhikr nafi itsbat, namely the sentence La Ilaha Illallah, if If it is steady then it will increase to deep remembrance. According to him, there are



two kinds of remembrance, namely *fana* all the characteristics of *basyariah* and *fana ma siwallah*. According to Asywadie Thankfully, this teaching is closer in the form of *dhikr* than the *Syadzaliyah* order.

All of *Datuk Kalampayanini*'s thoughts, both aspects of *aqidah* and *sharia*, as well as *da'wah* and *tasawuf*, are points of thought that can develop the intellectual and spiritual aspects of the people. Even so, the thought of *aqidah* is not too able to develop the roots of intellectual development because it is more doctrinal and normative, although it is still scientific. Likewise in the aspect of *shari'a*, the studies are still dominated by the doctrinal and normative aspects rather than the scientific aspects. This can be seen in the efforts to compile the thoughts of various experts such as *Zakaria al-Anshari*, *Zamal Ramli*, *Bin Hajar al-Haitami al-Rafi'i* and *Noruddin al-Raniri*, while he adds some of the results of his thoughts originating from dialectics to reality or social conditions. *Banjar people*

### 3. Thought in the Shari'a Field

*Datuk Kalampayan*'s works in the field of *sharia* are found in the following books: a. The book *Sabil al-Muhtadin li al-Tafaqquh fi Amr al-Din* describes the problem of *Fiqh* based on the *Shafi'i* school of thought. *Datuk Kalampayan* mentioned several books that were used as references, including the *Nihayah* book, the *Tuhfah* book, and others. This book was published by the publisher *Darul Ihya al-Kutub al-Arabiyyah*, consisting of II juz. b. Book of *al-Nikah*. This book discusses the problem of marriage. This book was published by *Maktabah al-Haj Muharram Afandi* in 1304 H, after being printed for the first time by the *al-Asitanah al-Aliyah* printing house in *Istanbul*. These sources were written by scholars based on the *Syefi'i* school of thought.

Many of the problems and their explanations are quoted from *Shafi'iyah* scholarly sources such as *Syarh Minhaj* by *Syaikhul Islam*

*Zakariya Anshari* and *Nihayah* by *Sheikh Jamal Ramli*, *Mugni* by *Sheikh Khatib Syarbaini*, *Tuhfah* by *Ibn Hajar Haitami*. *Datuk Kalampayan*'s strength is that he is very accurate in selecting important matters to be explained in detail, and further enhanced by giving real examples in the lives of the general public. In fact, sometimes such explanations are not found in Arabic literature books. These problems include: a. Unclean and purify b. How to purify the unclean place/cloth with a little water Various kinds of *hadats* divided into three levels d. Definition of *musta'mal* water e. *Kaifiyat* and forms of prohibition during *qadha hajat* f. Suggestions for making a place for *qada hajat* g. Issuing *zakat* on fruits, especially with regard to mixed agricultural products that are irrigated and rained h. Regarding whether livestock is obligatory or not i. How to collect *zakat* for the poor j. Guidance and law on planting corpses k. Organizing the bodies of children who miscarried l. *Ijab* and *kabul* in marriage Many of *Datuk Kalampayan*'s findings are relevant to people's lives until now, for example: a. In the field of *taharah*, *Datuk Kalampayan* gives an understanding of *musta'mal* water and how to purify *mutanajjis*, places or clothes with a little water. b. In the field of *zakat*, *Datuk Kalampayan* explained in detail the *zakat* of agricultural produce which was worked on with a mixture of irrigation and rain-fed systems, and the concept of the technical arrangement of *zakat* for the poor. It is also interesting to state *Datuk Kalampayan*'s thoughts which are controversial among the general public, namely regarding the law of *kenduri* which he considers *makruh* and *heresy*. This law applies to those who organize and people who come to fulfill the invitation of the feast.

### 4. Thoughts in the Field of Education.

One of the things he did after being in *South Kalimantan*, specifically in *Martapura*, was to establish an Islamic educational institution which is very important to educate Muslims

in order to increase people's understanding of Islamic teachings and practices.

To realize his ideas, an Islamic education center was built, which is similar to a surau in West Sumatra or a Islamic boarding school in Java. The Muhammad Arsyad al-Banjari Education Center consists of rooms for lectures, student dormitories, teachers' houses and a library. The center is economically self-sustaining, as Sheikh Muhammad Arsyad al-Banjari along with several teachers and students transformed the land in the neighborhood into productive paddy fields and vegetable gardens. Before long, the center had established itself as the most important locus for training students who later became prominent scholars in the South Kalimantan region. (Azra; 1995; 254-255).

This non-formal educational institution, the first in the Banjar community, has taught various branches of knowledge more broadly and deeply. (Hasbullah; 1998; 64). Some of the education developed uses the halaqah system, which is generally followed by the community. In this education system, the students sit in a circle around the teacher to receive lessons. In addition, there are also special or sorogan lessons that are only given to close family and certain people using standard Arabic books as the main reference. In this system the students take turns facing the teacher by reading the book to be studied (Baderi, 1986: 13). This sorogan system is the most difficult part of the entire traditional Islamic education system, because it demands patience, diligence, obedience and personal discipline from students. . After that this system proved to be very effective, because it allows a teacher to supervise, assess and guide maximally the ability of a student to master his lesson (Dhofier; 29). The basic lessons given by Muhammad Arsyad were the Al-Qur'an and Arabic Malay reading and writing, and worship (fiqh) by means of imlakkan, followed by Nahwu and Nerves (Arabic), Interpretation, Hadith, Monotheism and others. (Hasbullah; 1998; 66-67).

## 5. Thoughts in the Field of Islamic Law

The reforms carried out by Muhammad Arsyad in the field of Islamic Law (Fiqh) include:

a. Implementation of congregational prayers in a special place (langgar) for the purposes of worship activities and the interests of the surrounding community. According to Muhammad Arsyad, it is a symbol of Islam so that travelers can know that the area is a Muslim community area. He stipulated the law of congregational prayers as fardu kifayah for a small hamlet with a population of around 30 male Muslimmukallaf. (Rasyidah; 1990; 128).

b. Regarding funerals, Muhammad Arsyad requires the use of tabala or coffins. This law was stipulated closely related to the natural conditions of the South Kalimantan region which are watery, swamps and peat soils. Besides that, it is also to avoid being disturbed by wild animals that eat carrion, so he makes it obligatory to wear tabala. (Rasyidah, 1990; 128).

c. The implementation of zakat as a manifestation of social justice has advanced according to the times, and is even still relevant today. According to him, zakat must be given to people who mustahak (people who are entitled) and have work skills, so that zakat can be used as productive business capital, not for consumptive purposes, with the intention that the recipient of zakat will receive it until the age of most people (approximately 60 years). ), no longer includes the poor who receive zakat. This attitude needs to be raised to the surface in fighting poverty among Muslims. (Rasyidah, 1990; 129).

d. Muhammad Arsyad's opinion regarding Kenduri, namely: (a) circumcision for the whole village and their families brings food for the dead family, (b) it is makruh again bid'ah for those who die to provide food to be eaten by many people, both before and after the body is buried, as is the case in the Banjar

community, (c) it is makruh and bid'ah for those who attend the banquet invitation provided for the feast by the family of the deceased, (d) it is forbidden to provide food for the family of the deceased who cries loudly (loudly) because it is considered to be helping the person in question. immorality. (Muhammad Arsyad, Sabilal Muhtadin II; 87).

e. Thoughts in the Field of Da'wah

Datuk Kalampayan has the ability and advantages in all things, has brilliant thoughts. In the field of da'wah, he applies his thoughts in various aspects of life fundamentally. In general, there are three classifications of da'wah developed by Datuk Kalampayan, namely bil hal da'wah, oral preaching and written preaching.

a. Da'wah bil p.

Da'wah bil hal is a da'wah activity carried out with various forms of activity and the positive impact can be felt immediately, or the results to be achieved are clearly defined. There are several forms of da'wah bil hal that have been practiced by the Datuk, namely, regeneration of the clergy, purifying religious teachings through marriage and building partnerships between businessmen and the community. In the context of regeneration of the clergy, Datuk Kalampayan built a fostered village called "In the Fence". This village was specifically intended for the recitation and development of Islam by forming a cadre of scholars who were able to carry out da'wah duties throughout the kingdom and even outside the Banjar kingdom. The study is carried out in a guided manner with strict supervision.

In the first two decades Datuk Kalampayan worked hard to create a cadre of scholars who were reliable and ready to use. Those deemed capable and knowledgeable enough were sent back to their respective hometowns to teach religion or preach there. The ulama regeneration process was carried out by Datuk Kalampayan until he was 80 years old.

Datuk Kalampayan has also carried out purification of Islamic teachings in a wise manner so that there has never been unrest among the people. After studying in the holy city of Mecca al-Mukarramah, Datuk Kalampayan returned to his homeland and saw that the Banjar people still strongly adhere to animist beliefs through several rituals, including bandaging and throwing away pasilih. The ceremony is accompanied by placing offerings or ancak which are offered to the spirits, so that the spirits will grant their wishes.

Datuk Kalampayan refused such rituals, but through a persuasive approach and finally succeeded in enlightening the community to return to the true teachings. In addition to purifying religious teachings from the influence and practice of animist beliefs, Datuk Kalampayan also purified religious teachings from the Wahdatul Wujud ideology taught by Syekh Abdul Hamid Ambulung. According to Datuk Kalampayan, this teaching is considered contrary to the teachings of Ahlussunnah wal Jama'ah and royal law. Datuk Kalampayan finally managed to abolish this teaching in a wise way.

Wisely and with mutual understanding, Sheikh Abdul Hamid Ambulung finally accepted the death sentence handed down by the kingdom to him. Datuk Kalampayan 's wise action was finally able to save Islamic teachings from the wahdatul existential ideology that was contrary to ahlussunnah wal jama'ah and saved the kingdom from conflict among the people because of this belief. The da'wah approach through marriage turned out to be very effective for the spread of Islam, because his descendants then spread throughout the kingdom and even outside the kingdom in carrying out the task of Islamic da'wah. Most of his descendants from eleven wives and one of Chinese descent, are great scholars who are respected and respected by the wider community. Datuk Kalampayan succeeded in uniting the ruling class of the

kings and the people of the jaba class under Islamic ties, so that there was no gap between the clergy, aristocrats and the jaba group. The success of approaching this noble class, made Sultan Tahmidullah or Nata Alam become his friend and student and even supported and encouraged all kinds of da'wah activities carried out by Datuk Kalampayan. By order of Sultan Tahmidullah, Datuk Kalampayan studied religion in the holy city of Makkatul Mukarramah for 30 years.

Sultan Tahmidullah also ordered Datuk Kalampayan to compile a book which was later named the book *Sabilul Muhtadin*, which was a guide for all the people of the kingdom in carrying out worship. His integration with the community is manifested in the form of his pioneering work in cultivating dead land so that it can function as fertile agricultural land. One of the ways he did this was by digging a river for the benefit of irrigating rice fields which became known as the Tuan River.

b. Da'wah with Oral

The pattern of preaching by word of mouth is a common pattern carried out by preachers because it is the easiest and most practical, as well as the technique of implementation and at the same time it can cover a large number of people. This pattern was also applied by Datuk Kalampayan to the activities of coaching cadres of ulama and ta'lim assemblies in the Foster Village, "In the Fence" within the Banjar kingdom. In fact, before returning to his homeland, Datuk Kalampayan was entrusted with giving lessons at the Grand Mosque in the field of Shafi'iyah law. One of his students was a Jin group named al-Badakut al-Mina, who accompanied him to the land of the Banjar kingdom.

c. Da'wah in writing.

The ability of Syekh Muhammad Arsyad Datuk Kalampayan which is very special is his ability in the field of composing, compiling religious books. Covering the

fields of Shari'at, Monotheism or Ushuluddin science and the field of Sufism. Most of these books were written in Malay, the language commonly used throughout Southeast Asia since the 14th century AD using Arabic-Malay letters. Some of his books are still used as handbook for teaching to the wider community, in fact, the book of *Sabilul Muhtadin* is still used as a reference book in Brunei Darussalam and throughout the Southeast Asian region. The results of this paper are the most valuable legacy of Datuk Kalampayan for all people to this day. Datuk Kalampayan has instilled six da'wah frameworks which serve as the main capital for the success of his da'wah. The six frameworks in question are as follows: 1) Da'wah must be followed by solid wisdom and full diligence in studying knowledge 2) Da'wah must be clearly oriented by prioritizing the development of cadres of scholars according to the demands of society 3) Da'wah must have a broad foundation of insight in various aspects of life society which is manifested in the bil-hal da'wah strategy 4) Da'wah must be able to protect all levels of society so that there is no social gap between the nobility and position groups in the banjar royal community 5) Da'wah must be realized with full wisdom and wisdom so that it can touch human civilization through oral, written and deed 6) Da'wah must be imbued with sincerity, high dedication and selflessness in accordance with Islamic teachings.

The definition of qalam etymologically comes from the Arabic qalam with the plural form *aqlām* which means the words of the writer, pen, writer (Yunus, 2010: 355). Other definitions mentioned in the *Universal Journalism* book include: according to Quraish Shihab that the word qalam refers to all kinds of writing instruments up to sophisticated writing and printing machines (Kasman, 2004: 118).

Al-Qurtubi states that qalam is an explanation like the tongue and qalam used to write (by Allah SWT.) Both those in the heavens and

those on earth. So al-Qurtubi's explanation shows that qalam is a tool for composing writing, then it develops into a printing tool. Al-Shabuni revealed that the qalam is a pen for writing, a tool for recording various knowledge from the knowledge that is in the book of Allah SWT. to what has become human experience from time to time (Kasman, 2004: 119). Al-Qurtubi's explanation is the same as what was conveyed by Imam ash-Syaukani in the book *Fath al-Qadir*, that al-qalam refers to the tools used for writing. And according to most scholars, the meaning of al-qalam is what is written in the tablet of al-mahfudz (Asy-Syaukani, 1994: 332). In this context, bilqalam must also be able to become a professional mover. In addition to being professional, the readiness of the da'wah subject, both mastery of material, methods, media and psychology, determines the success of da'wah activities (Amin, 2009: 13). Professional can be interpreted as an activity or job based on expertise and quality, in other words work that is in accordance with the field.

The skills and qualities of a person are usually obtained from special education and training. The job takes up time ( full time ) and becomes the foundation of a source of life while maintaining reputation, accompanied by adequate knowledge and skills, then the job is a profession, the perpetrator is called a professional.

As previously disclosed, the works of Datuk Kalampayan in writing as many as 18 books described in the description above, show that Datuk Kalampayan was a very productive scholar in his old age, because he returned to his hometown of Banjar land at the age of 65 after studying at Haramain for 35 years.

His works were also the result of a process of interaction and communication between the people within the Banjar sultanate which was very harmonious with their scientific discipline, so that Datuk Kalampayan 's role in the empire was so significant, even though he was not in the palace environment, he

preferred to live outside the palace. palace with his family. Datuk Kalampayan shows more in the form of works in the form of books that will guide his children, grandchildren, society and the continuity of the sultanate's government itself,

In this context the sultan of Banjar responded positively to the communication and preaching of this bil Qalam/bil kitabah, because it also provided benefits for the sultanate of Banjar in carrying out the sultan's government system, so that what Datuk did Kalampayan is good for the sultanate and its people.

In the communication and da'wah bil qalam / bil kitabah model, Datuk Kalampayan can broadcast Islam through the field of education, this is in accordance with the theory of the multi-dimensional communication model from the dimensions of the relationship Cuyno (1986) in Said Lestaluhu (2017; 17), indicating that there are five elements the basis of communication that interact with each other as a multi-dimensional relationship, which is used in politics or in the field of education.

Communication is seen from a multidimensional perspective, so there are two levels that can be identified, namely the content dimension and the relationship dimension . The content dimension shows the words, language and information carried by the message, while the relationship dimension shows how the communication participants interact with each other. Multidimensional communication is built on more than one relationship, namely one element can have four attachments to other elements. The basic assumption of multidimensional relationships is that an element may affect and be affected by one or more elements. This means that the source not only influences the message but can also influence the channel and receiver. Likewise, the channel and receiver can affect the source.

Datuk Kelampayan is a scholar who is very productive in writing books and teaching knowledge to the public. His existence meant a lot to the sultanate and the people of Banjar,

many of the books he wrote became guidelines for religious life according to Islamic law, among the books he wrote included;

**Table 2.** Authors of the books that are used as guidelines for religious life according to Islamic law

Abu Dawud version	Aswadi Thanksgiving version	Wan Sagir Abdullah's version
Kitâb Luqtât al-'Ajlân The Book of Usûl al-Dîn Kitâb Tuhfa al-Râghibîn fi Bayâni Haqîqat Imân al-Mu'minîn wa Mâ Yufsiduhu Min Riddat al-Murtaddîn Kitâb al-Fara'id Kitâb 'Ilm al-Falak Kitâb al-Qaul al-Mukhtasar fi 'Alâmât al-Mahdi al-Muntazar Kitab al-Nikâh Fatawa Sulaymân al-Kurdi Risâlah Kanz al-Ma'rifah Kitâb Sabîl al-Muhtadîn li Tafaqquh fi al-Dîn Mushaf al-Qur'an al-Karîm Kitâb Majmû' (Majmû')	Risâlah Usûl al-Dîn Risâlah al-Qaul al-Mukhtasar fi 'Alâmât al-Mahdi al-Muntazar Risâlah Tuhfat al-Râghibîn fi Bayâni Haqîqat Imân al-Mu'minîn wa Mâ Yufsiduhu Min Riddat al-Murtaddîn Basar Association Risâlah Luqtât al-'Ajlân Kitab al-Nikâh Risâlah Fatwa 'Atâ Allah Syarh Fath al-Jawwâd Kitâb al-Fara'id Kitâb Sabîl al-Muhtadîn li Tafaqquh fi al-Dîn Risâlah Fath al-Rahmân bi Syarh Risâlat al-Wali al-Ruslân. Risâlah Kanz al-Ma'rifah	Risâlah Tuhfat al-Râghibîn fi Bayâni Haqîqat Imân al-Mu'minîn wa Mâ Yufsiduhu Min Riddat al-Murtaddîn Kitab Sabîl al-Muhtadîn li Tafaqquh fi al-Dîn Risâlah al-Qaul al-Mukhtasar fi 'Alâmât al-Mahdi al-Muntazar Risâlah Kanz al-Ma'rifah Risâlah Usûl al-Dîn Kitab al-Nikâh Kitâb al-Fara'id Hâsiyah Fath al-Wahhâb Mushaf al-Qur'an al-Karîm Risâlah Fath al-Rahmân bi Syarh Risâlat al-Wali al-Ruslân Arkân Ta'lîm al-Şibyân, 1 Bulûgh al-Marâm Fî Bayân al-Qadâ' al-Qadar wa al-Wabâ' Tuhfat al-Ahbab Bidâyat al-Mubtadi' wa 'Umdat al-Aulâd

In another version, Abdussalam mentions several additional works written by Datuk Kalampayan, namely: Mushaf al-Qur'an with qira'at Hafs, Wars and Ibn Katsîr (text of the Koran in Datuk Kalampayan's handwriting), Jawâmi' al -Asrâr (in Arabic and accompanied by a translation by Usri Uthmân), Majmû'ah al-Asrâr, Risâlah al-Qiblah, Kaur al-Ardi wa Khâtî al-Istiwâ' and Risâlah Du'â' Anfaz.

The difference in the number of versions of the book is caused by several things, including: first, there is an ancient custom of viewing written works based on the writings of their own or the writings of their students, such as the Parukunan Malayu book. Second, relying on the translator of a certain book as his work even though it is only a translation. Third, there are still a number of papers in

various libraries both at home and abroad that have not been examined by ilologists. And it is possible that some philologists then attribute a work under study to Datuk Kalampayan.

In his busy teaching and preaching, al-Banjari also wrote several, among others; others Usul ad-din (written in 1188H/1774M.), Tuhfat ar-Raghibin fi Bayani Haqiqat Iman al-Mu'minin min Riddat al Murtaddin (written 1188H/1774), Kitab al Faraid, Kitab an-Nikah (never published in Istanbul in 1304 H), Lughat al-Alan fi Bayan haidh wa Istihad wa Nifas an-Niswan (printed in 1992M), Al Qaul al-Mukhtashar fi Address al-Mahd al-Muntazhar (written in 1196H), Kanz al-Ma'rifa h, falaq science, Fatawa Sulaiman Kurdish, Mushhaf al-Quran al-Karim and Sabil al-Muhtaddin li at-Tafaqaquh fi Amr

ad-Din. This latter book is a very famous Malay figh in the Archipelago, Malaysia, Thailand and Cambodia; and is the monumental work of al-Banjari. This book is stored in major libraries in the Islamic world, such as in Makkah, Egypt, Turkey and Beirut. (Abdullah, 1982: 47)

In addition, there are several books whose truth is still uncertain, including: Majmû', Arkân Ta'lîm al-Şibyân, Bulûgh al-Marâm Fi Bayân al-Qadâ' wa al-Qadar wa al-Wabâ', Tuhfat al-Ahbâb, Bidayat al-Mubtadi' wa 'Umdat al-Aulâd, Fatâwa Sulaymân al-Kurdi and Risâlah Fatwa 'Atâ' Allah. Muhammad Sagir Abdullah said that the book Bulûgh al-Marâm Fi Bayân al-Qadâ' wa al-Qadar wa al-Wabâ', Arkân Ta'lîm al-Şibyân, Bidayat al-Mubtadi' wa 'Umdat al-Aulâd and Tuhfat al-Ahbâb is really the work of Datuk Kalampayan'

Datuk Kelampayan was given the ability and advantage in many ways, he has brilliant intelligence and thoughts. In the field of da'wah, Datuk Kalampayan applied his thoughts in various aspects of life fundamentally. In general, there are three classifications of da'wah developed by Syekh Arsyad, namely bil hal preaching, oral preaching and writing preaching.

Datuk Kalampayan's special ability is his ability to compose and compile religious books. Covering the fields of Shari'at, Monotheism or Ushuluddin science and the field of Sufism. Most of these books were written in Malay, the language commonly used throughout Southeast Asia since the 14th century AD using Arabic-Malay letters. Some of his books are still used as handbook for teaching to the wider community, in fact, the book of Sabilul Muhtadin is still used as a reference book in Brunei Darussalam and throughout the Southeast Asian region. The results of this paper are the most valuable legacy of Datuk Kalampayan for all people to this day.

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From some of the information obtained by researchers during the research, it was found that Datuk Kalampayan served as a preacher also serves as:

1. As an educator, namely establishing the first Islamic boarding school in the 18th century in carrying out its educational function. Through the bil qalam communication model, he educated and taught the people and environment of the empire to carry out Allah's commands. and stay away from His prohibitions. Therefore the book Sabil al-Muhtaddin was written at the request of the sultan to him to write a book of worship in the Malay language, the statement of the sultan's request is contained in the words of the introduction to the book Sabil Al Muhtaddin. This aims to prevent people from deviating from Islamic law in the sultanate.

2. As an information straightener. There are three things that must be straightened out by dai through bil qalam communication. First , information about the teachings of Datuk Kalampayan in the Banjar sultanate. Second , information about the works or achievements of him who was a very productive person at

that time and gave the spirit of present and future generations. Third, as a writer, he was able to dig into the conditions of the people who were geographically very different from the geography of Haramain so he came to adapt Islamic teachings to the current situation and conditions. Islam.

3. As a reformer, namely the disseminator of renewal understanding of the understanding and practice of Islamic teachings (Islamic reformism).

4. As a unifier, namely to become a bridge that unites Muslims.

5. As fighters, namely fighters spreading Islamic teachings and trying to form public opinion that encourages the enforcement of Islamic teachings, rahmah li al-'alamin.

Datuk Kalampanyan's communication and preaching in the Banjar sultanate, when connected to today's dynamics, is still very relevant, bearing in mind that the trias politica was also carried out by him even though at that time the form of government was with a royal monarchy system. However, for him, whatever the form of the state and its governance system is not crucial, but how the implementation of Islamic values is carried out and gets support from the government.

#### Spirit of Spirituality.

If you examine Datuk Kalampanyan's work in developing his da'wah in the land of Banjar with the culture of the people, what he did was really a golden ink in his preaching work, he gave an Islamic light in the Land of Banjar. This is based on the spirit of spirituality that he has, where Spirituality can uncover the real causes of problems. Problems can occur because it is a reversal of ultimate truth, divine truth. What always appears to our senses is what is on the surface and not what is real. Humans cannot and will not find ultimate truth in past experiences. It is only a form of a repeating pattern and what humans can learn is only how that pattern works in life. Humans must move forward beyond all experience and the past.

Because the process is always progressing like space and the whole essence of the work of spirituality is that it changes consciousness and results in changes in things and forms. Everything is a manifested form of consciousness or energy. The concept of spiritual realization is to reduce high-level spiritual ideas to a physical form that can be touched and gross. Physical form that can be reached by human sensory devices. The essential point of all spirituality is the perfect way of doing worship, based on love. Not out of want of any gain or out of fear. This is the way to understand the profound facts about the meaning of spirituality when compared to its outward appearance.

Spirituality is directed to the subjective experience of what is existentially relevant to humans. Spirituality is not only concerned with whether life is valuable, but also focuses on why life is valuable. Being spiritual means having more attachment to things that are spiritual or psychological than things that are physical or material. Spirituality is self-awakening or enlightenment in achieving the goals and meaning of life. Spirituality is an essential part of a person's overall health and well-being. (Hasan, 2006:288)

Something spiritual has eternal truths related to the purpose of human life, often compared to something that is mundane, and temporary. In it there may be belief in supernatural powers as in religion, but has an emphasis on personal experience. Spiritual can be an expression of life that is perceived as higher, more complex or more integrated in one's view of life, and more than things that are sensory. One aspect of being spiritual is having a sense of purpose, which continually increases one's wisdom and willpower, attaining a closer relationship with divinity and the universe and dispelling illusions of wrong ideas originating from the sense organs, feelings, and thoughts. Others say that the spiritual aspect has two processes, the first is the upward process which is the growth of internal power that changes one's relationship



with God, the second is the downward process which is marked by an increase in one's physical reality due to internal changes. Another connotation of change will arise in a person with increased self-awareness, where the divine values inside will manifest out through experience and self-development, with beliefs expressed by certain institutions connected with beliefs expressed by certain institutions held by its members. . Religion has testimonies of faith, community and code of ethics, in other words spiritual gives answers to who and what a person is (existence and consciousness), while religion provides answers to what a person has to do (behavior or action). Someone may follow a certain religion , but have spirituality . People may follow the same religion, but they do not necessarily share the same path or level of spirituality.

#### 4. Conclusion

Datuk Kalampayan as a pioneer of 18th century clerics in the land of Banjar, was able

to contribute to the Banjar sultanate in conveying his da'wah in the land of Banjar and realizing its regeneration from time to time. He is also a scholar who is very productive in writing. The books he wrote as a form of productivity in his old age can be used as a role model for current scholars in conveying da'wah in the midst of dynamic social life, so of course it is hoped that they can make a positive contribution to the development of da'wah in the land of Banjar. The communication and da'wah approach is carried out using an argumentative dialogic communication approach and a persuasive approach, as stated in the following Al-Quran :

"Call (people) to the way of your Lord with wisdom and good lessons and argue with them in a good way. Verily, your Lord is He who knows better about those who have strayed from His way and He is the one who knows better those who are guided (QS Annahl: 125)."

Likewise , in carrying out his preaching, especially in teaching the books he wrote to his students, he did it very wisely.

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## RELIGIOUS BASED MANAGEMENT PLANNING ON HUMAN RESOURCES ENGINEERING IN THE ENVIRONMENT WORK

**Abstract:** *This article highlights the importance of Human Resource Development (HRD) in achieving organizational goals and objectives in the era of globalization. The article argues that HRD is a critical parameter for organizations to attain competitive advantage and survive in the highly competitive global market. Human Resource Management (HRM) is an organizational function that plays a vital role in recruiting, managing, and navigating employees to work towards a common goal. The article cites various studies that show how ineffective and inefficient human resources can negatively impact an organization's performance. The article emphasizes the need for organizations to focus on HR development as their primary asset, which includes improving employee performance, career advancement, competency improvement, and talent development. Ultimately, the article concludes that organizations can increase productivity, quality, customer satisfaction, and organizational effectiveness by effectively managing their employees.*

**Keywords:** *Human Resource Development (HRD), Human Resource Management (HRM), Organizational competitiveness, Employee productivity, Career advancement, Competency improvement, Talent development, Organizational effectiveness.*

### 1. Introduction

This era is characterized by very attractive global competition. The competition that occurs becomes material for study for the development of the resources of a company/institution/organization. Human Resources (HR) is an important asset for any organization to achieve competitive advantage in the era of globalization. Therefore, Human Resource Development (HRD) is an important parameter for organizations to achieve goals and objectives in order to continue to exist on the National

and International level.

HRM is an organizational function that focuses on the recruitment, management and navigation of employees in working for an organization which is realized through synergy to strengthen mutuality towards a common goal. Susan (2012) stated that HRM is a strategic and comprehensive approach to managing people, workplace culture, and the environment to effectively and productively contribute to organizational goals and objectives. In recent years, many good companies have performed poorly due to ineffective and inefficient human resources

(Townsend and Wilkinson, 2010; Okoye and Ezejiofor, 2013).

Most organizations ignore HR development as their main asset. Okoye and Ezejiofor (2013) said that business in an organization is filled with uncertainty regarding the understanding of employee contributions in increasing organizational productivity and profitability. This is what causes a lot of unskilled workforce, uncompetitive organizations, high levels of poor performance, and low productivity. Various efforts have been made by the organization by emphasizing its employees regarding improving performance for the sake of beneficial outputs and outcomes as long-term effects (shodhganga.inflibnet.ac.in).

Human resource management (HRM) efforts aim to improve employees in handling various types of tasks in order to strengthen organizational competitiveness and adaptation to the environment, especially external turbulence (Jumawan, 2015) while at the same time benefiting employees for career advancement, competency improvement, and talent development. HRM increases productivity with high quality, satisfied customers and beneficial impact on the organization. In line with what was stated by Pfeffer (1998) that "the key to long-term success has been, and will continue to be, how organizations manage their employees, because creating meaningful work and otherwise keeping employees happy is central to fostering organizational effectiveness". Often organizations experience serious problems in managing employees to work optimally.

In line with Simon (1997) that "the basic challenge for all organizations is "inducing their employees to work toward organizational goals". In fact, to achieve long-term and sustainable success, organizations need human resources that create meaningful work (according to the talents and competencies of employees). In addition to talent and competence, organizations need to

pay attention to aspects of the resilience or toughness of employees at work so that an organization can continue to exist in the long term. Many competitive business organizations have emerged recently. However, the existence of these business organizations did not last long. This is because employers do not pay attention to aspects of the resilience or toughness of employees in recruiting. In fact, in addition to talent and skills, a job really requires resilience at work. This was made possible by management planning in human resource engineering not going well so that the achievement of goals did not go according to the desired goals.

Planning is a concept that realizes structured ideas and ideas and is manifested in working papers, as a basis for developing strategic and tactical steps for developing human resources in the work environment, so that engineering human resources is an impossible part, because it is a crucial part in improving productivity performance in the work environment itself.

Usmalian (2011; 48) says planning everything is also a concept taught in Islam. Rasulullah SAW said: "Whoever is someone who always plans every business, then he will be forgiven by Allah" (HR. Thabrani). As well as several verses of the Qur'an that teach to prepare (planning) for tomorrow.

The urgency of a plan is intended to be able to position an appropriate human resource in the right position and time. Planning is also a sunatullah because nature and everything in it and everything that befalls it has been planned by Allah SWT beforehand so that the natural system is able to run automatically well until now even until the end of the world arrives. Thus, human resource planning will also affect the sustainability and existence of an organization in the work environment.

Management planning in the work environment is the key to success in achieving goals, having abundant human



resources without being accompanied by the ability in good management planning, it is difficult to reach the goals to be achieved. Human resource management planning plays an important role in the successful management of an organization or work environment anywhere, be it a company, government agency, or educational institution and so on.

HR Management develops and works through a human resource management system that is integrated with other parts of a management. In general, there are five functional areas in effective human resource management: staffing, human resource development, compensation, safety and health, and staff relations. Planning in these five areas is absolutely necessary so that the provision and development of staff, compensation systems, safety and health systems and relations between staff are properly prepared and directed in line with organizational goals.

Nawawi (2005; 137-139) states that human resource planning can be interpreted as: first, a process that involves a series of activities such as forecasting or estimating, efforts to meet the needs of the organization's workforce within a certain period in the future including efforts to match internal and external HR with job vacancies that are expected to be needed, managing HR flow and utilizing available resources effectively and efficiently. HR flow arrangements are intended to determine certain requirements for new HR who will replace outgoing HR with resources that work effectively and efficiently.

Second, as a strategy for developing the contribution of human resources to the organization in order to achieve success. Quality resources owned by the organization will have an impact on increasing the organization's competitive ability. All tasks and work are carried out in a direction towards the success of the organization. Human resource planning is a process of carrying out one of the management functions

Machine Translated by Google includes activities, forecasting, fulfillment and management of the workforce so that it is efficient and effective as possible in order to achieve organizational success.

Human resource planning should be based on compatibility with strategic planning and organizational operational planning. Incompatibility will be a burden to the organization and can be a hindrance in the future. In addition, human resource planning must also be based on the results of job analysis. By using the information in job/position descriptions, qualitative and quantitative needs can be predicted so that the organization can run effectively and efficiently. (Nawawi, 2011; 141).

Religion-based management planning is crucial and strategic in human resource engineering, this should be disclosed more for organizations/companies/government agencies and even educational institutions to do, because outwardly everyone always wants to do good in managing a better tomorrow.

This description wants to review the importance of paying attention to religious-based management planning in the engineering of human resources in the work environment so that employees have resilience or toughness at work.

## 2. Research methodology

This study uses a literature study, namely a series of activities related to data collection methods through reading and recording, as well as managing research materials (Prabawati et al., 2018; Rizani et al., 2021). Literature studies were carried out by searching books, articles, national and international journals as well as using dictionaries and thesauruses. The literature used is adapted to the title of the study on religious-based management planning in human resource engineering in the work

environment.

### 3. Results and discussion

Human Resource Management, or abbreviated HRM is a science or method of how to optimally manage the relationships and roles of resources owned by individuals so that a goal is achieved. The definition of management according to Marwansyah is the utilization of human resources within the organization through the functions of human resource planning, recruitment and selection, human resource development, career planning and development, compensation and welfare, occupational safety and health, and industrial relations.

Marwansyah (2010) according to Flippo Human Resource Management is called personnel management, namely planning, organizing, directing and terminating employment, compensation, incentives, maintaining and terminating employment with human resources to achieve individual, organizational and community goals

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(Flippo;1995: 4)

According to Sastrohadiwiryo, Human Resource Management is replaced with workforce management, namely utilization, coaching, knowledge, regulation, development, elements of the workforce. Good and bad employees or employees to achieve maximum efficiency and effectiveness according to the organization (Sastrohadiwiryo; 2002; 57).

### 4. Conclusion

In conclusion, HRM is the process of planning, organizing, implementing, and controlling human resources in an organization to achieve goals effectively and efficiently. Human Resource Management has a broad scope, one of the meanings and limitations used is human resource management, which are the policies and practices needed by someone to carry out aspects of human resources from a manager's position.

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## BADAMAI CULTURE COMMUNICATION: CHARACTER DEVELOPMENT OF NATIONAL LAW

**Abstract:** *This article discusses the challenges faced in building and implementing law in society. The balance between law and the interests of the community is important, as the law should be created to protect the interests of the community. Sociologists view law as a cultural product, and laws will only be effective if they are created with an awareness of their urgency and sincerity to carry them out. The law is for humans and cannot be separated from the human aspect. It is centered on humans and made by humans, formulated in a human language that only humans can understand, and run by humans to serve the interests of humans. The article also highlights the importance of legal culture, which consists of structure, substance, and culture, in measuring law enforcement in a country. Lawrence Meil Friedman's legal system theory includes these components, and they are often used as standard references for measuring law enforcement. The article emphasizes that without legal culture, the legal system will be ineffective and will not serve its purpose of protecting the interests of the community.*

**Keywords:** *law, society, legal culture, law enforcement, humans, interests, challenges, balance*

### 1. Introduction

Building and realizing law in people's lives will definitely be faced with various challenges, both caused by internal and external factors of the community itself. Society as a translation of the term society is a group of people who form a semi-closed (or semi-open) system, where most interactions are between individuals who are in a legal group. It will be good if society accepts it voluntarily. Conversely, the law will be bad if the community even though the law will be good if the community accepts it voluntarily. Conversely, the law will be bad if the community cannot accept it, because it cannot protect the interests of the community. Thus the law and the interests of the community

must have a balance, in the sense that the law is created to protect the interests of the community. Sociologists see law as a cultural product. Laws are just inanimate objects, meaningless if they are not made with an awareness of their urgency and sincerity to carry them out. Laws will only become jokes and jokes if those who make them number one lawbreakers, and those who implement them are a nation without a culture of law. Lawrence Meil Friedman has an interesting anecdote on this subject, "Without legal culture, the legal system is where dead fish lying in a basket, not a living fish swimming in its sea." The law in this country is surely powerless, like a dead fish, if it is not supported by the nation's own legal culture. Law is for humans, meaning that a rule of law

cannot be separated from the human aspect. In fact, it is centered on humans because its essence and existence is centered on humans (anthropocentric), from, by, and for humans. It is the embryo of human desires, motives, ideals and concerns. It was made by humans, and formulated in a human language that only humans can understand. It is run by humans and to serve the interests of humans. This basic belief does not see law as Satjipto Raharjo, (2007; 151) dissecting progressive law stating something that is central in judging, but humans who are at the center of the law cycle. The starting point of all legal theorizing basically pivots on one thing, namely the relationship between humans and law. The more the basis of a theory shifts to regulatory factors, the more it considers law as a closed formal legalistic unit. Conversely, the more it shifts to humans, the more the theory opens and touches the social mosaics of humanity. Lawrence Meil Friedman includes components of legal culture in his legal system theory, namely: (1) structure, (2) substance, and (3) culture (legal culture). These three components in the legal system are often used as standard references to measure law enforcement in a country.

In the rhyme of the Banjar Culturalist Datu Adjim Arijadi (1940-2016), which has a character in the cultural values of the Banjar people can be seen in the strings of his words, as shown below;

Tapas salawar on a hot day  
 Dadai on the stairs to the right of the steps  
 Carrying small talk but a hot heart  
 Mun can't overcome many regrets  
 Saungan basingkingan chicken,  
 Maurak's feathers,  
 Baakuran, mbah bakahian.  
 Traditionally, then ours

Pantun Culturalist Banjar Datu Adjim Arijadi (1940-2016), we relate relevantly to the writings of Dr Anang S Tornado SH MH MKn (BPost 1-2-2023) entitled "Remedial Justice in Indonesia". Lately, law enforcers often socialize the need for legal settlement

outside the court, restorative justice, namely a restoration of relations and amends for mistakes committed by perpetrators of criminal acts (their families) against victims of criminal acts (their families) by deliberation to reach a consensus outside the court so that the problem can be resolved. law can be resolved properly.

Restorative justice is relatively the same as the customs of bapeace, baishlah, bapatut or baparbaik in the Banjar community. According to Ahmadi Hasan's dissertation research (2020), there has long been a tradition of "bapeace" as a way of resolving disputes within the Banjar community, both civil (such as debts), criminal (fights and abuse), husband and wife quarrels, and moral issues (immorality, adultery, adultery). The adat of bapeace was inherited from the time of Sultan Adam al-Watsik Billah (1825-1857), and became one of the articles in the Law on Sultan Adam (UU-SA), enacted since 1835. Even though the Sultanate of Banjar was abolished unilaterally by the Dutch in 1860, the spirit of the Law -SA related to peace is still widely practiced by the Banjar people until now.

The peaceful formula as an effort to overcome disputes, conflicts and grudges that can endanger lives, peace and social order, is adopted by many tribes in Indonesia, including the Dayak tribe. They have adat barunding, hapakat and nyangkalang procedures. Barunding means negotiating or agreeing. If the relationship between the parties heats up, in the term ela hakalawan, it is discussed together. Negotiations are carried out by representatives of the disputing parties. The parties to the dispute prepare whatever is needed or desired by the other party or the opposing party. The parties may not ask for their rights at a fixed price, but bargain so that there is a meeting point. Furthermore, granting concessions, leeway and lowering the bid on the limits of ability.

Hapakat (consultation), the disputing parties ask for opinions or advice from other parties

who can help solve the problem. Usually the Damang Traditional Chief is chosen as the negotiator, because the Damang knows customary law regulations and can resolve them according to custom. Nyangkelang, means mediation, namely the settlement of cases using neutral and impartial intermediaries. The mediator then resolves the issue actively but voluntarily. The principle of this settlement is in accordance with the motto of the Dayak Ngaju people in Central Kalimantan, namely hatangku manggetu bunu, hanangkalu penang mamangun betang, meaning to unite together to solve problems, agree to build togetherness. The Dayak people also have a motto: Penyang hinje simpe, paturung kumbak tamburak manggatang sent by the Dayaks, which means living in harmony and peace for the common good, with the will of the heart and unanimity to elevate the dignity of the Dayak people.

Even though our court principles are easy, cheap and fast, the resolution can be complicated, consuming energy and emotions, takes a long time and costs, and may not necessarily satisfy the parties to the dispute. If resolved peacefully (ishlah), the settlement can be faster and simpler, as long as the parties have good intentions and an agreement. If the case has already been reported to the police or court, peace is still important, at least it can lighten the sentence and eliminate resentment in the future. That is why, even in court hearings, peace is still being offered.

Peace is important and can be realized well if it is supported by the parties. First, family and community institutions (RT/RW), religious and customary leaders should have the influence and power to reconcile. That way when disputes and crimes occur, the family and community can immediately mediate, appease, negotiate settlement formulas and then reconcile.

Second, the police should be able to help, for example temporarily detaining the

perpetrators of crimes, but after peace is established the perpetrators are released, if the crimes committed were not so serious. Of course with a stamped agreement that the perpetrator will not repeat it again. If the perpetrator continues to be prosecuted, it is estimated that he will still hold a grudge.

Third, the victim or the victim's family who feel hurt, suffered and harmed by a crime, should be a priority for recovery, with compensation, compensation or other forms of compassion. This means that the money spent by the perpetrator or his family is not mostly for other parties who are not hurt and harmed. If the victims or their families do not receive proper compensation and compensation, it is feared that peace will still be half-hearted, unless they forgive sincerely. Forgiving is very commendable from a religious point of view, but giving compensation and compensation is also very important.

On the other hand, when viewed from the aspect of communication, it is very clear that communication is the key in interacting with each other, where the messages conveyed cannot be separated from the realm of applicable law, both positive law and customary law that apply in every region in Indonesia, including South Kalimantan. Culture and communication have a very close relationship and play an important role in human survival. People communicate according to the culture they have. When, with whom, and how much was communicated depended on the culture of the people interacting. It is the existence of cultural differences and influences that people learn to interact through communication. Communication lies in the process, namely an activity that "serves" the relationship between the sender and receiver of messages beyond space and time. Humans cannot be said to interact socially if they do not communicate in a way or by exchanging information, ideas, thoughts, intentions and emotions expressed in symbols with other

people (Alo Liliweri, 2013: 5).

The reciprocal relationship between culture and communication is like a symbiosis of mutual influence. Like culture affects communication and vice versa communication affects culture. Culture can affect the process by which a person perceives a reality. All communities in all places always manifest or manifest what is their view of reality through culture. On the other hand, communication helps in creating the cultural reality of a community (Judith N. and Thomas K. Nakayama, 2003).

Basically cultural communication is ordinary communication, what distinguishes it is the people involved in the communication differ in terms of background. When someone tries to communicate with people of different cultures and adjusts for the differences, it proves that culture is learned. Cultural differences in cultural communication interactions are very easy to occur. Adjusting to and studying different cultures will create harmony in the process of cultural communication. As stated by Stewart, intercultural communication is communication. Basically, cultural communication is ordinary communication. What distinguishes it is that the people involved in the communication differ in terms of background.

When someone tries to communicate with people of different cultures and adjusts for the differences, it proves that culture is learned. Cultural differences in cultural communication interactions are very easy to occur. Adjusting to and studying different cultures will create harmony in the process of cultural communication. As stated by Stewart intercultural communication is communication, between people of different cultures, for example between ethnicity, ethnicity, race and social class. Communication that occurs in a condition that indicates cultural differences such as language, values, customs, habits.

Thus the Communication on customary law culture, if you look at Lawrence Meil Friedman's view, includes components of legal culture in his legal system theory, namely: (1) structure, (2) substance, and (3) culture (legal culture). These three components in the legal system are often used as standard references to measure law enforcement in a country. LM Friedman then places "legal culture" as one of the components in his "grand theory" building, namely The Legal System.

This theory has become very monumental in legal science, because of its "great" nature, law can be studied with a systems approach to all aspects related to law. Law is constructed as a system that is related to one another (substance, structure, and culture). Due to the strong influence of the legal approach as "the legal system", the theory has become a reference in legal textbooks around the world. Seeing how important the study of legal culture is as a component of the legal system, this paper will present several theoretical concepts which are the substance and essence of LM Friedman's thought, especially those related to legal culture as a fundamental component of his phenomenal thinking. In addition, a correct understanding of the substance and essence of thought needs to be clarified, so that the intended assumptions can be understood everyone's right when talking about Legal Culture.

Therefore, it is an obligation to conduct a review of the concept of Legal Culture and attempt to reconstruct it into a theoretical study as a very appropriate step in fully understanding the theory of the "legal system". Apart from examining in depth the aspects of legal culture, it will be found that the operation of a legal system in society (law in action) cannot be separated from the influence of aspects of values and attitudes, which provide an understanding of the operation of the legal system.



## 2. Research methodology

The research method used is to use a socio-judicial (socio-legal) approach by using an interdisciplinary approach or a hybrid between aspects of normative legal research and a sociological approach using qualitative analysis, namely by analyzing a data in depth and holistically. This research is supported by the statutory approach (statute approach), historical approach (historical approach), and the concept approach (conceptual approach). The research data includes primary data, namely field studies using interview techniques and observation. Primary data is supported by secondary data, namely reviewing and analyzing primary legal materials in the form of laws and regulations governing dispute resolution outside the court, and secondary legal materials, namely materials that provide explanations regarding primary legal materials such as research results, works from legal circles others are authoritative. Using a purposive accidental sampling technique considering the characteristics of the study population whose number cannot be known with certainty, spread over a relatively wide geographical area. Primary data was obtained directly from informants by referring to structured interview guidelines that were compiled to obtain data related to patterns of dispute settlement outside the court, local government policies. The data collected from field research is primary data about everything that has to do with the problem under study. In obtaining the primary data, the area, object of research and secondary data are determined in the form of primary, secondary and tertiary legal materials.

## 3. Results and discussion

### Cultural Communication

Humans are social beings who always interact with each other, be it with others, customs,

norms, knowledge or the culture around them. In fact, we often cannot accept or find it difficult to adjust to the differences that occur as a result of these interactions, such as problems with technological developments, different habits of a friend from a different region or ways that become habits (language, traditions or norms). ) from one area while we come from another area.

In relation to cultural processes, communication addressed to other people or groups is a cultural exchange. The process contains elements of culture, one of which is language, while language is a means of communication. To study communication as a cultural process, we must first understand what is meant by the term culture or culture and what is meant by the term communication, because understanding these two terms will make it easier for us to discuss communication as a cultural process.

Culture and communication have a very close relationship and play an important role in human survival. People communicate according to the culture they have. When, with whom, and how much was communicated depended on the culture of the people interacting. It is the existence of cultural differences and influences that people learn to interact through communication. Communication lies in the process, namely an activity that "serves" the relationship between the sender and receiver of messages beyond space and time. Humans cannot be said to interact socially if they do not communicate in a way or by exchanging information, ideas, thoughts, intentions and emotions expressed in symbols with other people (Alo Liliwari, 2013: 5). The reciprocal relationship between culture and communication is like a symbiosis of mutual influence. Like culture affects communication and vice versa communication affects culture. Culture can affect the process by which a person perceives a reality. All communities in all places always manifest or manifest what is their view of

reality through culture. On the other hand, communication helps in creating the cultural reality of a community (Judith N. and Thomas K. Nakayama, 2003).

Culture is basically the values that appear in the process of interaction between individuals. Julia T. Wood (2013: 132) defines culture as one of the most important systems in which communication emerges. When we are born, we do not know how, when, and to whom we speak, just as we are not born with different attitudes regarding race, religion, sexual orientation, and other aspects of identity. It can be said that the definition of cultural communication is a communication process carried out by two or more people to get a common understanding through symbols or behavior from human activities of different cultures. Cultural communication refers to communication activities between people from the same culture or different cultures who have cultural beliefs, values, or ways of behaving. Basically cultural communication is ordinary communication, what distinguishes it is the people involved in the communication differ in terms of background. When someone tries to communicate with people of different cultures and adjusts for the differences, it proves that culture is learned. Cultural differences in cultural communication interactions are very easy to occur. Adjusting to and studying different cultures will create harmony in the process of cultural communication. As stated by Stewart intercultural communication is communication between people of different cultures, for example between ethnicity, ethnicity, race and social class. Communication that occurs in a condition that indicates cultural differences such as language, values, customs, habits. Martin and Nakayama (Judith N. and Thomas K. Nakayama, 2003) review how communication influences culture. He explained that culture cannot be formed without communication. Communication

patterns that are certainly in accordance with the background and cultural values will describe one's cultural identity. Distinctive characteristics are born because of communication behavior that is built and patterned in such a way. This distinctive characteristic will form a habit/culture of communication for a particular cultural community. It is clear that the communication activities of a person from a particular cultural community can represent the beliefs, values, attitudes and even the worldview of that culture.

Communication is a form of culture. Because, communication can only be realized after previously there is an idea that will be issued by the individual's mind. If the communication is carried out within a community, then it becomes an activity group (a complex of activities within a certain community). And in the end, the communication that is carried out often results in a physical form, for example a work like a building. Wasn't the building erected because there was a concept, an idea, then it was discussed (with family, workers or architects) and a house was built. So communication, actually becomes a form of culture. In other words, communication can be called a cultural process that exists in society.

If viewed in a more concrete way, the relationship between communication and cultural content will become clearer:

1. In practicing human communication requires certain equipment. At a minimum communication requires means of speaking such as mouth, lips and matters relating to the sound of speech. There are times when hands and other body parts are needed (non-verbal communication) to support verbal communication. Viewed more broadly with a wider spread of communication as well, mass communication tools such as television, newspapers, radio and others are used.
2. Communication produces the livelihood

of human life. Communication conducted via television, for example, requires a person who is paid to "take care" of television.

3. The social system becomes an inseparable part of communication, for example the legal system of communication. This is because communication will be effective when regulated in a regulation so as not to violate societal norms. In the field of the press, guarantees of legal certainty are needed in order to realize freedom of the press. However, freedom of the press also does not necessarily develop outside of societal norms. This is where the need for a legal communication system.

4. Communication will find its form better when using language as a means of conveying messages to others. The form of the number of languages used as a means of communication shows that language is the content or form of communication. How to use language effectively, using what language, who is the target is a manifestation of communication as a cultural process. Included here are also manifestations of communication as an artistic process, for example, on television there are motion arts (drama, soap operas, films) or sound arts (singing, dialogue).

5. The system of knowledge or knowledge is a substance that cannot be separated from communication. How is it possible that a communication will take place interestingly and dialogically without the support of science? This knowledge also includes the knowledge of speaking and expressing opinions. Evidence that each person is different in delivery, style, knowledge possessed shows this reality.

Communication as a cultural process is undeniably an objectivity between culture and communication. This process includes the role and influence of communication in the cultural process. Communication is a cultural process because in it there is a process like a cultural process, which has

form and content as well as a whole complex. Something is said to be communication if there are elements involved in it. Culture can also only be called culture if there are elements involved in it that form a system.

According to the definition of Littlejohn and Foss (2009:460), communication ethnography is a simple application method in the pattern of communication of a group. Communication ethnography looks at, (1) the communication patterns used by a group, (2) the meaning of all these communication activities for the group, (3) when and where group members use these activities, (4) how communication practices create a community, (5) the diversity of codes used by a group.

The founder of the ethnographic tradition is an anthropologist, Dell Hymes. According to Hymes (Sumarsono, 2007: 311), the term ethnography of communication itself shows the adequacy of the study, namely the ethnographic basis and the communicative range and types of complexity involved. Actually, the ethnographic concept of communication studies is more on sociolinguistics. Before the term ethnography of communication became more popular, the term ethnography of speaking was earlier referred to as the use of spoken language. However, the ethnography of communication becomes broader because it does not only cover modes of spoken communication (speaking), but also involves written communication (writing) as well as gestures, body movements (kinesics), or signs (signing). In the ethnographic concept, it is stated that there is a language community or speech community. Hymes denotes a speech community, a concept that has become an ornament in ethnographic studies of continuous communication. Conversational communities are very different from one another and this makes generalizations difficult (Littlejohn and Foss, 2009:460). However, it is not only the conversational communities that are different from one another, in which there are modes of

communication of gestures, body language or signs that use different limbs or tools.

A communicator can use almost all members of the body to convey messages that contain certain meanings according to what the communicant understands. In addition, it can also use an object or tool to show a meaning that can be understood. For example, the color yellow for the Malay ethnicity is the color of greatness which symbolizes majesty and only certain groups can wear something yellow, such as the Sultan or the King. Other categories include the use of traffic lights to send messages or signs to motorists when to go, be careful, and stop.

#### Legal Culture

If a society is observed, it will appear that even though the individual characteristics are different, the citizens as a whole will give the same reaction to certain phenomena. With the same reaction, they have the same general attitude. The things that belong together in cultural anthropology are called culture. Drawn from this understanding, legal culture is a part of human culture that is so broad.

Legal culture is the same general response from certain communities to legal phenomena. The response is a unified view of legal values and behavior. So a legal culture shows the pattern of individual behavior as a member of society which describes the same response (orientation) to the legal life that is lived by the community concerned. Knowing the legal culture of the local community is an important information material, meaning to become more familiar with the structure of the local community, the legal system, legal conceptions, legal norms and human behavior.

Legal culture is not a personal culture but rather the overall culture of a particular society as a whole of attitudes and behavior. Therefore, in discussing legal culture, it cannot be separated from the condition of society, the system and structure of society that contains this legal culture. Legal culture

is a response that accepts or rejects a legal event. It shows the attitude of human behavior towards legal issues and legal events that are carried into society.

Types of legal culture can be grouped into three forms of human behavior in public life, namely: 1) parochial culture, 2) subject culture, 3) participant culture. In parochial (insular) societies, ways of thinking the members of the community are still limited, their response to the law is limited only within their own environment. Such a society still adheres to its own legal tradition, the legal principles laid down by the ancestors are a talisman that cannot be changed. If anyone behaves deviantly, will get a curse. This type of society has a high dependence on leaders. If the leader is egocentric, then he is more concerned with himself. Conversely, if the nature of the leader is altruistic, then the members of the community get attention, because he places himself as *primus inter pares*, the main one among equals. In general, a simple society, the nature of its legal culture is ethnocentric, prioritizing and being proud of its own legal culture and considering its own law to be better than the laws of others. In a subject (subject) cultural society, the way of thinking of members of the community is already concerned, there has been a general legal awareness of the output of higher authorities. Input from the community is still very small or nonexistent. This is because the knowledge, experience and association of community members is still limited and there is fear of hidden threats from the authorities. The orientation of their views towards the new legal aspects already exists, there is already an attitude of acceptance or rejection, even though the method of disclosure is passive, not openly or still hidden. This self-conquering type of society considers itself powerless to influence, let alone try to change the legal system, the legal norms it faces, even though what it feels is contrary to its personal and societal interests. In a participatory

(participating) cultural society, the ways of thinking and behaving are different for community members. There are those who still have a culture of submission, but many feel they have the right and obligation to participate because they feel they are part of the general legal life. Here the community already feels that they have the same position, rights and obligations in law and government. He does not want to be ostracized from responding to legal inputs and outputs, participates in assessing every legal and judicial event, feels involved in legal life both concerning public interests and the interests of his family and himself. Usually in such a society, the knowledge and experience of its members is extensive, there are already associations of organizations, both those whose composition is independent and those that have relationships with other regions and from top to bottom. Legal culture, as described above, is only part of the attitudes and behaviors that influence the legal system and conception in the local community. There are other factors that also have no small influence on legal culture, such as social, kinship, religious, economic and political systems and arrangements, the environment and ways of life, in addition to the nature of a person's personal character, all of which are interrelated.

## **THE TRADITION OF THE THREAD**

adat bapeace status can rise to become customary law, because the community already considers mutual forgiveness and peace as a positive attitude, something that should apply and is a tradition in the communal environment of the Banjar adat community. In addition, the adat badamai which is also commonly referred to as baakuran or settlement by means of torches, can also be interpreted as a process of deliberation or consensus deliberation to reach a joint decision as a settlement of a dispute that has arisen.

Apart from that, the election of adat adat being part of the social institutions of the Banjar tribal people because the deliberation-style mechanism to get the best decision is considered the most suitable for the Urang Banjar culture, so it is believed to be very effective in preventing the occurrence of feuds, disputes, hostilities, disputes, and even effective in neutralizing feelings of resentment between communities which can harm the social order of society.

As befits "deliberation" in general, adat bapeace also become an effective communication medium to strengthen friendship, as well as kinship between fellow members of the community, so that it also strengthens and tightens the process of social control in society which is expected to suppress the emergence of disputes or disputes, so that the Bapeace custom also plays a role as a catalyst for order and peace, as well as security.

Refers to factual roles adat Badama i in the socio-cultural structure of Urang Banjar, it is only natural that until now the people who are used to settling all disputes, disputes or disputes with adat badamai tend to be reluctant to settle them through litigation institutions (the courts), even for matters related to traffic violations. or even related to actions that could lead to criminal offenses such as fights that lead to persecution

Based on these references, a framework can be made that the Badamai Customary Law in the Banjar community consists of 3 elements, namely:

(1) unwritten elements, in the form of habits that grow and develop in the practice of social life in society. This includes everything that society is used to seeing as good and will cause reactions from various layers of society if it is violated. Strictly speaking, violations will get a minimum sanction in the form of reproach from the community. Such habits in the Banjar community differ from one place to another, especially in terms of the size of

the influence of education and modernization as well as other development activities carried out by the Government.

(2) elements originating from Islamic law, which includes all provisions of Islamic law and fiqh laws that are maintained and adhered to by the community as a large part of their religious teachings. In this regard, the determination of what constitutes religious teachings depends on the perceptions of the community according to what has been conveyed by the ulama in this area since ancient times. The determination of something as obligatory, circumcision, mubah, makruh and haram is basically determined by the scholars and is still being held as a criterion for judging when someone faces certain facts that require an assessment.

(3) elements originating from the Banjar kingdom era, for this matter no provisions were determined other than the so-called Sultan Adam Law (1835) a Sultan who was known to be pious and respected by his people. It seems that this law which consists of several articles depends on the Sultan, so that after the death of Sultan Adam, even more so after the death of Sultan Adam, he received little attention except in the area of land law which is still obeyed by the people.

Judging from this framework, what is called the Adat Law of South Kalimantan or more specifically the Customary Law of Badamai in the Banjar community is a reality that can be found in the Banjar people in South Kalimantan.

Traditional Customs Past, Present and Future  
In Banjar society, respect is generally given to older people, people who because of certain personal qualities are elders in society, people who occupy certain positions in their village community, or other positions outside their village, and are respected for serving as teachers, especially religious teachers, or carry out certain functions in society. The mentions mentioned above actually cover each other, but it will be clear after just an

explanation below. A form of courtesy that is first taught to a child is how he should pay respect to adults in the extended family and other adults.

This respect is continued until the child becomes an adult, which is addressed to parents, and generally to the older generation, to older siblings and generally older relatives. In addition to older relatives in the village and older people in general. The elders in the community are usually the village elders who are considered figures, who are always included in every village activity, and are always the first to be contacted when there is an attempt from outsiders to make peace (babaikan) with a group of relatives. (bubuhan) or one of the community members in the village.

Within certain relatives, there are usually residents who hold positions that are prominent (such as providers, civil servants in the city, and so on) compared to other residents in the affix, or are considered wise after being proven in various events, so that they are elders and thus are equated with their parents. foam symbol. There is a tendency for figures who are elderly in this particular affix to be elderly among the village community, especially if the group of relatives who support them is influential or large. 39 In the village there are also people who are elders not because they are considered wise and are the people's trust, because that is always the case. invited to participate in solving the problems faced by the village. Someone who is respected because of his extensive experience or because he is considered brave (warrior figure) belongs to this last category.

Likewise, certain village officials include people who are also respected, namely the head of the village (pempekal), the head of the RK (formerly pengrak, recently the head of the hamlet), the head of the padang (head of agrarian affairs), and the deputy head of the village, and also the village head who has resigned from his position. According to Alfani Daud, among the Banjar community,

especially those who still adhere to their customs, socialization is expected only between age groups of more or less the same age (papantaran) 40, perhaps so that they do not have to always carry out the formalities of respect as stated earlier. Contact with older age groups is necessary. It is also expected that children obey the orders of their parents and those of the same generation. A respected figure in a village or among certain tribes stands out when there is a dispute in the community and there are attempts by one of the parties to persuade the other parties to reconcile. A dispute in the community, especially if there is bloodshed, even though it is actually only minor injuries, is usually always considered to be sustainable and if this happens it will endanger the peace of the community.

In the past, before the influence of legal modernization came into effect with the issuance of Law no. 1 of 1974 concerning Marriage, the position of Penghulu is still very prominent in resolving marital disputes. The prince can reconcile people who want to divorce, even the prince can provide a way out for couples to divorce in accordance with the requirements according to the provisions of the Shari'a (Fiqh understanding). Along with the birth of Law no. 1/1974, the dualism of the role of the dispute resolution institution emerged. The proof is that in the villages to this day there are still terms of underhand marriage and divorce, which in terms of laws and regulations are considered unofficial (not tauliyah).

Modernization of law has also affected the attitude of the people in viewing or responding to the existence of this peaceful institution. In practice, even though people have started to get used to resolving disputes through court institutions, in the view of the community, they still cannot resolve feelings of resentment and have not been able to resolve problems unless they are brought to justice. in the bapeace forum. Now, along with developments in various fields, dispute

resolution is used as an object of side work for certain sections of society. Usually such a profession is commonly referred to as a motorcycle taxi, sometimes this work can be used as an object of extortion against the parties. Because of his position as a third person, sometimes his position can be advantageous for him. Coming to the first party with information that is somewhat negative when it isn't, but to the other client is scenariod as if it doesn't want to open a dialogue and make peace unless it fulfills a number of requirements. Even though the requirement was made up by the person concerned to gain personal economic benefits.

In the research report there are 10 cases that are the object of research, each of which has a motive to fulfill the demands of the respondents from Party I respectively to seek financial gain, redeem self-esteem, tatamba takajut, 44 contain deterrent. Apart from that, there is a motive to comply with the demands of party II, each of them is just threatening, forced, to maintain security, not wanting to prolong the problem.

The Process of Communication of the Indigenous Culture of Badamai.

Adat bapeace is a form of dispute resolution that is commonly practiced by the Banjar people. Adat bapeace also means the result of a process of deliberation or deliberation in joint discussions with the intention of reaching a decision as a solution to a problem. Adat bapeace are values that live in society. Customary values are considered important as part of a culture that from time to time experiences ups and downs. Especially when dealing with change and modernization.

Adat bapeace describes eastern culture that is familiar with the values or views of society which is characterized by mechanical solidarity, in conditions like these adat adat is functional and very appropriate as a solutive mechanism in resolving various problems in society. When society changes according to

the changes and modernization that has occurred, the position of adat bapeace still has a place in the civil aspect, namely when it is in a space and social order characterized by organic solidarity, which relies more on dispute resolution mechanisms using a litigation approach. However, in the criminal aspect, it seems that the customary law approach cannot function, except for rural communities who are still familiar with mechanical solidarity. In the future, the position of adat adat is quite prospective and is still being maintained by the community, although it still needs to receive support from the community itself to fight for and perhaps strive for the preservation of adat adat values as a living law in society.

As an example, we can see that traditionally the National Police has developed a Community Guidance program (Bimmas) and programs related to the Independent Security System (Siskamswakarsa). The police tend to see themselves solely as the holder of authority and the police institution is seen solely as a tool of the state so that approaches to power and even repressive actions often color the implementation of the duties and authority of the police. Even though the principles of "serve and protect" (to serve and to protect) are emphasized, bureaucratic, centralized, uniform/uniform approaches color the presentation of police services.

This policing style encourages the police to prioritize the mandate of the central government and ignore the "approval" of the local community served, even though local people have their own wisdom in resolving disputes. In addition, the police tend to cultivate an attitude that presents itself as a formal and exclusive figure from other members of society. In the end, all of this resulted in the waning of the legitimacy of the police in the eyes of the public, on the one hand, as well as diminishing public support for carrying out police duties as well as a bad image of the police, on the other hand.

This condition occurred even more so when the Police were made an integral part of ABRI and the police were ABRI soldiers who in carrying out their duties were characterized by rigid and even disproportionately militaristic attitudes and actions. Such policing is also characterized by, among other things, the implementation of police duties, especially law enforcement, which is authoritarian, rigid, tough and insensitive to the needs of the public to feel safe.

On the other hand, the implementation of daily police duties prioritizes law enforcement, primarily to deal with criminal acts. Based on TAP MPR Number II/MPR/1993 concerning GBHN relating to the Independent Community Security and Order System, the Police are burdened with the task of carrying out Kamtibmas development which is played by Babinkamtibmas as the forefront. Such an approach positions the community as if they were only objects and the police as a "all-more" subject so that figures are able to handle and resolve all Kamtibmas problems faced by the community.

In line with the shift in human civilization, universally, especially in developed countries, people tend to be increasingly "saturated" with the ways of government institutions that are bureaucratic, official, formal/rigid, general/uniform and others in providing public services. There is a tendency that people prefer personal approaches and emphasize problem solving rather than just fixating on rigid legal formalities. In the field of law enforcement, especially those involving disputes between citizens, settlements using informal mechanisms are seen as more effective than processes in the formal criminal justice system which often do not provide a significant role for victims in making decisions to resolve their problems. From the paradigm shift in the role of community policing community policing officers, it is hoped that the role of the police can encourage the resolution of disputes



between communities through informal or adat bapeace mechanisms. Because the goal of criminal or criminal settlements in the end is to create peace, order and justice in society. If these things can be achieved by itself the purpose of punishment is achieved.

Another example is when there was a fight between two tribes that resulted in the death of the victim, where according to information obtained in the field it started from the harassment of someone who was drunk on the victim. However, the victim did not want to give money to the perpetrator, resulting in an argument and a fight that ended in the loss of the victim's life. The victim's family asked to find the perpetrator who had fled to be processed according to criminal law, but on the other hand they were also asked to be processed according to customary law, so as to avoid lives are paid for with lives, which can disrupt the stability of community security.

In the demands of the victim's family from one of these tribes asked the tribal leader who killed his family, resulting in intercultural communication to find solutions and ways out of this incident. From the meeting through mediation that was held, it was agreed that the perpetrators should be found from their escape, and as a result the perpetrators were picked up to be processed according to criminal law, and applicable customary law.

In this example, there was a process of cultural communication of the adat bapeace carried out by the two respected tribal leaders in the area through deliberation as a way of mediation, in which community leaders and religious leaders were also involved together with the National Police as the government representative who handles security in the community.

### Settlement of Criminal Cases Through Criminal Mediation on the Banjar Indigenous People

Adat bapeace is a form of dispute resolution that is commonly practiced by the Banjar

people. Adat bapeace is meaningful as the result of a process of deliberation or deliberation in joint discussions with the intention of reaching a decision as a solution to a problem. 17 BaPema decisions produced through deliberation mechanisms are alternative efforts in finding solutions to solve problems that occur in society. The Banjar people tend to resolve disputes through adat adat. Adat bapeace is recognized as effective in resolving disputes or disputes. At the same time, to get rid of feelings of resentment, Adat badamai is a term for settling disputes, both civil and criminal. Adat bapeace in the settlement of criminal disputes is also known as *Baparbaik* and *Bapatut*. 18 According to Ahmad Bahruni's research results from traffic accident data that occurred in Banjarmasin during 1995-2000 there were 43 (forty three) traffic accident cases. A total of 25 (twenty five) traffic cases were resolved amicably. Settlement initiatives were taken from the perpetrators or their families in 17 (seventeen) cases, initiatives were taken by the victims or their families in 5 (five) cases, and initiatives were taken by the police and the victims' families in 3 (three) cases. 19 Through peace negotiations then reached an agreement in general can be divided into three, namely: 20 a. Victims received assistance for treatment or medical expenses, found in 15 (fifteen) cases. 21 b. The victim died.

### Steps in the Process of Communication of the Culture of Customary Law of Badamai.

According to Law Number 30 of 1999 concerning Arbitration and Alternative Dispute Resolution, mediation is a continuation of negotiations and is carried out if the negotiation process has failed, and is specifically regulated in the realm of private law. As stipulated in Article 6 paragraph (2) of Law No. 30 of 1999 states "Disputes or differences of opinion through alternative dispute resolution are resolved in direct meetings (negotiations) by the parties within a maximum period of 14 (fourteen) days and

the results are set forth in a written agreement.” Furthermore, in paragraph (3) it is clearly stated, “In the event that a dispute or difference of opinion as referred to in paragraph (2) cannot be resolved, then by written agreement of the parties, the dispute or difference of opinion is resolved through the assistance of one or more expert advisors or a mediator. ”. The success rate of mediation carried out by village officials is very high, this is evident in the success of mediation carried out in Banjar Regency and Barito Kuala Regency. The mediation process is carried out in a family manner, paying attention to the interests of both parties, considering aspects of long-term relationships between community members, this is because the parties are residents of the same village.

So that the agreement that is taken is beneficial for both parties, the relationship between the people is maintained. The role of the Village Head is very important in resolving disputes in village communities. Strengthening the role of the village head in resolving disputes in the village is strengthened by Article 26 paragraph (4) letter k of Law Number 6 of 2014 concerning Villages which confirms that the village head is obliged to resolve community disputes in the village. The function of the village head as a mediating party is in line with the provisions of Article 3 of the Law of Sultan Adam of 1835. Article 3. Every village I tell them to pay attention to their subordinates by reaching a consensus, *astamiyah* again between relatives so that they don't talk and argue. The article reflects the existence of peaceful methods that must be taken if a problem arises in society. The pattern applied is to prioritize the aspect of deliberation for consensus between the community. The obligation of the village head to resolve community disputes as stipulated in Article 26 paragraph (4) letter k of Law Number 6 of 2014 concerning Villages embodies an attitude as a just leader, by referring to a

concept of harmony between peace and order so that peace will be achieved in society. The village head as a mediator creates peace when in the mediation process he maintains the harmony of the pattern of community interaction at every stage of the community dispute resolution process in the village. The village head appears as a judge of peace for the community who is neutral in facilitating the parties to reach an agreement. Paying attention to the characteristics of disputes that are resolved in the customary way through mediation, the mediation that has been carried out is based on interests. Mediation is carried out by the village head using the settlement mediation model. Settlement mediation is a compromise mediation whose purpose is to encourage a compromise from the demands of the two conflicting parties. This mediation model requires a high-status type of mediator even if they are not very skilled in mediation processes and techniques.

If we examine the elements in the settlement mediation model applied by the village head in the mediation, they are very relevant, namely:

1. Adat *bapeace* is intended to allow communication to bring differences closer and find agreement
2. The mediator (village head) focuses only on the main issues, namely the problems faced by its residents
3. The village head is a figure in the village who acts as a mediator, carrying out this task only based on experience and has never received special training regarding mediation techniques.

The implementation of peace by way of mediation by the village head is directed at the substance of the interests of the parties, based on aspects of joint resolution of a problem starting from the elements of interest for both parties, resolving the root of the problem, avoiding prolonged conflicts between the parties, and the desire to have good relations long-term. These factors have

been well applied by the village head in mediation.

By emphasizing the aspect of interest, the various interests of the disputing parties can be maximally accommodated. This will affect the level of satisfaction of the parties in achieving win-win solutions that are decided voluntarily by both parties. Empowerment of the settlement mediation pattern with an emphasis on current interest-based in resolving disputes is something that can have a beneficial impact on both parties. The dispute resolution mechanism through mediation outside the court is a form of dispute resolution by reducing state interference (state justice), this dispute resolution prioritizes cooperative ways of the parties prioritizing land dispute settlement with the principle of a win-win solution.

Customary customary law cultural communication as a concrete step that is carried out through elder/respected figures such as religious leaders, traditional leaders, and community leaders, as well as academics, who are part of mediating those who are in dispute to be resolved by deliberation and agree in agreement.

To maintain this harmony in South Kalimantan, an institution was formed which acts as a communication forum for these figures called the Ethnic Communication Association, abbreviated as IKASBA South Kalimantan, which is the only one in Indonesia.

The South Kalimantan Ikasba is a synergy of ethnic groups living in South Kalimantan. According to Masrani, one of the Ikasba administrators, the existence of the Ikasba is a bridge and mediation if there are disputes between ethnic groups in South Kalimantan. exists in South Kalimantan as a cultural heritage of the Banjar people which was sparked by Sultan Adam in the Banjar sultanate under the name of the Sultan Adam Law (UUSA), as a spirit in resolving disputes on Banjar lands as stated in Article 21 of the

UUSA.

Cultural communication in adat law can be carried out through the Ikasba institution of South Kalimantan, which is an element of the ethnic leaders in South Kalimantan, and religious leaders and academics are also involved, so that the content of cultural communication in the steps of the adat law communication process can be comply with the provisions and regulations that apply in Indonesia.

Besides that, other institutions in South Kalimantan are other forums such as the National Mixing Forum (FPK), which was formed by the government, whose duties and functions are to strengthen the nation's cultural values in South Kalimantan, so that cultural communication synergizes with the traditional culture of the people of Aceh. Alone. Besides that, there is also the Community Early Warning Forum (FKDM), which was formed by the government, which, if you look at the management elements, also consists of Traditional Leaders, Religious Leaders, Community Leaders, Youth Leaders, Press, Academics, who have their duties and roles in anticipating potential vulnerabilities. social conflict, as a preventive action with the motto Quick Gathering - Quick Report as part of Early Detection, because preventing social conflict before it occurs is better than dealing with it when the conflict occurs itself. The two forums were formed in all districts/cities and even sub-districts/and villages, especially the FKDM itself.

The existence of these institutions is a strategic step in anticipating and overcoming problems in South Kalimantan, including resolving disputes from those who are in dispute themselves. Usually, these three institutions always go to the field to gather information and data which will become material for study to provide recommendations to the government, so that any problems can be taken as soon as possible to take preventive measures, and other

actions. If then the problem enters the realm of positive law, a customary law approach is also carried out, the aim of which is peace/ishlah towards the common good in goodness.

The cultural communication approach to Badunia's customary law is carried out using an intercultural communication approach, an interactional communication approach, and a multi-way communication approach, where the three communication approaches will be in line with the Badamai customs that apply in South Kalimantan.

received compensation in the form of money for condolences from the crashing party, found in 6 (six) cases.22 c. Victims received assistance with vehicle repair costs and maintenance costs, in 4 (four) cases.

Analysis of the Development of Indigenous Badunia.

In the indigenous Banjar community, there are several terminologies for criminal cases such as cases of traffic decency violations and acts of violence, better known as Badamai, Baparbaik (babaikan) mamatut , baakuran and so on. As for civil cases, the terms basuluh or ishlah are used .

Adat Bapeace is carried out in order to avoid disputes that could endanger the social order. The Bapeace decision that is produced through a deliberation mechanism is an alternative effort in society. In the Banjar community, if there are disputes between residents or acts of persecution or violations of (traditional) norms or there are fights or traffic violations, the community members tend to settle peacefully. This bapeace custom is recognized as effective in resolving disputes or disputes. As well as being able to get rid of feelings of resentment.

If there is a conflict or dispute between the residents and the customary rituals are not carried out, it is believed that it will damage the harmony order which is a violation of traditional wisdom. If conflicts occur especially those related to criminal incidents,

community leaders (tetuhakampung) take the initiative to reconcile the disputing parties. Family meetings (deliberations) are sought, followed by congratulations with apologies and sometimes accompanied by agreements not to prolong disputes and hostilities. even between the two parties bound in a brotherhood which is commonly referred to as baangkat dangsanak (brotherhood) or baangkat kuitan (being parents and adopted children).

The distinctive feature that distinguishes Adat Badamai from peaceful settlements in other communities is the existence of values or norms that must be obeyed, the existence of accompanying ceremonies as a symbol of resolving disputes or disputes, the event of maangkat dangsanak or maangkat kuitan (brotherhood) which is full of elements religious rituals such as the batapung bargain ceremony (a peace ceremony marked by the symbol of sprinkling likat baboreh oil (coconut oil mixed with fragrance) on the heads of the parties as a symbol of brotherhood), complete with a dish of sticky rice and grated coconut mixed with palm sugar.

The role of Adat Badamai in the form of settlement of disputes over criminal cases is so important, it is not accompanied by a legal basis that regulates or recognizes the existence of adat Badamai in the regional regulations of the province of South Kalimantan. Its existence is only regulated in general in the 1945 Constitution. Laws that recognize the existence of indigenous peoples such as the basic agrarian law, the forestry law and so on.

Taking into account customary law as a form of dispute resolution that lives in society (customary law), its position in the future is quite prospective and still exists, considering several things:

1. Constitutionally received recognition from the 45 Constitution Article 18 B (2).

2. There are statutory regulations that are still ambiguous, for example Law no. 5 of 1966 concerning Basic Agrarian Provisions, that the applicable agrarian law is customary law. Law no. 41 of 1999 concerning Forestry.
3. Academically, many Law Colleges have developed non-positivistic legal studies such as "Law and Society" and Legal Anthropology which explores the study of Folk Law and legal pluralism.
4. The development of post-reform regional autonomy which began with the enactment of Law no. 22 of 1999 concerning Regional Government which has now been replaced by Law no. 32 of 2004 has opened up opportunities for the widest possible autonomy, giving fresh air to the development of local laws, although in some cases there is a tendency to regulate law through regional regulations as a form of formalization of applicable customary law.
5. The emergence of the indigenous peoples movement began with the convening of the Indigenous Peoples Congress of the Archipelago on 15-22 March 1999 by declaring March 17 as Indigenous Peoples Awakening Day and the formation of the Indigenous Peoples Alliance of the Archipelago (AMAN).
6. There is a political statement that promises to prepare legal instruments. Legislation that will specifically regulate the existence and recognition of indigenous peoples, such as President Soesilo Bambang Yudhoyono's statement on the commemoration of the International Day of World Indigenous Peoples on 9 August 2006.
7. Finally, the issue of the position of customary law was discussed at the Seminar on Legal Pluralism and its Challenges for the Formation of a National Legal System which was organized by the National Legal Development Agency of the Indonesian Ministry of Law and Human Rights in Makassar, 1-2 May 2007. The issue discussed was that the issue of legal pluralism would be shifted to the realm of politics, at least to the politics of national law. Besides that, there has been a change in the paradigm of law enforcement officials, especially starting from significant changes made by the Indonesian National Police.

Adat bapeace is a form of dispute resolution that is commonly practiced by the Banjar people. Adat bapeace also means the result of a process of deliberation or deliberation in joint discussions with the intention of reaching a decision as a solution to a problem. Adat bapeace are values that live in society. Customary values are considered important as part of a culture that from time to time experiences ups and downs.

Especially when dealing with change and modernization. Adat bapeace describes eastern culture that is familiar with the values or views of society which is characterized by mechanical solidarity, in conditions like these adat adat is functional and very appropriate as a solutive mechanism in resolving various problems in society. When society changes according to the changes and modernization that has occurred, the position of adat bapeace still has a place in the civil aspect, namely when it is in a space and social order characterized by organic solidarity, which relies more on dispute resolution mechanisms using a litigation approach. However, in the criminal aspect, it seems that the customary law approach cannot function, except for rural communities who are still familiar with mechanical solidarity. In the future, the

position of adat adat is quite prospective and is still being maintained by the community, although it still needs to receive support from the community itself to fight for and perhaps strive for the preservation of adat adat values as a living law in society.

#### **4. Conclusion (Times New Roman, 12pt, Bold, align Left, Hanging 0.5cm)**

Conflict resolution between perpetrators of criminal acts and victims of criminal acts in indigenous peoples in Indonesia, as found in the indigenous Banjar community, shows a similar form, namely the existence of peace efforts and ending conflicts by involving third parties which is a form of criminal mediation approach known as Traditional village or tribal moots. Settlement of customary law through peace efforts can be the basis for modern mediation programs, including for criminal mediation which can be set forth in

statutory regulations.

The Bapeace Customary Law Process can provide us with a legal culture by carrying out cultural communication, with interpersonal and interactional communication approaches, as well as a multi-way communication approach, so that conflict or dispute resolution can be carried out through mediation from traditional leaders, religious leaders and community leaders together with security forces as representatives of the government.

The Adat Badamai community of Banjar, South Kalimantan, has cultural values that are very important to be maintained and preserved. The Bapeace tradition teaches us that in living a social life, if there is a dispute, it is as much as possible to resolve it in a family way, by deliberation for consensus and asking for papadah (advice) from wise people. Apart from that, maintaining harmony through Adat Badamai can also be done with the culture of raising dangsanak to expand a sense of solidarity (kinship).

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# 14<sup>th</sup> IQC International Quality Conference

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# **14. International Quality Conference**



**SCIENTIFIC FOCUS 6**

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## REGENERATION AND REMANUFACTURING IN EMAS REPORTS

**Abstract:** *Regeneration and remanufacturing are two of circular economy strategies. The aim of the study is to compare the degree of communication of activities that are part of the regeneration and remanufacturing strategies based on the reports of organizations operating in Poland and which are registered in the EMAS register. The analysis included the latest reports from 20 companies. The analysis was carried out in terms of the presence of keywords and activities related to regeneration and remanufacturing. An analysis showed that regeneration is a strategy better communicated in EMAS statements than remanufacturing. In this study, there were limitations connected with the type of organizations.*

**Keywords:** *circular economy, regeneration, remanufacturing, circular business models, EMAS*

### 1. Introduction

Circular economy (CE) is an economic system that displaced the “end of life” concept for reducing, reusing, recycling, and recovery of materials. CE can be realized at all economic levels: micro, macro, and meso. One of CE aims is to achieve the assumption of sustainability (Kirchherr et al., 2017). This is only one definition of CE. According to Kulczycka and Pędziwiatr (2019) in literature, there are more than 200 definitions of this term. Some of these definitions concentrate on the regenerative approach e.g., Geissdoerfer et al. (2017), Suárez-Eiroa et al. (2019).

The regenerative approach is one of the principles in circular business models such as ReSOLVE and 10R (Morseletto, 2020; Nobre & Tavares, 2020). The first model presents six CE-based strategies: regeneration, share, optimize, loop, virtualize, and exchange (Dev et al., 2020). The second model is made of 10 strategies which are divided in three groups and are arranged in terms of circularity. The most circular strategies, according to 10R

model, are connected to smarter use and production of products. This group included: refuse, rethink, and reduce strategies. In the middle, there are actions aimed to extend the life cycle of products and their components, such as: reuse, repair, refurbish, remanufacture and repurpose. The last group of circular strategies includes recycling and recovery. These two are connected with useful applications of materials (Potting et al., 2017).

In both of these models, there are strategies connected with the word “regeneration”. Regeneration in ReSOLVE model is based on environmental renewal, which is connected with, e.g., the health of ecosystems returning of resources to the biosphere, so it can be reborn. In this model also is mentioned remanufacturing but under a different strategy - looping (Ellen MacArthur Foundation & McKinsey Center for Business and Environment, 2015). In 10R model, there is only remanufacturing strategy, but there are also strategies in which activities are connected with regeneration. In Polish, both of these strategies are translated as

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“regeneracja”.

The implementation of activities related to the circular economy concept is possible with using the tools e.g., environmental management systems (EMS). EMS helps organizations achieve goals of reducing environmental externalities like CO2 emissions, water use or environmental pollution (Jain et al., 2020). There are two the most common EMS to implement in organizations: a system compliant with the requirements of ISO 14001:2015 standard and Ecomanagement and Audit Scheme (EMAS) (Erauskin-Tolosa et al., 2020). According to Martins & Fonseca (2018) EMAS include all elements of ISO 14001 but has added items like an environmental statement. In EMAS there is higher control of environmental performance. Organizations have to prepare environmental statements which are validated (Ociepa-Kubicka et al., 2021). According to Kryk (2017) environmental reporting is one of the tools to communicate activities connected with groups of stakeholders. In those statements are included, e.g., organizations ecological results.

Environmental reporting is an element of both EMAS system and EMS complaint with the requirements of ISO 14001. The EMAS regulation is about stricter requirements connected with external reporting. Organizations that have decided to join to EMAS register have to prepare environmental statements, update them per year, and make them available to all stakeholders (UE, 2009). That is why in this study, authors focused on the analysis of EMAS reports in terms of communicating activities related to the concept of the circular economy in them, which fit into the strategies of regeneration and remanufacturing. Moreover, according to Matuszak-Flejszman and Paliwoda (2022) EMAS system is one of the main instruments that can help organizations with transition from a linear to a circular economy.

## **2. Regeneration and Remanufacturing in Circular Economy – Literature Review**

According to Scopus Data Base, there are more or less 300 publications connecting remanufacturing with the circular economy (research in keywords and title for remanufacturing/remanufacture and title, abstract, and keywords for circular economy). In the same research fields, there were almost 140 publications which were including regeneration with the circular economy. According to this, remanufacturing is presented better than regeneration. Table 1. contains a review of publications which are presenting regeneration and remanufacturing through circular economy concept. In this table, there are also presented subjects of these articles and examples.

In these articles, there were no publications that presented regeneration or remanufacturing as a part of EMAS statements. None of these articles were connected with the level of communication actions connected with these two strategies.

According to 4 databases (Scopus, Science Direct, Web of Science, and EBSCO) there are only a few articles that connects EMAS with the circular economy. Only 4 of them analyze EMAS statements in terms of CE: Szafraniec (2018), Barón et al. (2020), Barón Dorado et al. (2022), Janik and Szafraniec (2019). In their research, Baron et al. (2020) focus on the analysis of EMAS environmental declarations in terms of identifying CE practices that organizations in Spain have implemented and quantifying them. The study identified 23 CE practices, which indicate that organizations are primarily focused on minimizing emissions by optimizing material cycles and improving production processes. Also, eco-projects have become an important element of the circular economy concept. Barón Dorado et al. (2022) focused on the analysis of EMAS reports in

order to determine the usefulness of this system to measure the level of implementation of activities in the field of the circular economy concept. The research results showed that the information contained in the reports is not sufficiently comprehensive or quantified, therefore EMAS statements are not a relevant tool for

measuring progress in the transition to a circular economy model. The last study presents an analysis of EMAS environmental statements in terms of indicating which CE-related information is already collected and reported. Information that could be presented in reports as part of monitoring the progress of the circular economy was also indicated.

**Table 1.** Examples of researches connected with regeneration and remanufacturing

General subject	Detailed subject	Examples
Regeneration in circular economy	Regeneration in adsorption process	Ghanim et al. (2020), Kandel et al. (2022)
	Removing harmful substances	Qie et al. (2019), Villarim et al. (2022)
	Regeneration in cities	Giorgi et al. (2020), Balletto et al. (2022)
	Regeneration of materials: production of biomaterials and raw materials from waste	Dobrotă and Dobrotă (2018), Melotti et al. (2021)
	Regeneration as possibility to improve life quality in cities	Nesticò et al. (2022), Ricci (2022)
	Energy recovery	Asiain – Mira et al. (2022)
Remanufacturing in circular economy	Remanufacturing with Industry 4.0 and automatization	Okorie et al. (2021), Mangold et al. (2023)
	Remanufacturing in supply chains	Dominguez et al. (2021), Zhou et al. (2022)
	Consumers perception of remanufactured products	Milios & Matsumoto (2019), Kabel et al. (2021)
	Barriers and benefits of remanufacturing	Matsumoto et al. (2021), Zhuang et al. (2023)
	Impact of remanufacturing process on the environment	Pamminger et al. (2021), Kanazawa et al. (2022)
	Achieving circularity through CE strategies e.g. remanufacturing	Yang et al. (2022), Schulz-Möninghoff et al. (2023)
	Critical success and ecological efficiency factors for remanufacturing	Jiang et al. (2019), Singhal et al. (2020), Khan et al. (2022)
	Methods and design for remanufacturing	Kimita et al. (2021), Handawi et al. (2021)
	Decision making aspects	Zhang et al. (2021), Cesur et al. (2022)
	Assembly and disassembly aspects	Assuad et al. (2022), Hartono et al. (2022)

Source: own research

### 3. Activities connected with regeneration and remanufacturing

The regeneration strategy, according to

ReSOLVE model, concentrates on the increasing use of renewable energy sources and improving ecosystems (Kouhizadeh et al., 2020; Mastos et al., 2021). Moreover, it determines to use renewable materials and establish a recycling energy system or

mechanism (Tu et al., 2020). According to Jastrzębska (2017) good practices related to regeneration include activities e.g., energy-efficient construction, energy recovery, and industrial symbiosis. In this model, there is also a strategy connected with remanufacturing – looping.

Model 10 R defines remanufacturing as using parts of products that are discarded in new products having the same function (Potting et al., 2017). According to Reike et al. (2018) remanufacturing is not only a repairing. In remanufacturing, products are reborn. In this process, products and their components are restored to a condition comparable to the new products. Remanufacturing is an opportunity to recover the residual value of used products through the reuse, renewal, and replacement of components. Taking these actions is aimed at bringing the product to a new state, and such a product is offered to consumers (Hazen et al., 2017). According to Morioka et al. (2005) a better option than traditional substitution and recycling is to extend the life cycle of products by remanufacturing. In remanufacturing, there is no need to use original materials and energy and the costs incurred in connection with them. It is an industrial process that allows you to restore used products to a usable state. It covers activities related to deletion, sorting, inspection, or reassembly. Remanufacturing helps to keep products in circulation and store them for a long time (Khan et al., 2022). This strategy contributes to reducing waste and resource use (Liu et al., 2019; M. Zhang et al., 2022). According to Fofou et al. (2021) not all products can be remanufactured. Some researchers concentrate on remanufacturing of engines e.g., Li et al. (2022). According to Barón Dorado (2022), CE practices that are included in remanufacturing are: remanufacturing products and easy separation of components.

In summary, the list of practices that are included in both strategies was prepared:

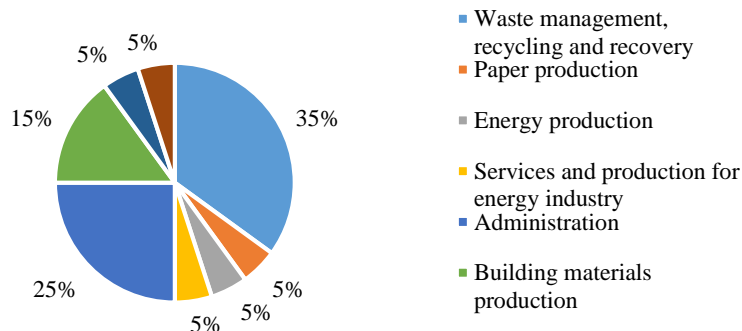
- a) Regeneration:
  - using renewable materials,
  - using renewable sources of energy,
  - recovery of energy,
  - energy-efficient constructions,
  - industrial symbiosis.
- b) Remanufacturing:
  - remanufactured products,
  - easy separation of components,
  - reuse, renewal, and replacement of components.

Those elements will be used in this study.

## **4. Methodology**

The study aims to compare the degree of communication of activities that are part of the regeneration and remanufacturing strategies based on the reports of organizations operating in Poland and registered in the EMAS register. In this study, the environmental declarations of organizations included in the EMAS register were reviewed. According to the register, there are 70 organizations entered into the EMAS in Poland. In the first stage of this study, organizations that had been suspended from the register were rejected (2 reports). One EMAS report was not identified in the register or on the organization's website. Therefore, 67 reports were included in further analysis. The next stage was connected with checking the publication date of the declaration. Only reports that were published in 2022 were taken into account in the research. So the reports that spanned several years were rejected (3 reports), but also reports that were not submitted in 2022 (13). Finally, 51 organizations were qualified for the selection of the research sample. From that sample, there were 20 reports selected randomly to analyze. All reports were in the Polish language. Figure 1 presents the characteristics of the examined organizations in terms of their activity profile.

## Organization business profile



**Figure 1.** Organization business profile

According to figure 1. in this research, 70% of organizations were service-oriented. Only 25% of organizations were connected with the production. And 5% of researched organizations were both involved in production and services.

All statements have been fully read. Two analyses of reports were carried out. In the first step, keywords were searched while reading the statements. Because of the Polish language in all analyzed reports, searching for keywords was in this language. In Polish, there is only one word for both of those terms called „regeneracja“. There were also used variants of this word like: „regenerować“ and „regenerowany“. The second analysis concerned a more detailed analysis of the reports and was related to finding activities that fit into the regeneration and remanufacturing strategies in accordance with the business models of the circular economy concept and literature review. Based on the literature review, it was found that regeneration has 5 components (using renewable materials, using renewable sources of energy, recovery of energy, energy-efficient constructions, industrial symbiosis), while remanufacturing has 3 (remanufactured products, easy separation of components, reuse, renewal, and replacement of components). All the analyzed reports were read, and then, based on the descriptions

contained in the reports, attempts were made to determine and track whether the content communicated in them could concern the components of both strategies.

The level of communication was calculated as the sum of the number of reports in which indicators determined on the basis of the literature review were reported.

## 5. Conclusion

In the first stage of this research, the keywords: „regeneracja“, „regenerować“ and „regenerowany“, have been searched to check if any organization communicates actions under the slogan of regeneration or remanufacturing. Only 2 reports include this word, but it was only mentioned. In the first statement keyword was mentioned not so much in terms of the organization itself as its shareholder. But it was connected with the regeneration of oils. And because oils are products, it refers to remanufacturing. In the second statement, organization presents that they transfer oils to organizations that also remanufacture them.

### 5.1. Regeneration in EMAS reports

In this part of the analysis, we were checking the level of communication activities that are including in regeneration according to

ReSOLVE model and literature review. The result of this analysis is presented in figure 2.

### Regeneration

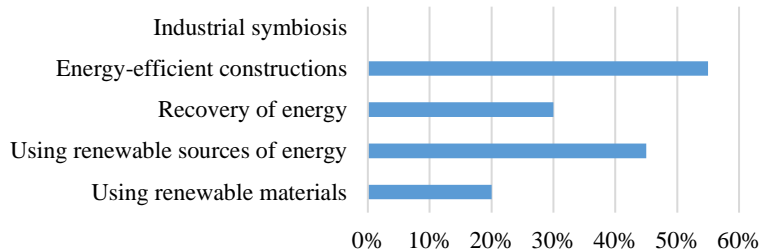


Figure 2. Regeneration in EMAS reports

According to figure 2 there is one activity connected with regeneration that is the most popular among reports – energy-efficient constructions (55% of declarations). The second most reported activity was using renewable sources of energy, which was mentioned in 45% of statements. The other three were presented in the following order: recovery of energy (30%), using renewable materials (20%), and none of the statements presented industrial symbiosis.

#### 5.2. Remanufacturing in EMAS reports

In this part of the research, the level of communication activities that are including in remanufacturing was checked. Only in 2 (10%) statements there were information about remanufacturing of oils. But it was not related to the activities of the organization that the statements concerned. Remanufacturing of oils was carried out by external organizations.

### 6. A Discussion Section

This research focused on two CE strategies and the level of their communication in EMAS reports. According to this study in EMAS statements were included mostly activities connected with regeneration strategy. The remanufacturing strategy was

presented, but it was on a low level of communication (10%). However, remanufacturing was not strictly related to the activities of this organization. The low communication level of remanufacturing strategy is also presented in Barón et al. (2020) and Barón Dorado et al. (2022) studies.

Definitely regeneration strategy is presented in EMAS reports better than remanufacturing strategy. This is confirmed by research conducted by Barón et al. (2020), Barón Dorado et al. (2022). In those publications using of renewable sources of energy is reported accordingly: about 32% and 38,5% of EMAS statements. In this study, in 45% of statements, this activity was reported. The level of communication regarding using renewable sources of energy is similar.

In EMAS statements of organizations operating in Poland, using of renewable materials was mentioned only in 20%. A similar level is presented in Barón Dorado et al. (2022) - 22,1% of reports. In this study, also was mentioned that remanufacturing of products was presented only in 3% of EMAS statements. In this study level of presentation of this category was only 10%. These results also can be compared. In the EMAS statements of organizations operating in Poland, there were activities connected with energy-efficient construction which allowed



to improve energy efficiency and saving. This category was presented in 55% of EMAS statements. According to Laskurain et al. (2017) as EMAS system includes indicators connected with energy efficiency. This might be the reason for the highest level of communication of this activity in EMAS statements.

This study had some limitations. Remanufacturing is connected with products but in material form. That is why organizations can separate some components or offer remanufactured products. In this research, 70 % of organizations were concentrated on services and administration. There is no possibility of remanufacturing services. But organizations that provide services definitely use some equipment and devices. In some of EMAS statements, it was mentioned that organizations repair their machines or devices. But there was no information about remanufacturing devices or machines or their parts. In the theory section, there was mentioned that not all products could be remanufactured. This is the second limitation connected with this study.

## 7. Conclusion

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Regeneration and remanufacturing are two CE strategies that, in translation to the Polish language, mean the same. But they are connected with different activities. The first one is more concentrated on the environment reborn, and the second one is connected with products. There is a possibility to research circular economy activities in environmental reports. EMAS reports have stricter requirements than other environmental reports. This was the main reason to choose them as materials for this study.

This research showed that there is a different level of communication actions connected with regeneration and remanufacturing strategy. Only a few researched organizations include remanufacturing in their EMAS statements. This can be connected with organization profiles which were connected mostly with services. On the other hand, the regeneration strategy was better described in EMAS statements. But not as much as in other results of research.

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## A REVIEW OF SUSTAINABLE DEVELOPMENT OF ADDITIVE MANUFACTURING IN THE CONDITIONS OF DIGITAL AND GREEN TRANSITION

**Abstract:** Additive Manufacturing (AM) declared is as 3D printing and represents a revolutionary technology in developing and applying the fourth industrial revolution (Industry 4.0). Models, rapid prototypes, components, and parts for final use realized are with 3D printing significantly cheaper than with classical technologies. The paper's main goal is to point out the sustainable development of three-dimensional 3D printing technology in the efficient implementation of Industry 4.0 in the conditions of the green and digital transition. Due to the possibility of successfully realizing every desired object, 3D printing has applications in almost all areas from industry, construction, architecture, automotive, aviation, and household according to medical applications. Additive Manufacturing 3D printing technologies analyzed and classified are according to the type of process, purpose, production equipment, energy, materials, and other factors influencing sustainable development. Green plans and digital transformation implemented have been at full capacity in these innovative 3D technologies.

**Keywords:** Sustainable development, Additive Manufacturing, 3D printing, Industry 4.0, Digital and Green transition

### 1. Introduction

Additive Manufacturing (AM), 3D printing defined by the American Society for Testing and Materials (ASTM) Committee F42 for all additive manufacturing technologies (ASTM F2792-12a 2014). Additive production or 3D printing also declared as Rapid Prototyping is an advanced sophisticated production technology in which the final object made is by adding material, layer by layer. Today, 3D technology can print almost anything we want, which in the first phase we turn into a three-dimensional geometric object, expressed in a computer-aided CAD program (such as CATIA, SolidWorks, Autodesk Inventor or many others), and in the second

phase is exported to STL file or G-code. In the next step, the STL add-on entered into the Slicer software to handle all relevant printing settings such as material selection, production time, temperature, speed and selection of support structures, and more following printer setup and finally commissioning, which is a universal input for all types of 3D printers (Alammar et al., 2022; Salmi 2022). 3D printing is very cost-effective for the production of the most complex geometric models/products that realized can very quickly in various variations according to the digital display. Additive manufacturing has the potential to support greater efficiency by

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combining with the integration of data and the Internet of Things (IoT) in Industry 4.0 providing greater utility and better environmental conditions for green and digital transition for acceptable manufacturing (Khorasani et al., 2022). 3D printing has a qualitative and quantitative impact on sustainable development and the

life cycle of the principle of multi-purpose optimization by digitalization (Khorasani et al., 2022). According to the standard (ASTM), Committee, F42 AM 3D printing technologies grouped are into seven categories as shown in Table 1 (ASTM F2792-12a 2014; Salmi 2022; Sljivic et al., 2017).

**Table 1.** The main classification of the process of AM 3D printing according to the typical material and field of application, listing some of the world's most famous manufacturers of 3D printers

PROCESS / Known companies	TYPICAL MATERIALS	APPLICATIONS
<b>1. Material Extrusion:</b> Fused Deposition Modeling (FDM); - <i>Stratasys, 3D Systems, RepRap, Prusa i3, Ultimaker, etc.</i>	Polymer (ABS, PP, PC, PPS, PLA, ASA), Composite, Wax, WPC-Wood plastic composite	Prototypes, tools, casting moulds, soft (silicone) functional parts/products, etc.
<b>2. Material Jetting:</b> Multi-jet modelling (MJM) – <i>Object PolyJet, 3D Systems, Project, etc.</i>	Polymer (ABS, PP, Acrylic), Rubber, Wax, etc.	Prototypes, tools, casting moulds, soft, functional parts/products, etc.
<b>3. Binder Jetting:</b> Powder bed and inkjet head, Plaster-based 3D printing; - <i>Zcorp, Voxleljet, etc.</i>	Composite, Gypsum, Ceramic, Sand, Metal, Polymer, etc.	Functional parts/products casting moulds, soft (silicone) tools, etc.
<b>4. Sheet Lamination:</b> Laminated object manufacturing (LOM), Ultrasonic (UAM); - <i>mCor Technologies Iris, Fabrisonic, etc.</i>	Paper, Metal: Steel, Aluminium, Titanium, Cooper, etc.	Prototypes, models, tools, functional parts/products casting moulds, soft, etc.
<b>5. Vat Photopolymerization:</b> Stereolithography (SLA); - <i>Digital Light Processing (DLP), Micro-SLA, (SLA)-Stratasys, etc.</i>	Polymer, Epoxy, ABS, PP, Composite, Gypsum, Ceramic, Wax, etc.	Prototypes, models, casting moulds, soft (silicone) tools, etc.
<b>6. Powder Bed Fusion:</b> Selective Laser Sintering (SLS), Electron beam melting (EBM), Direct metal laser sintering (DMLS); <i>EOSINT, etc.</i>	Metals: Alloy Steel, Steel, Aluminium, Titanium, Ceramic, Polymer, Composite, Rubber etc,	Prototypes, models, casting moulds, functional parts/products, etc.
<b>7. Directed Energy Deposition:</b> Focused thermal energy, - <i>Laser metal (LMD), (LENS), Trumpf...</i>	Metals: Alloy Steel, Steel, Aluminium, Titanium, etc.	Prototypes, models, functional parts/products, etc.

## 2. Applications of AM 3D printing technologies in the activities of the different sectors

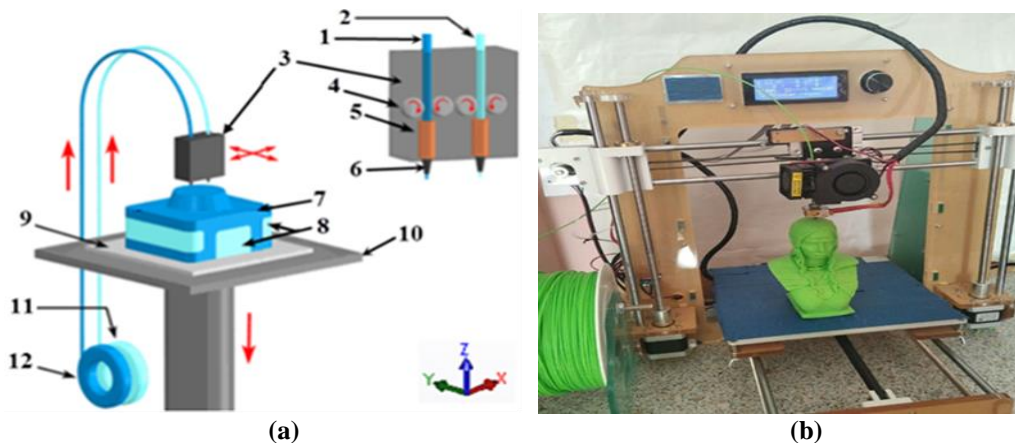
This paper discusses and provides an overview of the current state of AM 3D

printing technologies in terms of their efficient application in almost all industrial areas including aerospace, automotive, architecture, medicine, academic applications, and many other new applications within the conditions of sustainable development, and environmental



impact. AM 3D printing technologies very successfully applied are in the rapid production of prototypes, models, and tools, but also in the production of components and parts for final use in individual and serial production (Sljivic et al., 2017; Salmi 2022). The research focuses on the interrelationships between 3D printing, Industry 4.0, sustainability of technology, and environmental impact in relation to energy and resource use, as well as reducing the amount of waste material. Characteristic examples of sustainable development of AM 3D printing analyzed are in activities of different sectors. The application of material extrusion is one of the most prevalent processes in almost all sectors of activity. In

the process of fusion deposition of materials (FDM), filament from a coil of a certain diameter through is extruded a nozzle that follows the cross-section of the object forming the geometry of the body, layer by layer. The nozzle contains resistance heaters that heat and hold the material above its melting point, allowing the material to flow and form layers. Useable are various materials including ABS plastic, polyamides, polycarbonates, polypropylene, metal, composites, and molten wax. A scheme showing the formation of layers using the FDM method show is in Fig.2.1 (a), and Fig. (b) Shows a home 3D printer, with a printed model of a doll's head.



**Figure 2.1** (a) Fusion deposition modeling scheme (FDM): 1-Material, construction filament, 2 -Material, support filament, 3 -Extrusion head, 4 -Drive wheels, 5 -Flow manifolds, 6 - Extrusion nozzles, 7 -Model, fabrication facility, 8 -Support, 9 -Foam base, 10 -Fabrication platform, 11 -Support material coil, 12 -Model material coil, and (b) Image of one home 3D printer, with a printed model of a doll's head during the 3D process.

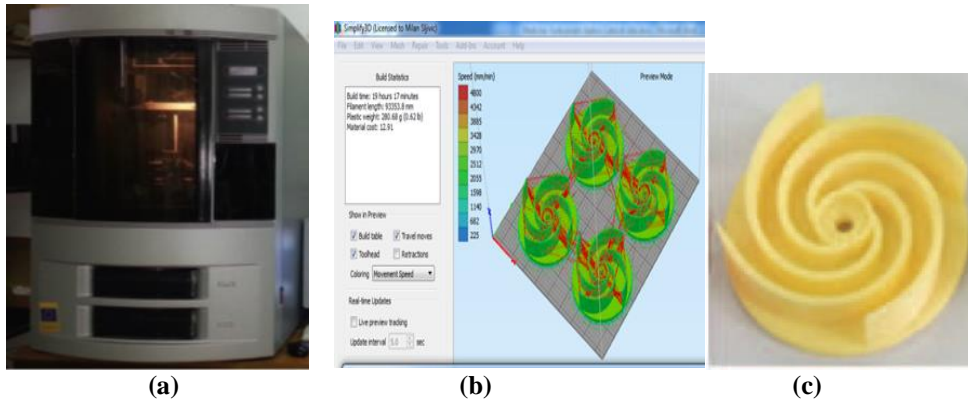
## 2.1. Applications of Material Extrusion - Fusion Deposition Modeling (FDM) technology

A characteristic development of a functional propeller investigated was for a water pump, which printed was on a professional FDM 3D printer Dimension Elite-Stratatis (USA) in the Laboratory of the Faculty of Mechanical Engineering in Banja Luka, shown in Figure

2.2 (a). The propeller printed is from ABS polymer, and post-processing performed has been successfully using the manual method. All the necessary parameters of the printing operation defined are through the Simplify3D software for cutting Fig. 2.2 (b). The functional propeller printed is a life-size in three copies per pass, Figure 2.2 (c) (Sljivic et al., 2017). The direct advantages are the

following: Full flexibility in designing complicated geometric shapes, directness of components from the digital model, shortened

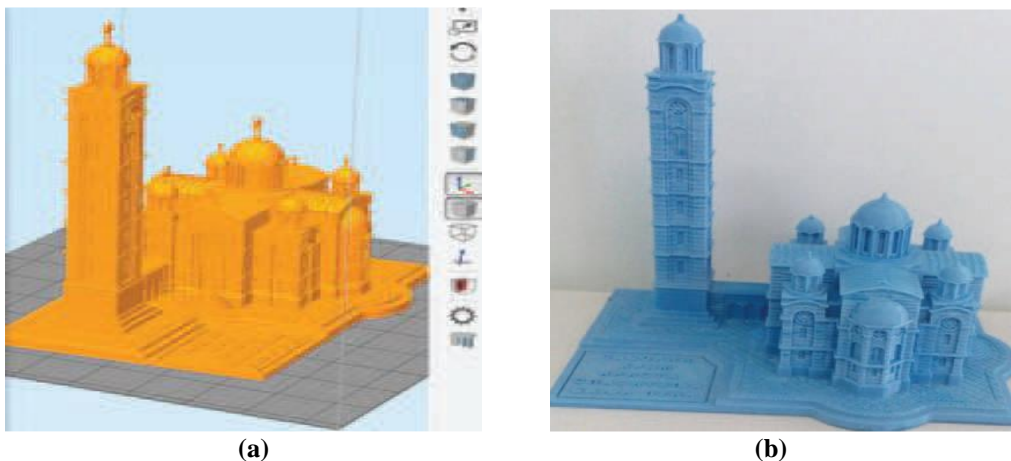
production time, fewer waste materials reduced to the lowest measure, and a green transition achieve.



**Figure 2.2** (a) 3D Printer Dimension Elite-Stratatis (USA) and (b) Defining all operating parameters in Simplify 3D software and (c) Printed propeller (Sljivic et al., 2017)

Development of a complex Model of the Church of Christ the Savior, Banja Luka, successfully done by FDM technology, Fig.2.3 (a) and (b). The Model of the Church scanned was with reverse engineering technology, and then created in the SolidWorks software Fig. 2.3 (a), and Fig. (b) Show the finished printed model of

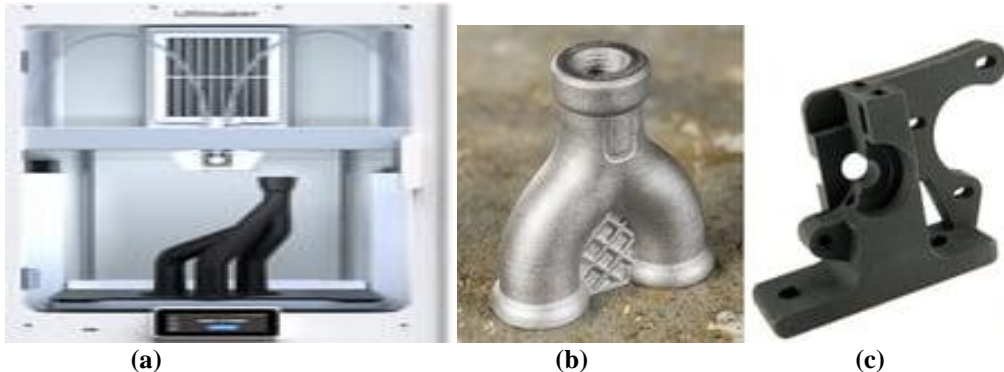
the Church. The applied technique for making the model of the church used can be successful for 3D printing of models of archaeological monuments, even entire settlements, independent buildings, bridges, museum exhibits, and many other valuable finds and objects.



**Figure 2.3** (a) Model of the Church of Christ the Savior, Banja Luka scanned and processed in SolidWorks and (b) Printed model of the church on a 3D printer Dimension Elite-Stratatis (Sljivic et al., 2017)

There are now professional FDM 3D printers suitable for serial and high-volume production on the market. We present one such from the company UltiMaker S7 with two characteristic printed end-use elements, Fig. 2.4 (a), (b) and (c) (All3DP, 2023). Using the professional 3D printer UltiMaker S7, a very wide range of models,

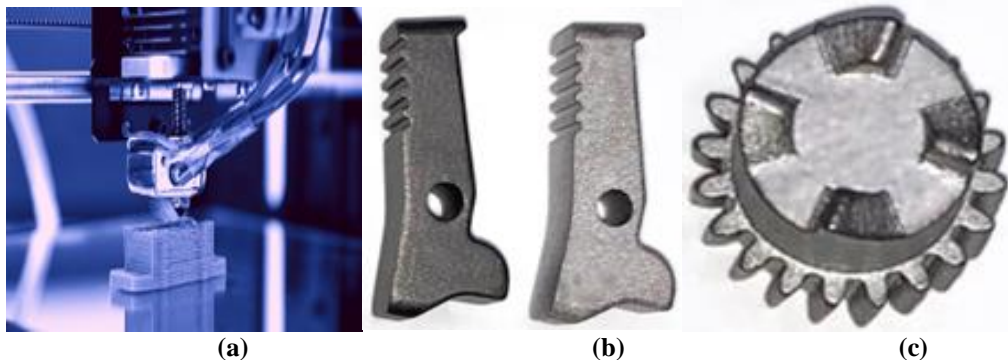
end-use parts and components for final use printed can be from stainless steel and plastic (All3DP, 2023). This process of 3D printing has the potential to support greater efficiency, cost-effectiveness, and reduced environmental impact on industrial systems and product life cycles compared to traditional production.



**Figure 2.4** (a) Professional 3D printer UltiMaker S7, (b) and (c) End-use parts made with the professional 3D printer UltiMaker (Source: UltiMaker), (All3DP, 2023)

Advanced 3D printers developed have been that use the same working principle as FDM called Fused Filament Fabrication (FFF) and can successfully print metal and ceramics (Sljivic et al., 2022; 3DEO, 2023). Fig.2.5 (a) shows one (FFF) 3D printer

from 3DEO (USA) capable of producing high-quality metal components of small to medium sizes up to 250 mm (3DEO, 2023). Two characteristic case studies of metal 3D printing produced by this company shown are in Figures 2.5 (b) and (c) (3DEO, 2023).



**Figure 2.5** (a) Metal FFF 3D printer from 3DEO (Source: 3DEO), (b) One end-use metal component (source: 3DEO) and (c) One optimized pair of toothed bars (Source: 3DEO)

For this printing, a metal wire developed has been that integrates a suitable metal powder with wax polymers into a wire

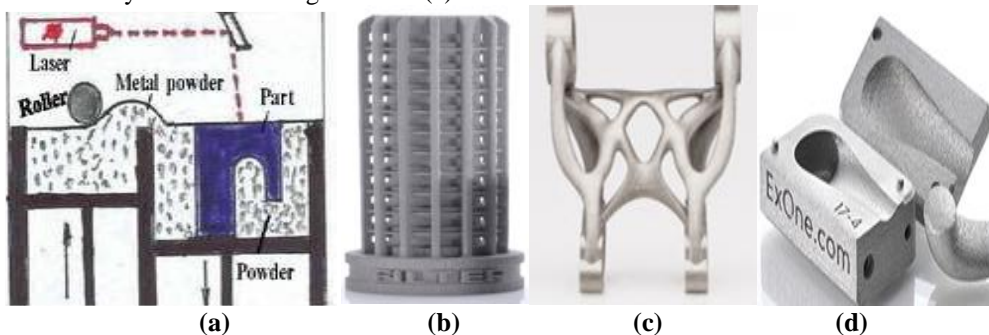
thread used in 3D metal extrusion printing. Parts printed in this way require post-processing such as ventilation for washing

and sintering and, if necessary, heat treatment or some other treatment in order to fully transform the printed parts into the final metal part. Despite this post-processing, the process of 3D printing by metal extrusion is far more profitable than traditional technologies because it has an impact on sustainable development as well as favourable conditions for the digital and green transition (Sljivic et al., 2022; 3DEO, 2023).

**2.2. Applications of Binder Jetting Metal 3D printing technology**

Binder Jetting metal 3D printing is a process of printing with metal powder and jet binder of complex geometric shapes of high precision, very fast, and economically viable for prototype and serial production, schematically shown in Figure 2.6 (a)

(Sljivic et al., 2022). The Inkjet-style head used is to apply the liquid binder to a fine layer of metal powder, and other powders (ceramic, sand or composite, etc.). The process continues in layers until the object is completed. Otherwise, the process includes complex powder management, mandatory sintering, and recommended post-treatment, such as surface finishing, heat treatment, etc (ExOne, 2020; Sljivic et al., 2022; Khorasani et al., 2022). ExOne.com is a global leader in the serial production of metal 3D printers using binder injection technology as well as companies: Stratasys, Digital Metal, 3DEO, etc (Sljivic et al., 2022; Khorasani et al., 2022). Typical cases of finished metal components produced by ExOne.com with Binder Jetting 3D printing shown are in Figures 2.6 (b), (c), and (d) (ExOne, 2020).



**Figure 2.6** (a) Schematic representation of the Binder Jetting process of metal 3D printing, (b) Metal filter, (c) Compound metal component and (d) Binding injection moulding by 3D printing of one metal casting tool from ExOne.com (ExOne, 2020)

In the metal industry AM, 3D printing revolutionizes the production process and is a major impetus for sustainable development and advanced applications in Industry 4.0. Metallic materials suitable for 3D printing are stainless steel, tool steel, steel alloys, superalloys, titanium, copper, and aluminium (Sljivic et al., 2022). These materials are mainly made of fine metal powder which is the basis for most 3D printing processes including filament fabrication for some types of 3D metal

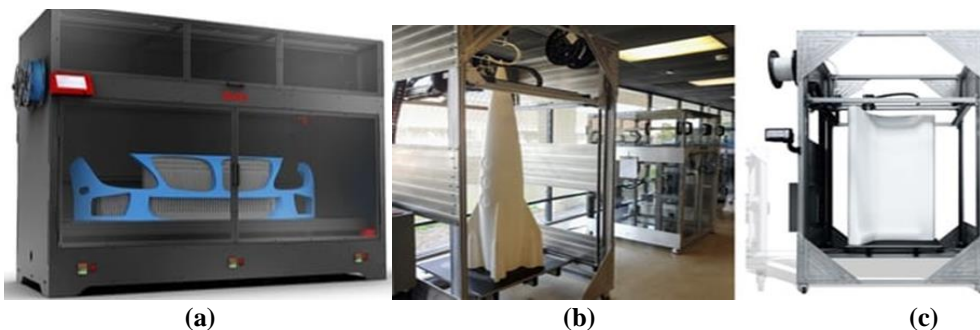
printing. 3D metal printing requires state-of-the-art printer solutions that are capable

of producing parts and components for the end-use of complex shapes. The classification of methods of metal additive production processes mainly done is according to the type of energy, the material in the form of a fine powder, wire, or metal paste, and the type of equipment for printing metal. The following four additive manufacturing processes are standard in the production of metal parts for end use: (a)

Metal Additive Manufacturing Extrusion, (b) Direct Energy Deposition, (c) Binder Jetting, and (d) Metal Powder Bed Fusion (Sljivic et al., 2022). The analysis showed that metal 3D systems in the production of metal components achieve mostly more favourable design flexibility, shorter production time, high precision of complex shapes, reduce the amount of waste material and achieve significantly lower production costs compared to traditional processes.

### 2.3. Applications of Large-format Additive Manufacturing 3D printing technology

Developed successful have been Large - format 3D printers for printing for industry, mass production, printing car prototypes, moulds, stencils, museum exhibits as well as end-use parts [Carlos et al., 2023, Schwaar, 2023]. In Fig. 2.7 (a) The mModix Big-180X large-format 3D printer for commercial use with a build volume of 1,800 x 600 x 600 mm presented is (Schwaar., 2023). Creating applications on this Large-format 3D printer is fast and cheaper than conventional technologies, and the production of waste is almost negligible. Recycled materials can used also successfully be for printing.



**Figure 2.7** (a) The Modix Big-180X large-format 3D printer for commercial use with a build volume of 1,800 x 600 x 600 mm (Source: Modix), and (b) and (c) The Exabot large-format 3D printer from Re3D (Source: Re3D). (Schwaar, 2023)

Fig. 2.7 (b) and (c) show The Exabot large-format 3D printer from Re:3D (USA) for a wide range of commercial needs. These printers have a dual extruder with base and soluble support material and can process PLA, ABS, PC, and thermoplastics with a melting point below 350°C (Source: Re3D) (Schwaar, 2023). Large-format 3D printers

have the ability to print the most complex geometric forms of models, prototypes, and parts for large-scale end use accurately and sustainably. The main requirements of the standard on the conditions for digital and green transition for the sustainable development of 3D printing in large formats fully implemented are.

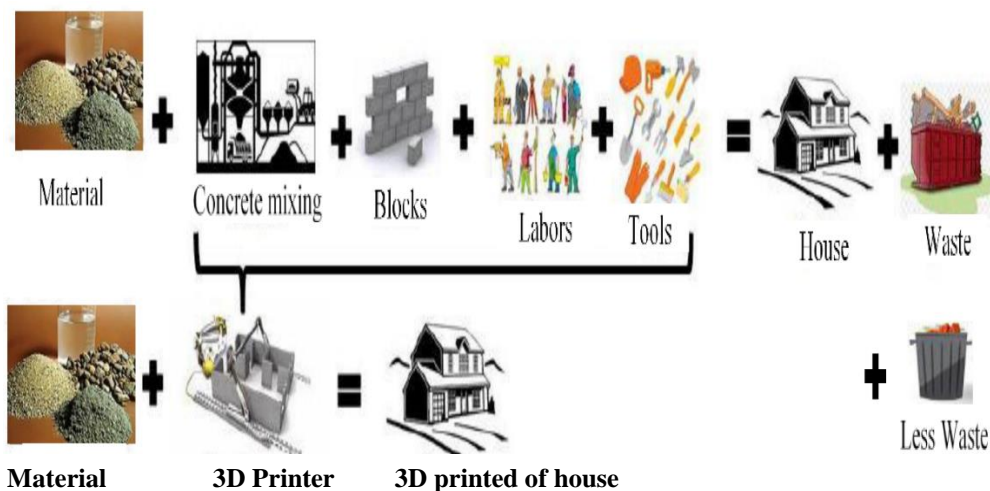
### 2.4. Applications of Additive Manufacturing 3D printing in constructions

The rapid development and implementation of AM 3D printing have initiated extensive research and experimentation for the

application of 3D printing of houses, apartments, and other construction and architectural achievements. The same principle of operation of 3D printers is used as in other 3D model prints that are successfully applied in prototype fabrication, and individual and serial

production. For application in construction, quality cement prepared as a quick-drying mixture is used. Still, there are also various new variants of technology for preparing materials for printing, depending on the company that deals with this 3D printing technology. The paper from the Journal "Sustainability" (Hossain et al., 2020) gives a comparative overview of the classic

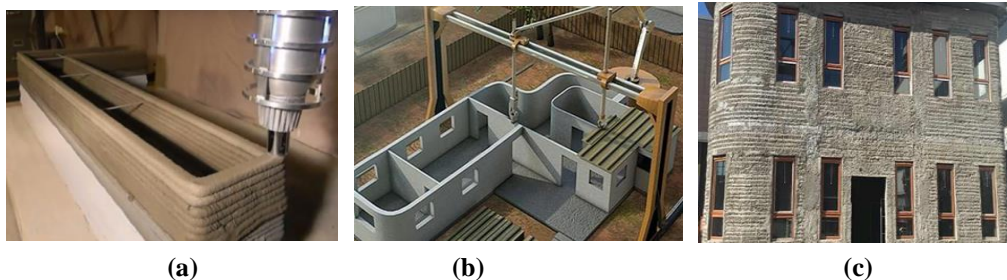
construction of a house and a printed house with a 3D printer. Significant advantages of the 3D printing house in terms of efficiency, speed of production, and very little waste (recycled mining waste and converted into usable materials) and the process is both economically and environmentally viable, as shown in Fig. 2.8.



**Figure 2.8.** Comparative overview of a classic built house and a printed house with a 3D printer (Hossain et al., 2020)

The research and use of 3D printing in construction in China have achieved quite good results in this area. Figures 2.9 (a) and

(b) show the 3D printing process, and Fig. 2.9 (c) shows a 3D-printed residential building in China (Cooke, 2016).



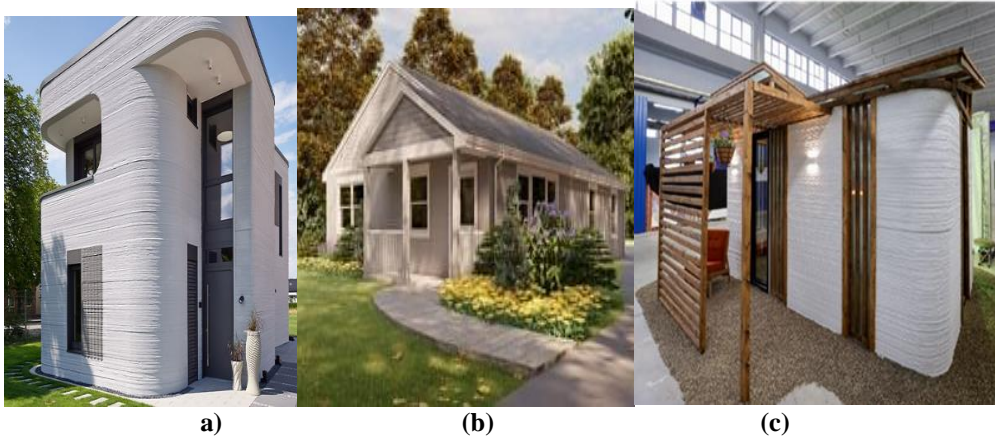
**Figure 2.9** (a) and (b) Illustration of the 3D printing process in constructions, and in Fig. (c) One 3D printed residential building (Cooke, 2016)

The first German ready-to-move 3D printing house printed was at the end of July 2021, printed by PERI at the COBOD BOD2 printer in Beckum, North Rhine-Westphalia, as part of the Innovative

Buildings program, shown in Figure 2.10 (a) (PERI AG, 2021). The American company SQ4D from New York, which focused on engineering and building high-quality sustainable houses, printed the first

3D-printed house in the USA for sale, shown in Figure 2.10 (b). The company believes that this 3D technology will soon be able to eliminate more expensive and inferior building materials, making 3D structures even more cost-effective. The use of concrete reduces costs by at least 30%, as well as makes the structure more fire-resistant than traditional methods (Fermin, 2021). The first 3D printed house in Serbia "ProtoDom" premiered in the

Science and Technology Park Cacak, made by two people and one 3D printing machine in just 21 hours and 15 minutes, shown in Fig. 2.10 (c). The manufacturer of the 3D printing house, the company Natura Eco made the house from concrete and performed the necessary tests, which confirmed the safety of being resistant to winds, earthquakes and other disasters (FoNet. 2021).



**Figure 2.10** (a). The first German 3D printing house ready to move in (PERI AG, 2021), (b) The first 3D-printed house for sale in the USA (Fermin, 2021) and (c) The first printing house in Serbia (FoNet. 2021).

From the analysis of additive production of 3D printing in construction, it can be concluded that this process has great potential to accelerate construction, contribute to the strength of structural elements, and significantly reduce waste material, which contributes to better environmental ecology and reduce the number of construction workers and

workers. In order to achieve this, it is necessary to adjust and make a suitable printer in relation to the type and size of the object to be printed. Then the appropriate mixture of materials for 3D printing is very important. Tests have shown that cement-based mortar mixed with appropriate components, which harden quickly, achieved the best results.

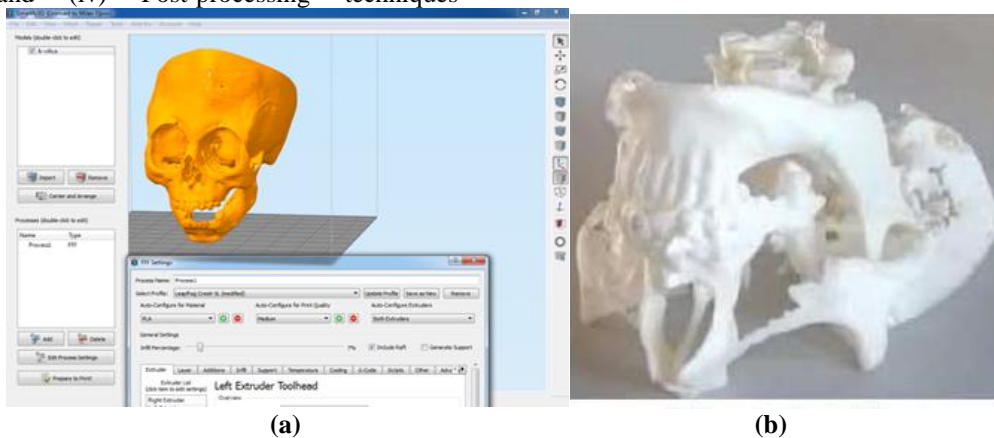
### 2.5. Additive Manufacturing 3D printing and 3D bioprinting for medical applications

Additive technologies of 3D printing and 3D bioprinting in medicine are used for a very large number of applications, namely: creating models for planning a complex surgical intervention; craniofacial implants in the hip, knee and spinal

implants and others; bioprinting of human tissues and organs; prosthetic dentistry; production of various medical tools and other 3D printed and bioprinted procedures (Murphy and Atala, 2014; Mironov et al., 2011). For the successful application of the technique of 3D printing and 3D bioprinting for medical applications, the most important influencing factor is the

choice of the appropriate material. The application of 3D printing and 3D bioprinting is based on 4 basic steps of a 3D printing system: (i) Imaging 3D image of the object by computed tomography (CT) or magnetic resonance imaging (MRI), with digital (DICOM) medical file format, (ii) Image processing, including segmentation and surface modelling steps, (iii) Production with a 3D printer or 3D bioprint, and (iv) Post-processing techniques

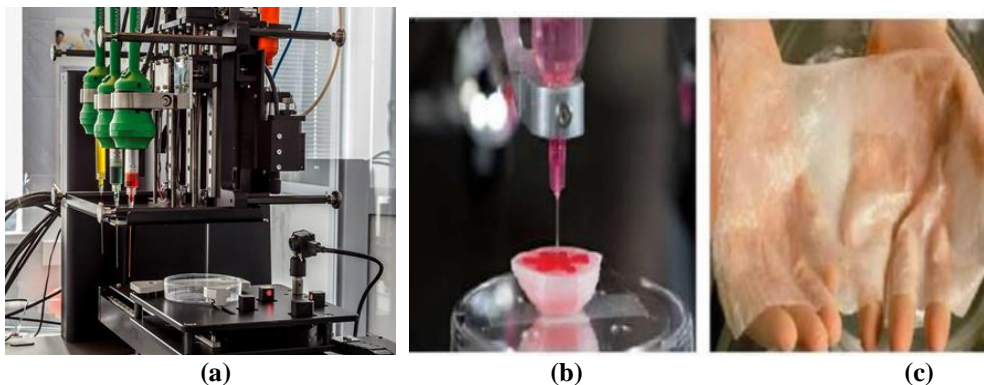
(Murphy and Atala, 2014; Mironov et al., 2011; Sljivic et al., 2017). Figure 2.11 (a) and (b) show an example of 3D printing of the skeleton of the head of an anonymous patient according to the above procedure for the preparation of surgery performed at the University Clinical Center Banja Luka in cooperation with the Mechanical Faculty of Banja Luka (Sljivic et al., 2017).



**Figure 2.11 (a).** Head jaws presented in SolidWorks, conversion of STL jaw format to CatalystEx for printing on Dimension Elite 3D printer (Banja Luka Faculty of Mechanical Engineering and **(b)** Printed head jaws for medical intervention preparation in UCC - Banja Luka (Sljivic et al., 2017)

Fig. 2.12. (a) shows one Inkjet 3D bioprinter from the Laboratory "3D Bioprinting Solution" Printer – Moscow (Mironov et al., 2011).

Fig. 2.12. (b) Bioprinting for testing drugs and vaccines and (c) Bioprinting for human skin (Murphy and Atala, 2014; Mironov et al., 2011)





**Figure 2.12 (a).** Photograph of Inkjet 3D bioprinting from the Laboratory “3D Bioprinting solutions” Printer - Moscow (Mironov et al., 2011), and on **(b)** Bioprinting for testing drugs and vaccines and **(c)** Bioprinting of human skin (Murphy and Atala, 2014; Mironov et al.2011)

3D bioprinting technology is a sophisticated technology of the future because products obtained by bioprinting technology can mimic both the biological and functional properties of the natural structures and tissues of our bodies. This leads to a wide range of different types of applications. World-renowned researchers are working hard to apply the bioprinting technique using stem cells that can be obtained from a patient's adipose tissue.

### 3. Conclusion

The paper highlighted the very significant potential of advanced additive manufacturing 3D printing in integration with the Industrial Revolution - Industry 4.0. This is at the forefront of the components of digitization tools use through the Internet of Things (IoT) and the effects that 3D printing brings. It has shown that the greatest effects are in design because 3D printing used can be to print any three-dimensional model, object, element, and anything else with the appropriate material in the required scale. This presented examples of the use of 3D printing for rapid prototyping, models, and tools as well as for use in single and batch production. Examples of successful use of

Stem cells are then transformed into a laboratory cell conglomerate that fills a bioprinter cartridge to process the formed biological production of the corresponding tissue or organ (Murphy and Atala, 2014; Mironov et al.2011).

We can conclude that the possibilities of 3D printing and 3D bioprinting applications in medicine are unlimited and represent a revolutionary future in modern medicine and dentistry.

3D printing in the fabrication of elements of plastics and composite materials, metallic materials in the metal industry, construction, and advanced applications in medicine are given. All these examples of 3D printing have shown that they significantly reduce the environmental impact of industrial systems on the life cycle of products and have a great advantage over conventional production systems. The review showed that Additive Manufacturing 3D applications in almost all sectors achieve mostly more favourable design flexibility, shorter production time, high precision of complex shapes, and environmental benefits because they reduce the amount of waste material and achieve significantly lower production costs compared to traditional processes.

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## IMPLEMENTATION OF CIRCULAR ECONOMY AND LEAN APPROACHES FOR A MORE COMPETITIVE AND SUSTAINABLE INDUSTRY

**Abstract:** *The circular economy concept has been considered one of the most innovative and essential approaches for more sustainable economic and industrial growth in the 21st century. Regardless of their size, organizations are frequently structurally designed to be efficient and optimized at all levels or defined as being LEAN. LEAN is a widely acclaimed approach for identifying and eliminating unnecessary and wasteful activities in the production process with simultaneously increasing the value of products. Observing the efficiency and advantages of circular economy and LEAN approaches, this article aims to show how their application can support the establishment of a more competitive, sustainable and green industry.*

**Keywords:** *circular economy, LEAN, sustainable industry, environmental improvements*

### 1. Introduction

Over the past decades, environmental issues such as ozone depletion, the greenhouse effect, air pollution, toxic materials, noise pollution, ecosystem imbalances, and loss of biodiversity have caused great concern in economies around the world (Safari et al., 2018; Yang, 2018; Kuo & Lin, 2020). This concern is justified by the growth of population, along with technological advancement. The global problem of population growth is that the production of material goods is also growing, in order to satisfy consumer needs through the market. Contemporary consumer society is characterized by the syndrome of instantism (Nikolić et al., 2013), which is caused by the speed of change and instability of market flows. The global economy has been fluctuating over the last few decades (Fu & Liu, 2023) so characteristics of business

environment at the global level have experienced significant changes. Since the beginning of the first industrial revolution, economic activities have been continually growing, while the basis of their development has recorded a constant reduction of available reserves. In the period from 1970 to 2017, a significant exploitation increase of natural resources was noted at the global level, from 27.1 to 92.1 billion tons, which represents an average annual growth of 2.6 %. Demand for natural resources per capita has increased annually from 7.4 tons in 1970 to 12.2 tons in 2017 (IRP, 2019). On the other side, for the global economy, it is devastating that about one-fifth of the extracted resources worldwide end up as waste (OECD, 2015). In accordance to prior, resource extraction and waste production have increased rapidly in recent decades (Marín-Beltrán et al., 2022).

To reduce the impact that population have on the environment at a global level, it is necessary to transform unsustainable patterns

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of production and consumption of goods. The rapid changes in technology and global politics that characterize the modern world require management methods and the business environment which is constantly changing and improving. Innovation, flexibility and the ability to anticipate, identify and meet market needs are considered as crucial mechanisms for the growth and development of the economic system (Ćosić & Maksimović, 2014; Stanković, 2018).

The development of the global green economic system can be realized if business management finds and manage new working procedures and methods in organizations in order to increase resource efficiency and sustainability (Bengtsson et al., 2018; Kurdve & Bellgran, 2020). One of the types of adaptation to the requirements of modern economic development and technological progress is a LEAN and circular approach, which implementation in a particular organization includes techniques for establishing a productive and efficient work environment. The combination of these concepts represents an ideal solution to the current global problems, such as resource scarcity and environmental damage as well as a solution for the establishment of a closed-loop economic system (Nadeem et al., 2019).

The recognition of LEAN management and circular economy by academics and policymakers is apparent, but of the highest importance is that organizations accept and implement those concepts. Consideration of these approaches has shown that many of their shortcomings of them result from the way they are implemented rather than any other aspect of business culture. These approaches allow rational business devoid of all forms of costs, losses and waste. Both analyzed approaches are considered relatively new and therefore there is still not much expert research on their long-term effect on industrial organizations.

In order to answer the question of whether the application of the circular economy and LEAN approaches can support the establishment of a more sustainable industry, this research aims to understand the relationship between the circular economy and the LEAN approach through a literature review and comparative analysis of their basic principles.

## 2. Literature review

The current global business environment is characterized by dynamism, unpredictability, and intense competition, creating a demand for innovation in various forms, particularly in business philosophy. Primarily, high competition in the global market forces organizations to look for ways to maintain and improve competencies and gain a competitive advantage (Simeunovic et al., 2012). Competitive advantage and consumer satisfaction can be achieved through continuous work on improving business processes (Abbas & Hosein, 2010), which is possible through the implementation of modern approaches such as the circular economy and LEAN.

### 2.1. Circular economy

The concept of the circular economy (abbr. CE) is observed in contrast to the traditional linear economy based on the "take-make-dispose" model, where resources are extracted, transformed into products, used, and ultimately disposed off in the form of waste (Morseletto, 2023). The CE can be described as an industrial economy which is based on the restorative capacity of natural resources (Bastein et al., 2013; Rizos et al., 2015) and in order to achieve minimization of generated waste, utilization of renewable sources of energy and gradual abolition of harmful substances (Ellen MacArthur Foundation, 2012) as well as retention of the value-added in products for as long as

possible.

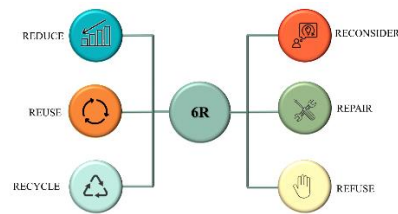
The implementation of CE is a process which takes place throughout society, involving different stakeholders and largely depends on the emergence of innovations in technology, social practices, organizational forms and business models. The main goals of adopting a CE are to reduce waste, increase resource efficiency and achieve a better balance between the economy, environment and society, in order to achieve sustainable development.

Consequence to prior, resource efficiency and green innovation have been identified as two key factors in achieving sustainable economic growth in developing countries (Sun et al., 2023). Namely, the fundamental principles of the CE are based on identified key factors in achieving sustainable economic growth. According to the Ellen MacArthur Foundation (2023), the implementation of a CE is guided by three main principles:

- Eliminate waste and pollution - materials used in the design of products should be able to re-enter the economy at the end of their life cycle;
- Circulate products and materials (at their highest value) - keeping materials in use, either as products or, when they can no longer be used, as components or raw materials.
- Regenerate nature - shifting the focus from extraction to regeneration of materials, since it is important to instead of continuously degrading nature, build natural capital.

In practice, the CE is implemented through a range of industrial and business solutions and applications based on 3R (reduce, reuse, and recycle) or an expanded 6R model (Jawahir & Bradley, 2016) that represents a new way of thinking about the use of resources.

The 6R model defines the CE through six activities that are shown in Figure 1.



**Figure 1.** 6R model

The mentioned activities in a context of a CE can be described as follows:

- Reducing energy and material consumption in production processes as well as pollutant emission through the application of eco-design;
- Reusing products by giving or selling them to someone who needs them instead of disposing of them;
- Recycling waste into products, materials, or substances for their original or alternative purposes;
- Reconsidering business models to reduce waste generation and achieve cost savings;
- Repairing components and parts to prolong the product's lifespan;
- Refusing the use of anything that is not strictly necessary.

In response to climate change and resource concerns, the industry has recognized the significance of implementing CE through 6R activities. As a result, there has been a noticeable increase in the number of publications and case studies that seek to explain and demonstrate the specific strategies and technical elements necessary to achieve desired sustainability and circularity level in the industry.

## 2.2. LEAN

LEAN thinking originated in the Japanese automotive industry after World War II and is

based largely on the Toyota Production System (abbr. TPS ) developed by Eiji Toyoda and Taiichi Ohno, and it was used to improve quality and productivity at the Toyota Motor Company (Čiarnienė & Vienažindienė, 2014; Kumar et al., 2022). Before the establishment of LEAN, traditional business practices were used. The traditional concept of business was focused on ensuring the welfare of capital owners neglecting the other aspects of sustainable business. However, this orientation is not compatible with the convictions of the LEAN business philosophy.

The LEAN approach is a set of tools that help identify and frequently eliminate losses, and improve quality, time and cost of production and business. The LEAN philosophy improves the entire organization by eliminating losses that occur during the work process. The LEAN organizations use fewer materials than traditional organizations, require less investment, use less equipment, require a lower labour force and generate less waste through the simultaneous creation of added value. Literally, the LEAN philosophy is a productivity approach used in business and production to optimize processes, provide resources, and maintain conditions that ensure the maximum quality of products and services delivered to customers. Implementation of the LEAN approach in the production process focuses on the reduction of waste and improvement of operational efficiency using a set of different tools to get these objectives (Al-Zuheri et al., 2021). The point of LEAN is not only in the concrete implementation of LEAN methods and tools but in the sweeping change of employees' and employers' consciousness (Abu et al., 2019).

Today, the implementation of the LEAN production system includes a large number of tools, but the type of applied tools depends on the conditions of certain goals specific to the company. Except for tools, this philosophy incorporates various models, methods and techniques to achieve predefined goals

including Kaizen, Jidoka, Poka Yoke, 5S, Total productive maintenance (abbr. TPM), Total quality management (abbr. TQM), Value stream mapping (abbr. VSM), Kanban, and Just in time (abbr. JIT), Heijunka, etc. (Despoudi, 2021). LEAN combines theory and tools that include both fundamental TPS concepts and newly created tools for process optimization and communication between people. TPS bases its philosophy on three Japanese terms, more precisely, on the 3Ms model shown in Figure 2.

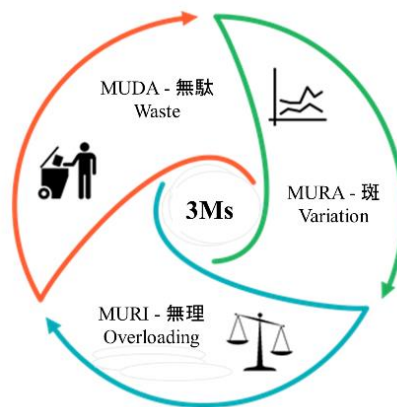


Figure 2. 3Ms model

Namely, the 3Ms model defines three causes of business inefficiency:

- MUDA - stands for loss (waste) and is used for any activity that does not add value to the product/service but adds cost to it such as overproduction, inventory, motion, defects, over-processing, waiting, and transport;
- MURA - represents all kinds of variations that can occur in production (in demand, in processing time, in product quality, etc.), which prevent the production process from taking place efficiently and effectively;



- MURI - shows the loss due to overloading that occurs due to the demand that a worker, machine or any technical system work beyond their capabilities.

The LEAN approach to process improvement is a popular and effective method for achieving significant positive results in various industries or organizations (Womack et al., 1990) but first, it is necessary to identify all inefficiencies in the organization. To ensure the benefits of applying the LEAN business concept, the following principles must be respected (Womack & Jones, 2003):

- Identify value - defining value from the point of view of the end consumer;
- Map the value stream - identifying all procedures in the business process and eliminating those that do not create value;
- Create flow - ensuring the smooth flow of products to consumers;
- Establish pull - harmonizing the product flow with consumer requirements;
- Seek perfection - clearly defining the value for consumers, adequately identifying and establishing the value stream and eliminating redundant procedures and resource losses in the process.

It is essential to understand that LEAN principles can be used to improve all processes in a particular industrial organization, and not only its production part (Jina et al., 1997). Applying the basic principles of the LEAN business concept leads to numerous benefits both at the operational and strategic levels.

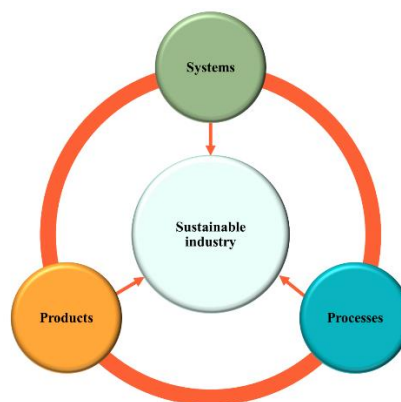
Application of the analyzed LEAN concept improves the level of sustainability in the industry. The contribution of LEAN tools to support organizations in achieving sustainable production is due to synergies between LEAN tools and sustainability (Silva

et al., 2021).

### 3. Implementation of CE and LEAN approaches for a more competitive and sustainable industry

Considering European Green Deal whose main objective is to form the world's first continent that is climate-neutral by 2050, industry will need a secure supply of clean and affordable energy as well as raw materials (European Commission, 2020). Additionally, one of the main European Green Deal goals is to encourage the development of new markets for climate-neutral and green products which is the result of an established sustainable industry.

Establishment of a sustainable industry has become a necessity for modern consumer society. Sustainable industry represents manufacturing of products using economically sensible procedures that reduce their negative effects on the environment while conserving energy and natural resources („EPA”, 2023). There are numerous benefits to promoting a sustainable industry including improving worker, community, as well as product safety.

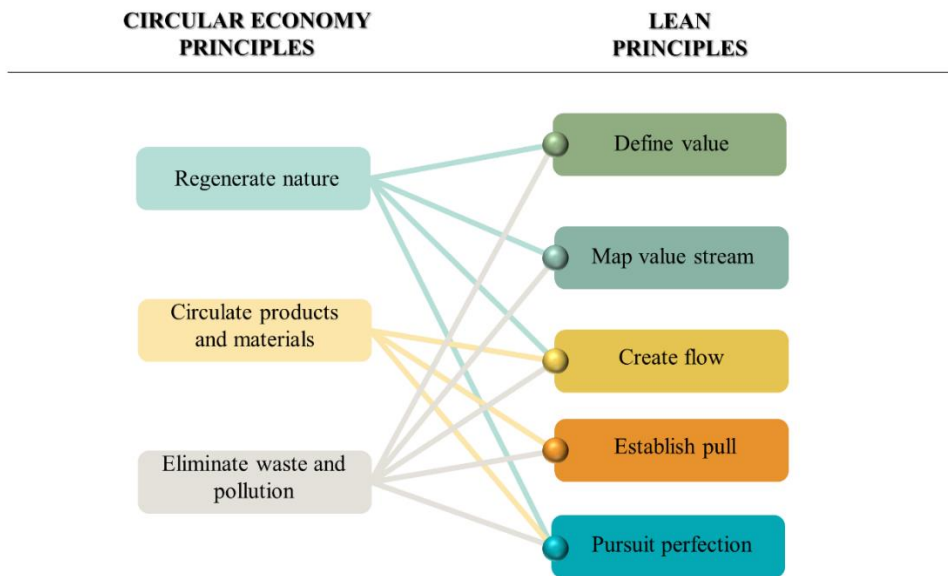


**Figure 3.** Integrated elements of sustainable industry (Jawahir & Bradle, 2016)

Contemporary and sustainable industry is based on the use of advanced manufacturing method which promotes innovative technology for improving products or processes that drives the industry. Therefore, three integral interacting levels must be taken into account to attain a sustainable industry: products, processes and industry systems (Figure 3). It can be concluded that the achievement of a sustainable industry is a very complex task since identified elements must be integrated. Regardless, organizations are faced with the need to innovatively address their product development challenges to remain competitive in today's market. More precisely, to improve the resource efficiency and environmental friendliness of industrial processes, manufacturers must

identify unique techniques or methodologies. Promising plans to accomplish this goal include a CE and green-LEAN production. Integrating CE and LEAN thinking into the product development process can encourage a sustainable industry since both approaches focus on optimization of products, processes or systems. Based on the findings of the literature, there is a necessity for the coalescing of these approaches in the industry (Schmitt et al., 2021; Ciliberto et al., 2021; Skalli et al., 2022).

The possibility of implementation of CE and LEAN approaches for a more competitive and sustainable industry can be verified by analysis of the principle between these two approaches (Figure 4).



**Figure 4.** Relation between CE and LEAN principles

Based on Figure 4, it can be concluded that the main common elements of analyzed approaches are waste minimization and value creation. LEAN and CE approaches have a lot in common to contribute to one another (Nadeem et al., 2019). Even though they have certain differences, these approaches complement each other in creating significant

results in industry (Pernstål et al., 2013). LEAN and CE differ in that CE takes a more holistic approach from a systems perspective to maximize the utility of the resource even after one life cycle of the product, whereas LEAN focuses on the immediate usage of the resource within a specific process (Nadeem et al., 2019).

Integration of the LEAN and CE is based on the maximum application and promotion of all positive sides of the analyzed approaches („Novotek“, 2022). In order to attain circularity as well as efficiency and effectiveness in industry, this integrating approach combines LEAN tools and processes with CE principles. Therefore, this paper introduces the first definition for proposed integration entitled **C-LEAN** which uses key principles from considered approaches. The abbreviated name of integration indicates that its application can contribute to the development of a **cleaner** production that is a crucial element for the transition to a green and sustainable industry. C-LEAN is a framework for the sustainability transformation of business models in industrial organizations. Industrial business models formed in this way would help organizations to make and save money by maximising resource use, reducing resource loss, and eliminating waste generation. C-LEAN emphasizes lean thinking, design thinking, systems thinking, extending life of product, as well as reuse and recycling.

Downside of C-LEAN is reflected during the actual implementation of this approach since is not universal and uniform and cannot be applied in every organization in the same way. To address these issues, a uniform methodology and implementation of the newly defined approach should be developed.

#### 4. Possibility for applying the C-LEAN approach in the Republic of Serbia

C-LEAN should be the target of many industrial organizations nowadays, all over the world. However, the problem is to implement this kind of model in industrial organizations operating in developing countries.

In general, the LEAN approach found application in the Republic of Serbia at the beginning of the 21<sup>st</sup> century, first in foreign

organizations, and then in domestic ones (Kirin et al., 2018). On the other hand, CE was popularized in Serbia since the European Union adopted a package of measures for the transition to a CE at the end of 2015 to improve the region's competitiveness, open new workplaces, and establish sustainable growth systems (European Commission, 2015). Given that these business models are still new in the Republic of Serbia, their coalescent implementation would require systemic transformation. One of the characteristics of such transformation is that the costs are relatively low and that improvements are achieved primarily by better resource utilization that organization already possesses (Stojanović, 2019). Therefore, C-LEAN could be interesting for organizations that operate in transition economies like the economy of the Republic of Serbia since there are limited resources.

Applying C-LEAN approach in the Serbian industry is possible through one complex 5-phase process shown in Figure 5.



**Figure 5.** C-LEAN implementation process („CircularTRANS“, 2023)

This implementation process starts with a diagnostic part where management of organization conducts research on the current business model and checks whether there is a possibility to apply analyzed approaches. Namely, in the first phase of implementation, performance measurement of CE, as well as LEAN thinking, is carried out. Obtained results represent a base for identifying opportunities in the C-LEAN implementation. The fourth step consists of defining a roadmap and finally, an action plan to address C-LEAN opportunities. C-LEAN

implementation process is created in accordance with the already developed CircularTRANS complete process. Undoubtedly, although Serbia is a developing country, applying C-LEAN in industrial organizations would create numerous benefits.

It is important to note that the biggest barrier to C-LEAN implementation in the Republic of Serbia is the lack of legal regulations in this area, as well as the lack of guidelines on how to implement and monitor this approach. Many organizations are not able to fully apply the C-LEAN due to the lack of a clear understanding of performance measurement of the CE as well as LEAN thinking which is considered as the first step of implementation (diagnosis).

## 5. Conclusion

C-LEAN approach in industry will create an opportunity to encourage circular, sustainable and working-intensive economic activities. CE and LEAN are two related concepts that are often discussed in the context of sustainability and operational efficiency in different aspects of business and production. CE is a sustainable economic model that seeks to minimize waste and maximize reuse of resources by keeping materials in use for as long as possible. It is based on the principles of reduce, reuse and recycle.

LEAN, on the other hand, is a production

philosophy that aims to optimize the flow of products and eliminate waste in manufacturing and service processes. It is focused on delivering high-quality products with minimum waste and maximizing value for customers.

Relation between CE and LEAN lies in their shared goal of reducing waste and maximizing efficiency. Principles of LEAN can be applied to support the implementation of CE by reducing waste in the production process and enabling reuse of resources. Additionally, CE offers a more holistic approach to sustainability, including the entire lifecycle of a product, which can be integrated into LEAN methodologies to further optimize the production process. When suggesting a particular organization to shift to a system where all operations are harmonized with the mentioned concepts, the risks associated with changes in the system must be analyzed. Namely, if one company already operates according to the LEAN approach, it will be easier for the management to transform it into a circular business, but there are undoubtedly certain risks. Barriers to the implementation of the CE in LEAN organizations largely depend on how much employers and employees are eager to change and to what extent they are engaged in the process of implementation. For this reason, further research will analyze some of the main structural barriers and risks when industrial organizations pursue C-LEAN business approach.

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Foued Sabbagh<sup>1</sup>

## THE IMPACT OF RENEWABLE ENERGIES ON SUSTAINABLE DEVELOPMENT

**Abstract:** *The people of the world have entered a decade phase after bidding farewell to the previous year 2019 and to begin with stability towards a future that is looming on the horizon of many variables that could shape the characteristics of the next decade with the start year of 2020, it will therefore constitute a fundamental change for the future of daily life and the international economy.*

**Keywords:** *renewable energies, sustainable development, green economy, natural electricity, clean technology*

### 1. Introduction

Today, the world is witnessing a continuous and growing renewal in various fields and sectors, in particular in the field of the digital economy, which has become a real bet in a direct way on the new technologies of communication and information. In addition, the green economy is considered to be the back home of sustainable development and it is classified among the characteristics of economic modernity of the last decade so that research development and innovation can be doubled at its heart so to achieve a true balance which guarantees the required productivity and national wealth and to maintain a healthy environment without gaseous toxins. The traditional energies that humanity used in the primitive phases of the industrial revolution to operate machines and energies such as cars, planes and trains, in particular petroleum energy and its derivatives such as gas or also nuclear energy, which has all caused a real environmental catastrophe today, which has caused the ozone layer to burst. They have also caused

land pollution and the spread of natural disasters such as floods, earthquakes, global warming and climate change. On the other hand, environmentally friendly renewable energies are considered to be a main alternative to these polluted traditional energies. They also have the same operational results as those with less disasters and costs, and among the most important of these energies, we mention in particular that the production of electricity from solar energy and the sales volume and the production of biofuels from vegetable oils such as corn, sunflower and the Jatropha or the use of new clean technologies which are considered a current event which can shape the main features of the future of the technological industry.

### 2. The production of natural electricity

Nature is considered a main source for the production of energy in large quantities and efficient and effective power. Also, it has become in consumption with the lowest

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possible costs, so that most countries of the world today reach it as a serious alternative to the production of electricity from fuels and large tanks. Nature has major advantages and contributes to maintaining a clean environment without toxic gas emissions, including mainly wind energy which is available continuously over a long period exceeding six months of the year. In addition, including solar energy, especially on the African continent, in Latin America and in some Asian countries, so that it forms a major production base with the lowest financial costs. First, by installing panels to produce these types of energies and then the storage and finally the conversions for electrical consumption. In this regard, many European companies, particularly in the southern Mediterranean countries, such as Egypt and Tunisia have already started to distribute and exploit these solar panels to produce natural electricity and then to direct towards the Northern Mediterranean countries, which means that the countries of the European Union will be among the largest consumers of natural electricity. Thus, also with regard to aerobic turbines to generate electricity from the wind, they also became propagated and visible on most of the hills of the mountain in various countries of the Southern Mediterranean. Overall, this electric power is currently considered the best to reduce the burden of public expenditure on the purchase of fuel, especially in non-oil countries to produce electricity at lower costs.

### **3. Biofuels - Biodiesel**

Today, the biofuels extracted from vegetable oil are among the most important types of emerging renewable energy, especially in emerging countries so that they have a direct impact on the consumer and also on public consumption. We note that the production costs and the prices of its supply which are generally less expensive. This energy, as under the name of biodiesel and it is even

capable of operating all industrial engines and machines constantly and continuously, and has almost the same operational capacities as the use of other energies. Among the most important oils extracted from this energy we note in particular corn, sunflower and the most important is the *Jatropha* plant which is very similar to the natural oils in terms of productivity. These oils are refined and processed in laboratories to produce large quantities of biofuels called biodiesel or "Green fuels". In addition, most of the stations of the world that supply gasoline to cars have become a major distribution of this type of fuel, especially in developed countries.

### **4. The clean technology**

The technology has become a tangible reality in our daily lives and this next decade is considered to be technological by excellence due to the increasing prevalence of technologies, research and innovations devoted to the industry, especially in the automotive sector, and household manufacturing which has become largely dependent on electronics and the use of the internet connection in the simplest parts of our lives. The clean technologies are the bet of the future in order to reduce the proportion of toxic gas emissions from the consumption of crude oil and fuels, which have globally become the main cause of major environmental disasters, in particular the problem of pollution nature and air in all cities of the world. It has also now become the main contributor to the stimulation of sustainable development because of its important role in achieving a balance between industry and environment. For example, we mention the TESLA car, which has spread rapidly in recent years to highlight charging stations for this type of car at supply stations, which is very similar in design to cell phone. This technology is also easy to use efficiently and achieves its goals with high quality and

equally effective precision.

## 5. Conclusion

The renewable energies have become the bet of the future of the world to achieve sustainable development which takes into account productivity in constant and required quantities and also contribute to the development of industry and technology and maintain an environment without of toxic gas. Furthermore, in this regard, the natural electricity extracted from wind and solar

energy is considered to have a direct positive impact on the national economies of most countries of the world so that it contributes to reducing the budget deficit, limits the accumulation of debts, increases the economic growth rates and therefore preserves the environment and is capable of achieving the desired sustainable development. The biofuels have recently been the main global event at the heart of the green economy, known as biodiesel extracted from vegetable oils, in particular from the Jatropha plant or also by the recycling of household waste, plant materials and plastics.

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## ECONOMIC SUSTAINABILITY OF INTERNATIONAL FINANCING AND LOAN PROGRAMS IN IRAQ

**Abstract:** *The spread of phenomenon of international loans and their positive or negative results, especially in countries of Middle East, require the development of economically sustainable plans for these loans, as well as their social and environmental sustainability for these countries in order to obtain best results from loans. Research included introducing these loans, especially in developing countries, and their objectives. As well as offering two successful experiences in benefiting from these loans, namely Malaysia and Turkey. Then research moves to main topic, which is Republic of Iraq, the reality of state of international loans resulting from it, and an inventory of all those loans and years of repayment.*

**Keywords:** *Loan, Iraq, sustainable, international, challenges*

### 1. Introduction

Idea of totalitarianism and totalitarism has dominated international relations system, taking its tendency to integrate all parts of globe into one society, with closer relations in various fields. Globalization has allowed free flows of individuals, goods, services and capital to occur, creating an integration of economies and societies until concept of global village has reached.

Stable and sustainable growth is a goal that most economies want to achieve, as it is indicator that can change direction of many economic variables towards desired direction from point of view of governments, as it is possible to achieve an increase in income and living capacity of population and elimination of unemployment and thus achieving social sustainability. Governments are trying to mobilize various local sources to maximum extent possible to finance development, but weakness of these sources poses to governments a real problem that calls for resorting to international financing of its various types in form of conditional

loans that may be of high cost, or resort to exploiting conditions produced by globalization subject to necessity of Liberalizing economy and reducing effects of restrictions to allow country to integrate into world market, which can provide it with an important amount of financing resources in form of capital flows looking for profits.

Within framework of dominance of idea of freedom of movement, these flows can enter at time they wish and withdraw also at time they wish. This is what can create with it serious repercussions on economy. Only here can we raise a fundamental question about possibility of promoting growth with foreign funding sources in light of developments imposed by globalization?

These phenomena have become focus of preoccupation at top of international economic deliberations table. There are developments that are not devoid of facts and are moving in direction of a more understanding of map of economic variables. There are also repercussions that are not lacking in evidence, and there are risks and concerns that are not reassuring in rapid and

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violent global movement of capital flows. money. research problem is focused on not taking advantage of time period in employing international loans in affiliated fields and activities. As for research hypothesis, length of international loan repayment period is a positive factor for implementation of short and medium-term development programs.

Research aims to:

1. Recognize concepts and importance of long-term loans
2. Benefiting from successful experiences approaching Iraqi case, especially Malaysia and Turkey.
3. Strengthening functional relations between activities in internal financing of projects.
4. Achieving productive convergence and developing secondary production lines from main programs included in financing.

## 2. International Finance: Concept, Importance, Objectives

Many economic researches indicate that term international finance consists of two words, finance, and this means provision of financial resources to cover current or capital expenditures according to certain conditions that include price and term, and this concept has become popular since first decades of twentieth century. A group of countries, and on its impact international institutions such as International Monetary Fund and International Bank for Reconstruction and Development have emerged... Also, other writings indicate that what is meant by international finance is that aspect of international economic relations related to provision and transfer of capital internationally, and this takes many aspects of them (1) commodity (real) aspect of international economy (2) monetary or

financial aspect, which usually accompanies flow of goods and services among countries of world (3) international capital flows for purposes of foreign investment in its various forms, and international finance falls within second dimension, and its importance appears, as an inevitable result Financial and monetary relations in international economy (Magdi El-Shorbagy, 2005).

Apparently, international finance, according to necessities presented, is a need for existence and continuity of any economy, whether it is developing or advanced, and it is a fundamental need for economies of developing countries, where process of economic and social development requires provision of many needs, to reach a level appropriate to rate of economic growth. In forefront of it comes capital as one of basic elements of production, and its loss or weakness in developing countries, we find that they are forced to use foreign capital to fill shortfall in development process in these countries, and thus search for it is most important challenge facing developing countries in order to raise economic growth rates.

## 3. Theoretical explanations for need for international finance

Many economic researches refer to several development models to explain problem of developing countries' need for external financing, including Harrod-Domar Model, which aimed to demonstrate extent of close interrelationship between national product and capital investment rates, that is, on gap between desired investment and level of savings. domestic resources gap, which is called saving gap or domestic resource gap foreign capital will be used alongside local savings to cover required level of investment, and this model is one of most important analyzes in highlighting vital role of foreign capital in process of economic development As for Walt Rostow's theory, it

focused on need to raise rate of investment, in order for economy to reach "take off" stage to be able to run itself, or so-called "self-sustained growth stage".

It is noted on both theories, Harrod-Domar + Rostow's theory, that they assume "existence of necessary conditions for development in developing countries, and reality is opposite, in addition to that, external factor or external factors are not appropriate" and are beyond control of these countries, by virtue of their dependence their economies to global economic system dominated by developed countries. As Professor Samuelson believes that as long as there are many obstacles, as for capital formation from real sources, it is necessary to rely on external sources. He explained that main problem in many developing countries is severe shortage of savings, especially in poor areas. , where phenomenon of competition of increasing current consumption is manifested, either need to invest scarcity resources, and result is directing a very small amount of investments to accelerate process of economic development. Thus, most important imbalances in savings in developing countries, including (R Gillet et Minguet ,1995). Disguised Unemployment , compactness , Irrational behavior of foreign exchange , Irrational consumption (public and private) , Tax evasion and "Capital Flight" and other remittances.

Economic equilibrium occurs when savings coincide with investments, but it is difficult to achieve because each of them is not necessarily identical, and what developing countries suffer in this aspect can be summarized in following points:

- a. A distortion in economic and productive structure
- b. Under-utilization of available resources
- c. Low productivity
- d. Low incomes
- e. A decrease in savings of individuals
- f. An increase in consumption

g. High inflation.

Therefore, these countries suffer an investment gap due to small amount of capital in their productive sectors, and here need for external financing appears... and thus an external gap occurs called "Foreign Trade Gap", which embodies imbalance in balance of payments, and this analysis is called a model Two Gaps Model (Christian Saint-etrenue 1998).

### **First: Economic Financing Systems**

It is that framework that is concerned with mechanism of accumulating savings surplus to needs of their owners and directing them to finance various activities and projects. Depending on activity of each party, two types of economic units can be distinguished; Surplus economic units and deficit economic units (J.M..Healey, 1979).

**Surplus units:** each unit that constitutes an economic decision-making center that, following its activity, has a surplus ability to finance other units.

**Deficit units:** They are economic units that need financing.

Depending on reality of direct and indirect financing, a distinction can be made between two forms or two financing systems that allow achieving this compatibility between surplus units and deficit units; We distinguish between debt economy and financial market economy.

**A - Debt economy:** It is economy in which non-financial dealers depend on loans they obtain from banks, which allow them to obtain sufficient resources to operate their investments and various activities.

**B - Financial market economics:** It is system in which non-financial dealers - in their financing to meet their various investment or exploitation needs - depend on issuance of financial assets in financial markets, which have witnessed tremendous development, and deepening of global trend towards financial globalization, and increasing level

of developments witnessed by financial tools that ensure availability of investment , employment tools according to tendencies and desires of dealers.

#### **4. Driving forces of globalization of finance**

Currents of globalization have imposed a continuous and rapid growth in role of financial markets; Markets that operate continuously, taking their way to development, driven by following factors:

A - Creativity in financial and banking industry and automation of various transactions.

B- Increasing number of companies that are active in financial intermediation, and steady growth of banking activity under pain of narrowness of local market. Investors or savers, while narrowness of local market with weak or slow economic growth formed a real restriction. As for decrease in banking brokerage profits, it is necessary to reduce severity of restriction imposed, and thus get out of local level on global markets in search of diversification in activity and exit from base.

C- tendency of banking financial intermediation institutions to comprehensive financing of activities such as carrying out leasing and bank insurance operations and entering into financial market activity with a specific branch, or creating a new department in bank to secure service of non-traditional activities (AsariFakhri Abdul Latif, [www.uluminsania.net](http://www.uluminsania.net)) as well as their tendency to benefit from capital flows that reached in year 2000 to \$7.5 trillion (GerdHassler 2002) with increasing trend to reduce number of banks operating in activity, and this fact resulted in banks entering into activities unrelated to financial intermediation, in an attempt to seize opportunities offered by financial market activity through possibility of converting

assets into traded securities, and Conducting interest rate swaps in order to avoid credit risks, and raise rates of return for benefit of bank owners to strengthen confidence of property shareholders, especially since non-bank financial intermediation has become a real constraint for it, as it narrows resources available to banks by accumulating cash surpluses from banking sector. Families or business sector and allowed them to achieve relatively high rates of return (GerdHassler 2002)

D- huge growth of multinational companies: their number reached 40,000 companies in late nineties after it was 7000 companies in s (United Nations - 2001.). To a very large financing resources Thus, it generated huge revenues, creating dynamism of ebbs in capital flows at global level, as it controls a large amount of capital flows (AsariFakhri Abdul Latif, [www.uluminsania.net](http://www.uluminsania.net)).

E- tremendous and steady growth of information and communication technology, development of use of computers, increase in use of Internet, and most of global markets have been linked to World Wide Web, thus allowing this field to further deepen globalization of financial markets, and this advanced technology provides a continuous flow of information to everyone who needs it in time. Location and location allow for evaluating market conditions, studying opportunities, monitoring and analyzing risks, and anticipating future trends in order to be able to manage them.

#### **5. Impact of foreign direct investment flows (IDE) on developing countries**

FDI flows express transfer of financial and material resources from exporting country to receiving country with aim of establishing long-term investment projects aimed at maximizing profits and benefiting from comparative advantages of host country.



John Perkins revealed in his book, *Confessions of an Economic Hit Man* about this profession, that he was not chosen out of nowhere as he was nominated by many parties. I told him that he had two primary goals in his job as a credit pirate: The first: creating justifications for the huge international loans granted to the country in which he will work, while reinjecting these funds into American companies (John Perkins, 2004). In addition, it will allow transfer of a certain amount of technical expertise and technology (Abd al-Salam Abu Qahaf, 2000) and This investment may take form of a unilateral direct flow in ownership of new project or ownership of assets of an existing establishment, or bilateral direct investment flows that take form of a partnership in which ownership of project is distributed between private foreign capital and local capital, and this type of investment flows occurs reinforced by strategies Multinational companies:

- Searching for best sources related to raw materials and idle energies in terms of costs that can be used in host country, which means making investments in order to take advantage of relative advantage of receiving country.

- Market search: Here IDE moves in search of a new market, whether it is in host country or in markets of its neighboring countries, reinforced by motives of establishing investments to replace imports. - Searching for elements that can serve strategic goal of company, so that foreign investment is supported by strategic forces drawn by multinational company. Foreign direct investment flows are financial resources that can serve path of sustainable development in recipient countries, but this will not be certain as it can produce negative effects on various variables, and this is what will prompt us to track foreign direct investment flows and their effects on various variables.

## 6. International experiences

### 6.1 Malaysia

Starting from 1986, Malaysia put forward a strategy for development through a five-year plan in 1986, whose main focus is to stimulate activity of private sector, as it is main engine of growth. To liberalize, many researchers have listed reasons for progress in Malaysia in following factors (Abdel Rahim Abdel Wahed, 2003):

1. political climate of Malaysia is characterized by appropriate conditions for accelerating economic development.
2. Malaysia has become among top five economies in world in terms of local economic strength.
3. Malaysia has pursued a largely self-reliant strategy by relying on indigenous population of country, who represent Muslim majority.
4. Malaysia's interest in improving social indicators of Islamic human capital, by improving living, educational and health conditions of indigenous population, whether they are indigenous people or Muslim immigrants to which authorities welcome resettlement.
5. Malaysia's dependence to a large extent on internal resources to provide necessary capital to finance investments, as gross domestic savings increased by 40% between 1970 and 1993, and gross domestic investment increased by 50% during same period.

There are other factors that contributed to success of Malaysian experience, most important of which are (Medhat Ayoub, 2009):

1. Malaysia treated foreign direct investment with caution until mid-1980s, then allowed it to enter, but under conditions that goods

produced by foreign investor would not compete with national industries.

2. 2 Malaysia's possession of a future vision for development and economic activity through successive and integrated five-year plans since independence until now. Rather, Malaysia's early readiness to enter current twenty-first century through planning for Malaysia 2020.
3. 3- Great diversity in industrial structure and its coverage of most branches of industrial activity "industries: consumer - intermediate - capitalist".

What are procedures that established success of experiment, which are summarized as follows:

First: Continuing success in managing macroeconomics and financial policies, with aim of achieving an information-based economy, with a low inflation rate supported by strong demand and private investment in local economy, and stable growth of global economy.

Second: Strengthening income distribution programs for a more balanced participation between ethnic groups, maintaining objectives of previous plans to address problem of poverty, reducing extreme poverty rates to less than 1% in 2005, and restructuring functional distribution between races and states with aim of building a just and unified society.

Third: Promoting development driven by more competitiveness, by improving levels and performance of workers and employees, and raising level of research and development.

Fourth: Enhancing competitiveness in main economic sectors with intensification of competition between countries to attract investment and market industrial, agricultural and service production.

Fifth: Expand uses of "information

communication technologies", and make Malaysia a regional and international center for its services and production, while working to provide a constitutional and legal environment, with aim of reducing digital difference between poor and rich, and between economic sectors, by expanding communication infrastructure.

Sixth: Supporting development of human resources, through an effective educational and training system, and building more schools, with application of central education system and concept of integrated schools.

Seventh: Achieving concept of "balanced and stable development" to benefit from country's wealth in most efficient way and to preserve environment.

Eighth: Providing better opportunities for all Malaysians to improve their standards of living, and expand access of poor and a section of middle class - which is majority of urban dwellers - to benefits of public services "education, housing and health".

Ninth: Continuing education on positive behaviors and moral values in working and living life, through educational curriculum and special programs for workers in organizations, government institutions, awareness institutions and media, given that existence of a morally disciplined society and a population with values and principles of straight transactions is basis for success of country.

## 6.2 Turkey

One of main reasons that helped Turkish economy to thrive and grow at these rates, are measures taken by country in such as (A report on the Turkish economy 2011):

- Banking reforms and rebuilding financial sector following local banking crisis that occurred in 2001.
- Implemented structural reforms that allowed different institutions and

markets to function properly (independent central bank, independent authorities, privatizations, in addition to reforms undertaken by European Union).

- Macroeconomic and political stability.
- currency reforms that took place in 2002, through which country succeeded in deleting six figures from Turkish currency.
- Providing support to small and medium-sized enterprises, which accounted for more than two-thirds of Turkish economy.
- Commercial initiatives through which country has been able to strengthen its ties with various African and Latin American countries.
- Establishment of Housing Development Department, which provided low-cost housing for more than one million Turkish citizens.
- Social security reforms, according to which a unified social security system was applied to self-employed, and Social Security Institution and retirement fund were merged into one body.
- Health care reforms through which country provided free health care services to elderly.
- agricultural sector accounted for 29.5 percent of employment in 2009.
- industrial sector remained main economic sector in country, and occupied a leading position in development process (An Overview of Turkish Economy, 2011).

## 7. Development in Iraq: goals and obstacles

Over decades, Iraqi economy has suffered a

state of deterioration and repeated crises due to circumstances that affected it and orientations of political system during period between 1980-2003, when Iraq witnessed two wars that overthrew foundations of economic development in it, followed by imposition of severe economic sanctions that threw They cast a shadow over entire economic life and imposed complete isolation on Iraq from its regional and international surroundings. Those sanctions contributed to increasing imbalance in Iraqi economy and deepening its crisis. With entry of US forces into Iraq in 2003, Iraqi economic crisis increased. Growth and development of any economy requires conditions, most important of which is existence of a safe and stable environment, as well as availability of a degree of cultural and civilizational sophistication, along with other factors. It can be said that there is an inverse relationship between existence of occupation and possibility of developing a solid national economy that has complete sovereignty in making its decisions, including economic ones. goals intersect with country's national interest represented in achieving economic advancement and growth. changes that took place under US occupation of Iraq have had their repercussions on environment of Iraqi economy as a whole, as Iraqi economic crisis revolved around collapse of state and all its institutions, and problems (unemployment, inflation, debts, infrastructure collapse, financial and administrative corruption...etc) appeared. And other problems.

### 7.1 First axis: challenges that faced economic development in Iraq after 2003 (reality of economic development)

Iraqi economy faced many problems that had accumulated during past twenty-five years, which hindered its growth and even led to its decline and collapse. Those in charge of fiscal and monetary policy in Iraq did not use any realistic solutions to problems that

began to accumulate since outbreak of Iran-Iraq war through Kuwait war and economic sanctions. Reason for this is not due to inability of specialists to find these solutions, but rather as a result of political decision that seems to have insisted on futile applications of its economic policies. second type is new or emerging challenges, and it is a group of challenges that surfaced strongly on economic and political scene after 2003.

#### **Inherited challenges**

Set of challenges and structural economic characteristics associated with Iraqi economy include a semi-rentier oil economy and a state of political and social instability. most prominent of these challenges are:

#### **Structural imbalances**

It includes set of imbalances related to structure of Iraqi economy as a semi-rentier oil economy resulting from dominance of crude oil sector over main contribution to gross domestic product and other macroeconomic variables, and at expense of relative underdevelopment of rest of productive sectors, especially agriculture and manufacturing. Those challenges were exacerbated at beginning of seventies After nationalization of oil, and huge increase in oil revenues, and consequent focus on goal of excessive oil production, and unjust exploitation of those oil resources for security and military purposes, and without this being accompanied by a serious effort to employ revenues generated in expanding productive investment and expanding non-productive capacities Oil and other material and human development investments to create necessary prerequisites for launch of Iraqi economy, which reduced opportunities for productive diversification and deepened phenomena of structural imbalances, and gave way to excessive government spending biased to policies of staying in power, and misuse and distribution of oil revenues, and those have deepened Imbalances after

imposition of international sanctions and imposition of an economic blockade in Following invasion of Kuwait, and since then Iraqi economy has entered a state of long-term stagflation, then Iraqi economy has been subjected to a severe structural crisis after devastating war in 1991, which caused worst damage to infrastructure and productivity, and that crisis continued to exacerbate after regime was overthrown and country turned into an occupied state. by United States of America in 2003.

#### **Political instability**

The history of Iraq is a long series of foreign invasions and counter-coups, which made most of changes in successive governments and leaders be in form of violent and sudden shocks, which prevented development process from achieving necessary stability and continuity, which resulted in failure of planners and implementers to spend money Allocated in development plans programs and in all its sectors, according to criterion of efficiency of performance or efficiency of spending. Despite hopes that were placed on process of political change in 2003, as it would be an entry point to end political and social conflict over power and establish principle of peaceful transfer of power, but that process came with low results Until now, weak role of parties and civil society organizations has made power-sharing process based on sects and national and religious components and not on civil and political foundations that have given priority in selecting ministers and senior state officials for considerations of political quotas and budgets. All this factor is a serious challenge at expense of academic specialization. Efficiency and integrity.

#### **Linking investment spending to increasing oil revenues**

All successive governments, regardless of their ideological inclinations, linked investment spending to an increase in oil

revenues, without taking into account limits of economy's absorptive capacity, or availability of specialized technological and human requirements, which made investment allocations directed towards all economic activities a variable subject to conditions of general budget, which in turn is variable. Continued to oil revenues, when government budget deficit rates rise as a result of decline in oil revenues, focus will be on covering requirements of current part of spending and sacrificing investment part, and this is what usually happened in most stages of development in Iraq, as it confirms Iraq's economic experience from fifties until now. On failure of successive governments to employ revenues generated in expanding productive investment, expanding non-oil production capacities and creating capabilities necessary to launch Iraqi economy, as a result of adopting a policy of rushing towards achieving maximum amount of oil revenues without a clear national vision and a specific economic strategy, so it failed to achieve goal of rational allocation of available oil revenues that will ensure achievement of a goal diversification, increase employment opportunities and reduce dependence on oil revenues.

Accordingly, financial budget for 2017 is a realistic budget of austerity and devoid of investment aspects, as "loans do not fill deficit in them", so this budget is not commensurate with size of investment projects and this is due to lack of revenues and because it is hardly enough for operational side as there are a lot of expenses including salaries of employees, so new budget is a perpetuation of previous projects that work has begun and have not been completed or may be deleted or postponed.

### **Failure of economic policies**

A careful review of economic policies in Iraq reveals absence of their role or their inadequacy, whether in their financial, monetary, commercial, industrial,

agricultural or other policies represented by misuse of oil revenues, in prevalence of manifestations of underdevelopment and deterioration of levels of production and productivity in various economic activities and thus weakness level of economic diversification, which deepened manifestations of imbalance and distortion in Iraqi economy, most prominent of which is distortion in economic structure as a result of dominance of oil sector and decline of commodity sectors, especially industrial and agricultural sectors, electricity and water sector, and growth of parasitic sectors, as well as distortion in exchange rate of dinar, and distortion in tax system In prices in interest rate structure, distortion resulting from lack of coordination between macroeconomic policies, and distortions in distribution of income and wealth, so most of economic policy measures in Iraq have failed in all mentioned aspects.

### **7.2 Second axis: Emerging challenges**

It is a set of challenges that surfaced on surface of Iraqi political and economic scene after process of change in 2003:

#### **Security challenge**

This challenge was linked to collapse of state's security and military institutions and decline in role of legal system, after collapse of government with all its institutions and transformation of Iraq into an occupied country in 2003, and accompanying chaos in management of institutions and failure to protect Iraq's borders. All of these developments inflicted most severe losses on infrastructure and productivity, after sabotage operations focused on oil pipelines and sabotage electric power transmission lines and generating stations as well as electricity and water, as well as directly targeting lives of citizens. Isolation, as dozens of innocent people are martyred or injured every day, and it is natural that

continuation of this daily challenge leads to giving priority in allocations to security aspect at expense of reconstruction and development process, however, after more than seven years of difficult and costly experience, I remain security file It constitutes a serious challenge facing development and transition process in Iraq, as a number of Iraq's governorates still lack a stable state. German, in addition to social and political instability, and there are still difficulties facing processes of imposing authority of law, public order and justice among citizens.

### **Unemployment Challenge**

Unemployment is one of factors of political, economic and social tensions due to its negative effects on large segments of society, represented in high dependency rates and inability of Iraqi family to meet its necessary needs. Such as army and police, in addition to activities of trade, building and construction, and so on. phenomenon of unemployment did not emerge clearly during eighties and nineties due to conditions of general military mobilization that included most of economically active, but this phenomenon has clearly exacerbated and posed a serious challenge, and after occupation administration dissolved former army and laid off thousands after fall of regime, and this crisis worsened as a result of continued deterioration Industrial, agricultural and service production, and failure to take quick measures to start reconstruction of infrastructure and rehabilitate main sabotaged industries, especially capacities for production of electricity and drinking water and provision of public services. unemployment rate reached 15% until 2015, according to statistics of Ministry of Planning.

### **Poverty Challenge**

High unemployment rates, continuation of security challenge and stagnation of

economic activity have resulted in a steady rise in poverty rates for vast majority of population, and absence of a clear improvement in level of middle-class incomes. phenomenon of poverty today is one of main dilemmas facing development process after its percentage reached More than 20% of population until 2015, and increase in this percentage is due to increase in population, and consequently increase in dependency rates, increase in supply of labor force, high unemployment rate and widening of phenomenon of marginalization. real thing is despite continuous increases in cash incomes, and result was continued high rates of poverty, and this situation provided ample space to push many residents of slums to carry out terrorist acts, and also led to high rates of theft and kidnapping crimes and distorted image of social scene in Iraq.

### **Corruption Challenge**

Administrative and financial corruption leads to disruption of development process in addition to its economic and social effects. spread of this phenomenon after change process in 2003 constituted one of main challenges facing transition process in Iraq. Abroad, entry of foreign companies in implementation of reconstruction projects and multiplicity of sources of economic powers related to reconstruction to create appropriate conditions for practice of corruption, and as a result of these developments, Iraq took first ranks in corruption in reports of Transparency International.

### **High Debt Challenge**

The external indebtedness of countries represents one of most important indicators of strength of their economy. greater external or even internal indebtedness of country, more this indicates weakness of economy in that country, and certainly size of high indebtedness means that burdens of servicing this debt will also be high, and these burdens

are represented in interests paid on debts and installments Pay off debt. Serving foreign debt means deducting a percentage of state's revenues that are supposed to be directed towards serving citizen and presenting it to crediting parties. Therefore, foreign debt is considered one of most important problems or obstacles that stand in way of growth of Iraqi economy, which must be addressed once and for all before Iraqi economy can regain its breath Achieving capital accumulation, which is key element in increasing investment and thus generating income.

### **Explosive inflation**

Challenge In economic terms, inflation means a decrease in purchasing power of money or an increase in prices of a basket of goods and services compared to a certain base period. Inflation is an indication of imbalance of forces of supply and demand in economy, but it may be explosive when it takes form of a spiral as it naturally rises at levels that reach prices at increasing, continuous and large rates for successive periods that cannot be easily controlled, and this is what Iraq witnessed during previous years. With existence of fixed exchange rate systems and central policy in pricing, black market has flourished in various types of commodities in Iraq, economy has suffered from price distortions, purchasing power of Iraqi dinar has decreased significantly, spending levels have increased, savings and investment levels have decreased, which led to Iraqi economy entering a cycle of depression and decline.

### **The challenge of transitioning to a market economy**

Development failure in Iraq during previous decades proved that dominance of public sector institutions, centralization of economic planning and severe centralization of decision-making processes were unable to achieve efficiency in use of available resources and caused many serious structural

problems, and led to squandering of oil resources on wars and various problems.

### **Soft country challenge**

Most of state agencies in Iraq suffered after change process in 2003, a state of administrative chaos that contributed to perpetuating chaos that accompanied occupation administration. Academic, competence and integrity, and result was to deprive advanced technical, organizational and administrative cadres and competencies of opportunity to assume these positions and these developments led to perpetuating phenomenon of soft state, a phenomenon that expresses state of state that suffers from slackness of its administrative apparatus as a result of its inability to carry out its functions and tasks and falling victim to lack of Efficiency, spread of corruption and nepotism as well as absence of pursuit of public interest, and lack of continuous evaluation and accountability of citizens or their true representatives constitute internal laws and main specifications of soft state.

As for most important elements for advancing developmental reality in Iraq, it is concentrated in availability of human resources, availability of enormous natural resources, diversity in economic sectors and investment opportunities. On other hand, development goals in Iraq are elimination of financial and administrative corruption, reconstruction of infrastructure, privatization, and finally attracting capital.

## **8. Finance and foreign loans and their impact on development programs in Iraq**

Iraq was subjected to two shocks, first of which was drop in crude oil prices and attack of terrorist entity ISIS, which led to a significant decrease in public revenues and an increase in expenditures. As a result, financial deficit in general budget for years (2015 to 2017) increased, which required

borrowing from local and foreign sources to finance fiscal deficit. This has led to a significant increase in public debt in last three years, from \$73.7 billion in 2014 to \$111.7 billion at end of 2016.

### 8.1 Public debt details

Debts are distributed according to funding sources as follows.

		(millions of dollars)
1	Paris club dues	5979
2	Dues of countries outside Paris Club	2045
3	large trade creditors	2790
4	Multi-currency creditors	68
5	Arab Monetary Fund dues	153
	Total	11033

Source:Ministry of Planning/Grants and Loans Division 2018

### 8.2 Old foreign debt

It amounts to about (11) billion dollars, distributed according to table 1 (Ministry of Planning / Division of Grants and Loans 2018).

### 8.3 New foreign debt

Iraq obtained a number of cash loans to support budget from major parties, according to Table 2.

### 8.4 New Loans (2017)

**Table 1.** External debt in Iraq / before 13/12/ 2016

No.	Statement	Amount
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**Table 2.** New Debt in Iraq 2010-2016

No.	finance agency	Loan Amount /Million Dollars	Benefit	Date	Payment duration	Grace duration
world bank loans						
	budget support	250	Administrative + fixed margin	2010	11	4
	budget support	1200	Administrative + variable margin	2015	11	5
	budget support	1443	-	2016	13	5
International Monetary Fund loans						
	SBA	1818	0.65%	2010	1.9	3.3
	RFI	1241	Administrative +1%	2015	1.9	3.3
	SBA	634	Administrative +1%	2016	1.9	3.3
	SBA	634	Administrative +1%	2016	1.9	3.3
JICA Loans						
	budget support	233	Administrative + margin	2016	10	5
	Total	6819				

Source:Ministry of Planning/Grants and Loans Division 2018

Table 3 summarizes loans in a year 2017.



**Table 3.** Foreign loans to Iraq in 2017

No.	Loan name	Loan amount
<b>Cash loans</b>		
1	JICA	30 billion yen
2	French loan to support budget	430 million euros
3	World Bank	Billion dollar
4	International Monetary Fund	\$1.2 billion
5	Foreign bonds	Billion dollar
<b>Project Finance Loans</b>		
6	Deutsche bank	500 million euros
7	Japan Bank for International Cooperation	50 million euros
8	British loan	10 billion pounds

Source:Ministry of Planning/Grants and Loans Division 2018

## 8.5 Sovereign guarantees

**Table 4.** Amounts of sovereign guarantees in Iraq

No.	Guarantor Agency	Guarantee amount/
1	Ministry of Finance	15,859.6 billion Iraqi dinars
2	Ministry of Finance	1275 / million dollars
3	Ministry of Finance	951 billion dinars
4	Ministry of Finance	

Source:Ministry of Planning/Grants and Loans Division 2018

## 8.6 Others

Countries whose debts amounting to (40.902) billion dollars, from Arab and foreign countries, have not been resolved.

## 9. Distribution of loans to sectors

External and internal loans were distributed over many sectors, and distribution ratios varied clearly, as shown in Table 5.

## 10. Payment period

Repayment periods varied according to type of loan (external or internal) and according to amount and lender, as well as sector covered by loan.with five years grace) i.e. by year 2039. According to Table 6.

**Table 5.** proposal for distributing foreign loans to economic sectors

No.	Sectors	%
1	Ministry of Finance	54
2	electricity	11
3	Water Resources	1
4	Defense	13.9
5	oil	1
6	Trading	0.5
7	Agriculture	1.4
8	investment	2.6
9	central bank	8.5
10	Housing and Construction	3.8
11	other	2.3
	Total	100

Source:Ministry of Planning/Grants and Loans Division 2018

**Table 6.** Proposal for time distribution of loan repayments

No.	Year	%
1	2018	3
2	2019	10
3	2020	18
4	2021	14
5	2022	18
6	2023	9
7	2024	10
8	2025	4
9	2026	4
10	2027	4
11	2028	2
12	2029	1
13	2030	1
14	2031	0.00

15	2032	0.00
16	2033	1
17	2034	1
18	2035	1
19	2036	1
20	2037	1
21	2038	1
		100

Source: Ministry of Planning/Grants and Loans Division 2018

### 11. Suggested strategy

Appropriate strategy for loan repayment program must be developed with required priorities for investment projects for their sustainability, and whose profits will contribute to economic development of country. Since repayment of loans is continuous, distribution of projects is carried out in two periods: short-term (1-3) years, and medium-term (4-10) years, and greatest weight, according to table (7), is on medium-term plan because debt repayment ratios are few and no It puts a lot of weight on budget.

#### 11.1 Statistical model and its inputs

Inputs are adopted as effective indicators in economic development process, and importance of these indicators varies according to: value of required capital, time period for implementation, possibility of actual implementation. As for evaluation of

indicators, they depend on extent of their impact and success through practical experiences and theoretical framework, and ineffective indicators can be excluded in line with Iraqi investment climate. In this research, indicators are identified as follows:

**First:** Economic indicators: They include main economic activities represented by:

- A. Agricultural sector
- B. Industrial sector
- C. Commercial sector
- D. Services sector
- E. Public transport

**Second:** Social indicators, including:

- A. Educational sector
- B. Health sector
- C. Labor opportunities
- D. Housing for all categories

**Third:** environmental indicators

- A. Waste recycling
- B. Expanding green areas
- C. Alternative energy

#### 11.2 Plan and distribute projects

The projects are distributed in two phases: short-term and medium-term, and all proposed projects are investment projects, and payback years are calculated within loan repayment period. According to following tables 7-8.

**Table 7.** Suggested distribution of short-term projects by sectors

Sectors	Projects	Estimated cost/\$	Project duration	Year of implementation	Notes
Economic	Agriculture	10 million	One year	2022	project is annually renewed for a period of 20 years
	Industry: construction industry	20 million	One year	2023	project is annually repeated for a period of 3 years
	Trade: Free Zone	15 million	One year	2023	Implementation of four free zones every one year
	Public transport: supernet	10 million	One year	2023	Repeat for five years

Social	private universities	12 million	Two years	2023	Five universities are established over subsequent years
	Specialized hospital with no more than 50 beds	15 million	One year	2023	Repeat for three stages
	vertical housing	20 million	One year	2024	project will be re-implemented until 2038
Environmental	waste recycling plant	5 million	One year	2023	Implemented every year a station until 2038

Source : Researcher

**Table 8.** Proposed distribution of medium-term projects by sectors

Sectors	Projects	Estimated cost/\$	Project duration	Year of implementation	Notes
Economic	Agriculture for industrial crops	20 million	Three years	2023	project continues until 2038
	Industry: construction raw materials industry	40 million	Three years	2023	project is repeated every 3 years
	Commerce: Airport Transportation, which is a development of existing airports	35 million	Three years	2024	Implementation of two airports every three years
	Public transport: metro network	50 million	Three years	2024	It can be implemented in stages, depending on size of cities
	Grand Mall	20 million	Three years	2024	It is distributed every three years
Social	international universities	25 million	Three years	2025	Four universities are established, distributed over subsequent years
	Specialized Hospital 200 Beds	60 million	Three year	2024	Repeat for three stages
	Large vertical housing projects	50 million	Four year	2025	project will be re-implemented until 2038
Environmental	recycling and recycling plant	30 million	Two year	2025	It is implemented in major cities every three years
	Electricity generation from organic matter	20 million	Three year	2026	project is repeated for subsequent years every two years
	solar power plants	30 million	Two years	2026	Repeat every three years

Source : Researcher

## 12. Conclusion

1. Project costs have been determined and distributed over years in a way that does not affect repayment of loans.
2. It is possible that proposed projects contribute to payment of debts instead of budget
3. projects provide very large job opportunities that reduce unemployment as an alternative to central appointments that put another burden on budget
4. Exploiting alternative energy from sun and wind that achieve environmental and economic sustainability, which contributes to reducing dependence on fuel and reducing environmental pollution
5. Developing knowledge cities through reputable universities, and providing amounts spent outside country. With bringing currency to country through foreigners who study inside country.
6. Providing opportunities for treatment inside country and providing amounts spent outside country on treatment. With bringing currency to country through foreigners who are treated within country.
7. Developing healthy, low-pollution cities through public transport networks and reducing polluting cars.
8. Contribute to reducing industrial and agricultural imports by providing a local alternative.

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# International Quality Conference

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## CLIMATE CHANGES - TRENDS AND PERSPECTIVES IN THE REPUBLIC OF SERBIA

**Abstract:** *Climate change definitely has a global character and is clearly happening and has an impact in every part of the planet Earth. In the last few decades, the climate on the territory of the Republic of Serbia has seen significant changes in most climate parameters. These changes have an unequivocal impact on the quality of life of the population of the Republic, as well as on the development of the economy. The paper analyzed the degree of change in certain climatic parameters, especially the increase in average temperature. A comparison with corresponding global trends was also made. As a comparison, two time periods were analyzed, the first from 1961-1990 and the second from 1991-2020 (in accordance with the periodicals of the World Meteorological Organization - WMO). The parameter values were observed at 26 main meteorological stations, i.e. the entire network in the Republic of Serbia, except for the stations on the territory of Kosovo and Metohija due to the unavailability of complete data for the period 1991-2020. Especially for the city of Kragujevac, the trend of changes in average temperature and precipitation was observed. In accordance with the results of the analysis, appropriate conclusions and assumptions of future trends in changes in climate parameters were drawn. As part of the final considerations, the possible impacts of climate change on the quality of life of the citizens of the Republic of Serbia, as well as on the living world in general, are listed.*  
(Times New Roman, 10pt, Italic, align Justify).

**Keywords:** *Climate change, Republic of Serbia, Global warming, changes in climate parameters*

### 1. Introduction

Climate, in fact, represents a kind of product of the climate system. The Earth's climate system is a complex dynamic system that consists of the five most important components: atmosphere, hydrosphere, cryosphere, lithosphere and biosphere, as well as their mutual reactions.

Climate changes, in a broader sense, are the

consequences of complex abiotic and biotic processes and are reflected in statistically significant changes in climate parameters over longer or shorter periods.

The phenomenon of global warming caused the first scientific polemics during the seventies and eighties of the last century. Today, just a few decades later, major changes in the entire climate system of planet Earth are an almost undeniable fact that is

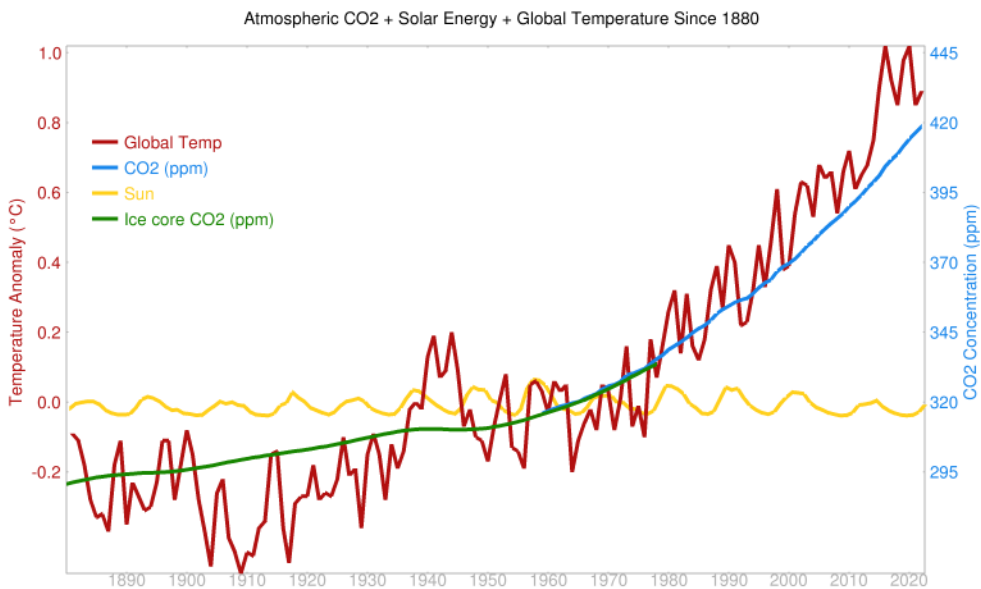
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contested by relatively few researchers. A somewhat more intense controversy is being waged over the real causes of this potentially catastrophic consequence for life on Earth. Nevertheless, the great coincidence with the extreme increase in the number of inhabitants on the planet and accelerated technological development as well as the enormous increase in energy needs indicates that the anthropogenic factor is dominant in terms of influencing dramatic changes in climate parameters [Jovanovic et.all].

Life on planet Earth is, among other things, possible due to the existence of the natural greenhouse effect. However, the greenhouse effect, which was a blessing for the planet Earth for millions of years, is gradually turning into a serious threat due to certain human activities. With accelerated

industrialization and rapid human population growth, greenhouse gas emissions—caused by the burning of fossil fuels, deforestation and land clearing for agriculture, and many other activities—are constantly increasing. In the last 100 years, greenhouse gases were emitted into the atmosphere significantly more intensively and faster than natural processes could remove them. The diagram shown in Figure 1 shows changes in the mean global temperature, changes in the concentration of carbon dioxide in the atmosphere, as well as variations in solar activity [www.co2.earth]. The coincidence between the increase in CO<sub>2</sub> concentration and the increase in global temperature is more than obvious. Also, it can be concluded that solar activity did not significantly change its intensity.



**Figure 1.** The connection between the change in mean global temperature and the increase in CO<sub>2</sub> concentration in the atmosphere [www.co2.earth]

It goes without saying that the climate of any climate on the planet is one of the most influential factors on the quality of life of

people, as well as on all economic activities. In addition, climate change is one of the five most significant factors that lead to the loss of



biodiversity, endangering many plant and animal species, whose survival depends mostly on their speed of adaptation to new conditions. And in this sense, these processes lead to the disruption of many segments that make up the quality of life of every inhabitant of this planet.

## 2. Changes in climatic parameters on the territory of the Republic of Serbia

The climate of Serbia, as a country located in the southeastern part of Europe, can be described as moderate-continental with more or less pronounced local characteristics. Spatial distribution of climate parameters is determined by geographical location, relief and local influence, as a result of a combination of relief, air pressure distribution on a larger scale, terrain exposure, presence of river systems, vegetation, urbanization, etc. Among the geographic features that characterize important synoptic situations important for the weather and climate of Serbia, we should mention the Alps, the Mediterranean Sea and the Gulf of Genoa, the Pannonian Plain and the Morava Valley, the Carpathians and the Rhodope Mountains, as well as the hilly mountainous area with valleys and plateaus. The predominant meridional position of the river basins and the plains in the north of the country enable the deep penetration of polar air masses to the south [[www.hidmet.gov.rs/klimatologija\\_srbi je.php](http://www.hidmet.gov.rs/klimatologija_srbi je.php)].

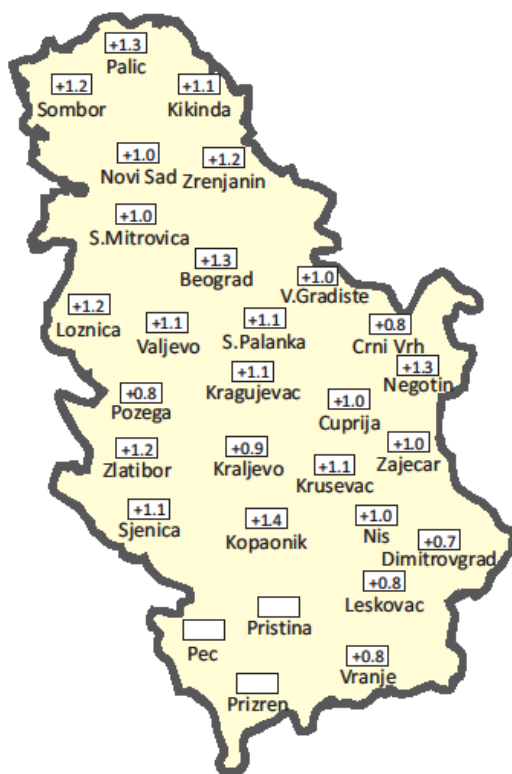
The characteristics of the climate in the territory of the Republic of Serbia have also undergone significant changes, especially in the last few decades. The size and trend of these changes depend on the observed climate parameter, but certainly the most pronounced change was observed in the increase in air temperature in all periods of the year (with different intensities), as well as in the entire territory of the Republic of Serbia. In this

part, an analysis of the change in certain climate parameters was performed, as well as the relationship with certain global climate changes.

Data from 26 synoptic stations throughout Serbia were analyzed, excluding the stations located in Kosovo and Metohija due to incomplete data. The structure of the observed stations is dominated by stations with a relatively low altitude (< 300 masl) - there are 19 of them. Three stations belong to the altitude zone between 300 and 500 masl, and the remaining four stations are at positions with an altitude higher than 1000 masl. Values for two thirty-year time periods (according to WMO periodicals), namely: 1961-1990 and 1991-2020, were observed and compared. As a result of the analysis, Figure 2 shows the change in mean annual temperature for each of the observed stations. It can be clearly seen that there has been an important change at all stations - an increase in the average annual temperature. The average increase in mean annual temperature for all stations is +1.06 °C. Only a few stations recorded an increase of less than one degree Celsius. It can also be seen that the biggest change, in terms of temperature, took place at Kopaonik (+1.4 °C), the station with by far the highest altitude (1710 masl). Of the remaining three mountain stations, two more (Zlatibor and Sjenica) also record above-average warming on an annual basis. Only the mountain station Crni Vrh has a below-average increase in mean annual temperature (+ 0.8 °C). Among the other trends, it can be pointed out that the largest number of stations in Vojvodina, as well as Belgrade, which is located on the border of this northern autonomous province, have an above-average growth in Tsr. The south of Serbia, on the other hand, generally has a below-average increase in temperature. In the cities of central Serbia, warming around average values (1.0 - 1.1 °C) was recorded in most cases. The region where the Negotin station is located showed a certain specificity of changes in

climate parameters. Until now, this region has shown certain specificities of the climate and important differences and characteristics

compared to relatively close localities.



**Figure 2.** Changes in mean temperatures at the observed stations for the two analyzed periods

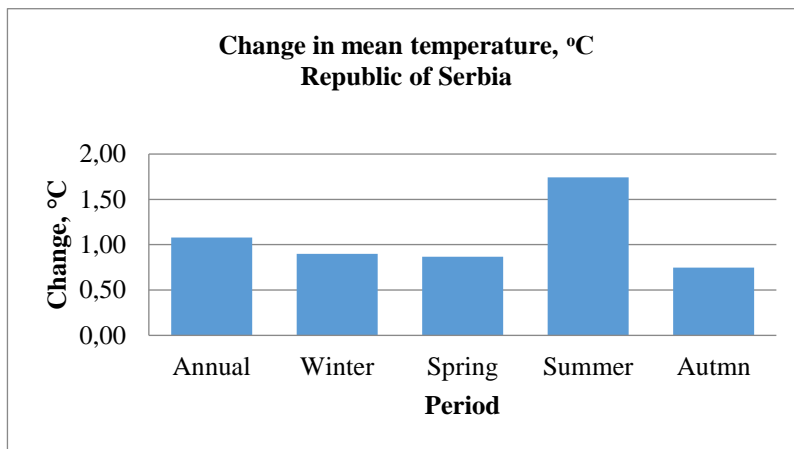
The change in temperature for the observed two periods at the annual level is not evenly distributed across all seasons. Figure 3 shows the observed change in temperature for four seasons: winter (January, February, December), spring (March, April, May), summer (June, July, August) and autumn (September, October, November). It should be noted that only in the case of the winter period, the months from the calendar year, which are not in a three-month sequence, were taken. What is unequivocally observed is a markedly higher increase in summer temperatures compared to the remaining three seasons. This increase corresponds to a significant increase in the number of days

with temperatures higher than 30 °C or 35 °C at all observed stations [[www.hidmet.gov.rs/klimatologija\\_srednjaci.php](http://www.hidmet.gov.rs/klimatologija_srednjaci.php)], which unambiguously affects the health of the majority of the population, the working abilities of employees, as well as the living world in general.

In comparison with the global increase in temperature [[www.ncei.noaa.gov/access/monitoring/monthly-report/global/202213](http://www.ncei.noaa.gov/access/monitoring/monthly-report/global/202213)], it can be noticed, at first glance, that the air temperature over the territory of Serbia has changed more than the planetary average. However, when calculating global deviations, air temperatures above water surfaces (seas

and oceans) have a significant share and in those locations, due to the temperature inertness of the water mass, as a rule, the effect of global warming is smaller (example of the month of March 2023 for the Northern Hemisphere: warming over the seas and oceans it was +0.84 °C, and over land surfaces as much as +2.66 °C, while in the

forest it would be, due to the dominance of water surfaces, +1.62 °C). In this sense, it is relatively difficult to compare the increase in temperature on the territory of the Republic of Serbia with the global average, but it can be said unequivocally that the warming is significant and has an accelerating trend.

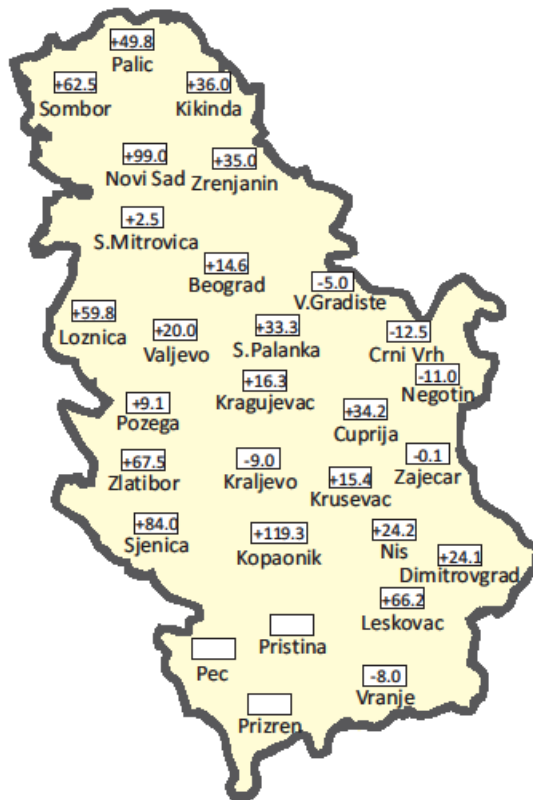


**Figure 3.** Temperature rise by season

When we talk about the change in the precipitation regime, there was not such a degree of change as in the average temperature, but it can be said with a high degree of certainty that there was a noticeable increase in the amount of precipitation. That average increase during the year, at the level of the Republic of Serbia, amounts to 30.44 mm, that is, almost 5% compared to the previous reference period (1961-1990). This increase indicates the fact that the increase in temperature, at least for the time being, caused a corresponding increase in the amount of precipitation and that this is one of the possible natural defense mechanisms. This fact is somewhat contrary to the majority of predictions that a warmer and drier climate awaits these areas in the future. However, due to increased evaporation due to higher temperatures, the question is whether the

increase in precipitation is sufficient compensation for that process, so that the possible effects of precipitation deficit can certainly be discussed. The largest absolute deviation, i.e. increase, was again recorded at the station on Kopaonik (+119.3 mm), and in percentage terms in Novi Sad (17.2%). Figure 4 shows the distribution of changes in the amount of precipitation at the observed stations.

At the stations in the north of Serbia, in Vojvodina, an above-average increase in precipitation was recorded in relation to the entire republic, and below-average in the east. In addition, the amount of maximum daily precipitation increased at a larger number of stations (on 21 of the observed 26), as well as the frequency of days with precipitation of over 10 mm (20 of the observed 26).



**Figure 4.** Changes in the annual amount of precipitation at the observed stations for the two analyzed periods (mm)

With the aim of a more detailed overview of the trends in average temperature changes for the city (station) of Kragujevac, a

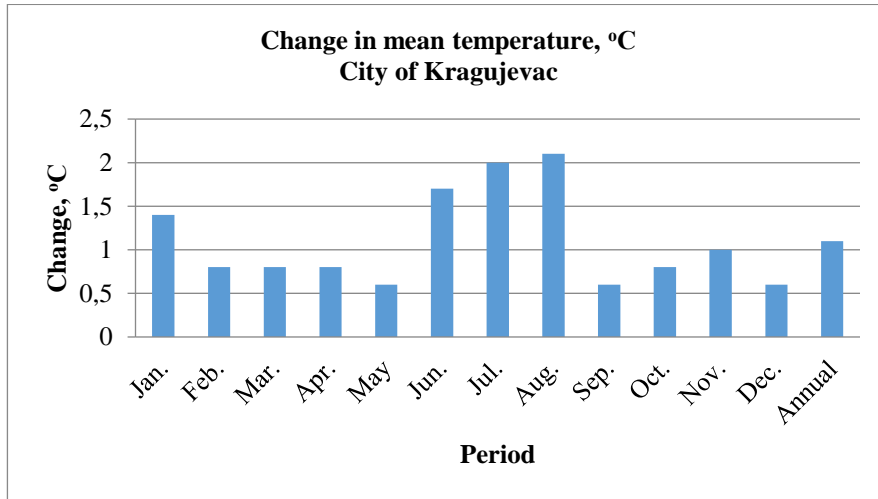
comparative analysis was performed for the two mentioned periods (Table 1), but on a monthly basis.

**Table 1.** Mean monthly temperatures and amounts of precipitation for the two observed periods for the Kragujevac station

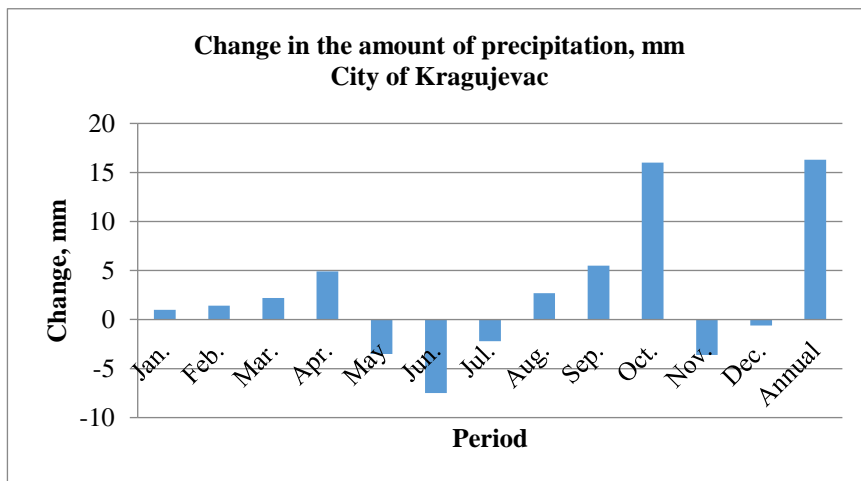
	Tsr, [°C]												
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
61-90	-0.1	2.2	6.3	11.3	16.1	19	20.6	20.2	16.7	11.4	6.4	1.8	11.0
91-20	1.3	3	7.1	12.1	16.7	20.7	22.6	22.3	17.3	12.2	7.4	2.4	12.1
Change	1.4	0.8	0.8	0.8	0.6	1.7	2	2.1	0.6	0.8	1	0.6	1.1
	Amount of precipitation, mm												
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
61-90	41.1	38.7	44.4	49.4	73.8	84.7	68	53.3	48.1	38.2	48.2	47.6	635.5
91-20	42.1	40.1	46.6	54.3	70.3	77.2	65.8	56	53.6	54.2	44.6	47	651.8
Change	1	1.4	2.2	4.9	-3.5	-7.5	-2.2	2.7	5.5	16	-3.6	-0.6	16.3

The diagram in Figure 5 shows the distribution of changes in average monthly temperatures for each of the 12 months during

the year, and the diagram in Figure 6 shows the change in monthly precipitation.



**Figure 5.** Temperature change by month for Kragujevac station



**Figure 6.** Change in the amount of precipitation by month for the Kragujevac station

The distribution of the increase by month (Figure 5) shows that several months, primarily the summer months - June, July and August, as well as the winter month of January - show a more significant increase in temperature than the average annual increase. This applies especially to July and August.

On the other hand, several months (May, September and December) have a relatively small change in mean temperatures. When it comes to precipitation, on a monthly level, for the city of Kragujevac, the biggest change is observed in the months of October (precipitation surplus of 16 mm) and June

(deficit of 7.5 mm). If we look at the change at the annual level, it can be seen that it is practically equal to the October increase, while the other months, in summary, are in balance for both observed periods (1961-1990 and 1991-2020).

### 3. Conclusion

Climate change, and above all global warming, represent a big and difficult problem for today's civilization. These changes are mostly caused by human activities, and especially as a result of the excessive emission of greenhouse gases. An increase in average temperatures has been recorded practically in every place on planet Earth, but this change is certainly uneven. The

aim of this paper was to indicate the scope and trends of climate change in the territory of the Republic of Serbia, as the central part of the Balkan Peninsula. In the paper, according to the presented data, the trend of a serious and accelerated increase in average temperatures, as well as a moderate increase in the amount of precipitation, is clearly indicated. There is also a clear trend of a marked increase in temperatures in the summer months and a more moderate one in the other seasons. This type of change, among others, has a special impact on the health, quality of life and work abilities of people in that time period. At the end, a shorter, more detailed analysis was given, by month for the city of Kragujevac regarding the change in mean temperature and amount of precipitation during the year.

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## MODELING THE OPERATION OF MULTI-SCENARIO SYSTEMS

**Abstract:** *The relevance of the declared subject of this research work is determined by the need to develop and implement software for users of various skill levels, as well as to create effective multi-scenario systems for describing processes occurring in multiple environments. The primary purpose of this scientific research is to study the principles of modeling the functioning of multi-scenario systems. The basis of the methodological approach in this scientific study is a combination of methods of system analysis of the principles of creating models for the functioning of multi-scenario systems with an analytical study of the prospects for building monolithic architectures of online learning systems. In the course of this scientific research, results were obtained that describe the principles of modeling a multi-scenario online learning system, as well as illustrating the features of the interaction of individual subsystems within a single multi-scenario system, taking into account the effectiveness of each of the subsystems performing the functions assigned to it within a single multi-scenario system. The results obtained reflect the fundamental principles of building the operation of multi-scenario systems in the conditions of the need to process a large amount of data, taking into account the difference in user characteristics, their levels of preparedness, as well as the variety of user requests that have a significant impact on the process of creating a multi-scenario system model and its functioning in constantly changing environments. External conditions. The practical significance of the results obtained in this scientific study, as well as the conclusions formulated on their basis, lies in the possibility of their application in the development of information presentation systems, the operation of which is based on the principle of multi-scenario, in order to provide the option of choosing modes of use and their automatic adjustment.*

**Keywords:** *Adaptive Interface; Monolithic Architecture; Microservice Architecture; Learning Systems; Information Systems; Software.*

### 1. Introduction

The problem with this scientific research is that today there is a tendency to transfer many areas of activity online, which

necessitates the search for adequate opportunities for the mass use of modern computer systems and the creation of maximum ease of use. In this context, the provision of convenience in choosing the

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modes of using computer systems and improving the quality of their settings are the fundamental factors for the success of modeling multi-scenario systems. The problem of modeling the quality of modern information systems was considered in a scientific study by V.A. Monakhov and V.Ye. Mager (2020). In the course of the joint research, the scientists concluded that each type of scenario for the system's functioning is characterized by specific steps necessary to determine these scenarios, as well as calculate their reliability and implementation time. According to the researchers, such systems scale well, while their accuracy does not deteriorate when the base scenarios change and the base set of components increases.

The topic is developed by a group of authors represented by V.V. Gribova, S.V. Parshkova, L.A. Fedorishchev (2022), who considered several problematic aspects of the development in a joint scientific study and implementation of adaptive user interfaces. Scientists concluded that today the expansion of interfaces for knowledge base editors is an urgent task in knowledge engineering. According to scientists, taking into account the difference in the level of training of experts in the field of modern information technologies, the convenience of an adaptive user interface is a fundamental aspect in assessing the quality of their development while providing prospects for including experts in the process of developing knowledge bases. For its part, the team of researchers represented by T.M. Zubkova, L.F. Tagirova, V.K. Tagirov (2019), considered in a joint scientific study the problems of prototyping adaptive user interfaces of application programs using artificial intelligence methods. Scientists note that the development of automated information systems allows you to select a user interface, taking into account the characteristics and conditions of a particular technical specialist. According to the

researchers, the practical application of artificial intelligence methods for selecting a user interface when designing application programs will make it possible to consider the specific properties of a particular user audience as much as possible.

In a joint scientific study, A.F. Verlan, M.F. Sopel, and Yu.O. Furtat (2014) raised the problem of organizing an adaptive user interface in automated systems. The scientists concluded that taking into account the cognitive characteristics of the user of a multi-scenario system and the specifics of work processes determines that the user interface adaptation system has the property of flexibility, which allows it to be effectively used in various fields of activity, in particular, in decision-making systems, in the development of learning processes, and also in automated control systems for workflows occurring in a wide variety of fields of activity. Building dynamic adaptive interfaces using artificial intelligence technologies is considered in the scientific study by I.M. Ismagilova and S.S. Valeyev (2018). The result of the research conducted was the conclusion of the authors that the practical use of the developed algorithms for adapting the user interface system by redistributing tasks between operators, taking into account their personal characteristics, can improve the efficiency of solving control problems. Researchers point to the fact that it is the quality of the interface of user systems that determines the effectiveness of the interaction between system data operators and the systems themselves at all stages of their management. The main goal of this research work is to study the fundamental principles of modeling the operation of multi-scenario systems used in various branches of modern science and technology and the field of education and training.

## 2. Materials and Methods



The methodological approach in this scientific study combines system analysis methods of the fundamental principles of modeling multi-scenario systems with an analytical study of the prospects for building monolithic architectures of online learning systems. The main research is preceded by the creation of a theoretical base, which includes an analysis of the results of research by several researchers on the problems of modeling multi-scenario systems and their practical application in various fields of science, technology, and the construction of an education system. A systematic analysis of the main aspects of creating models of multi-scenario systems made it possible to identify the main directions of their practical application, as well as to determine the real prospects for creating an effective software model of online learning for its subsequent use in various areas where there is a need to ensure high-quality interaction between users online. In addition, the analysis of a software multi-scenario system includes several aspects that determine the parameters of study within the system itself. At the same time, a systematic analysis of the sequence of operations for creating a model of a multi-scenario system includes an analysis of this system's critical functional requirements and modes of operation.

An analytical study of the real prospects for building monolithic architectures of online learning systems made it possible to analyze the features of user behavior in direct interaction with a multi-scenario system. At the same time, they were diagnosing the potential possibilities of building monolithic architectures that mainly affected non-specific and specific symptoms, individually and in their direct combination, within the framework of interaction in a single multi-scenario system. The selected combination of scientific research methods determined the presence of specific stages of the work.

At the first stage of this scientific research, the fundamental principles of constructing a

software multi-scenario learning model were considered. In the future can be used as a base for developing similar types of models of multi-scenario systems. The fundamental principles of creating a model of a multi-scenario system of this type are presented based on its subsequent functioning, as well as the interaction of an individual user and groups of users with the system itself. The main problems of interaction of this kind and ways to overcome them are considered.

In the second stage of this scientific research, a multi-scenario distance learning system model was presented and considered, indicating the main subsystems and assessing the features of functioning, both subsystems and the entire system as a whole. Graphic displays of the entire system and its individual structural elements are presented in the corresponding diagrams. The principles of the interconnection of particular aspects of the system were also shown in the context of their functions within a single multi-scenario learning system.

At the final stage of this scientific study, an analytical comparison of the results obtained during it with the results and conclusions of several researchers involved in the scientific development of issues of creating models of multi-scenario systems for their subsequent practical application in various industries was carried out. This made it possible to clarify the results of this scientific study and formulate, on their basis, final conclusions that act as their logical reflection and sum up the entire range of scientific research in the field of studying the principles of modeling multi-scenario systems.

### 3. Results

Today, due to the spread of the COVID-19 coronavirus pandemic, as well as several threats of a different nature, the problem of implementing the monolithic structure of the online learning system, as well as several

other data exchange processes and online differences, is relevant. At present, the issues of increasing the efficiency of data exchange, the development of computer training, and the introduction of methods of collective and individual training are the most relevant in the activities of educational centers in many countries of the world. In this context, developing a software learning model for its subsequent use in organizing online learning in various educational institutions, as well as in other structures where there is a need to ensure high-quality interaction between users online, is highly relevant. This scientific study proposes considering the program learning model, which can be used as a basic model for developing various types of multi-scenario systems in the future. When creating the interface, differences in the level of user training were considered, which led to the maximum adaptation of the model to various types of user characteristics. The basic concept of developing the proposed model of a multi-scenario system was based on the following principles:

1. The system's maximum possible and permissible adaptation to users' needs.
2. Accounting for differences in personal and psychophysical differences in the state of users, as well as differences in the level of technical training and health status at the time of using the system.
3. Adjustments to the model's functionality del each time users log into the system.
4. Possibility of upgrading the user's skills as his interaction with the system develops.

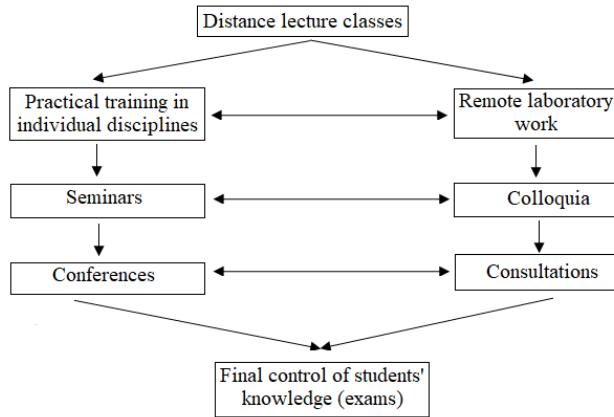
Adaptation of the system to the needs of users was implemented by setting the system services for specific user requests. In contrast, the user model is created directly when he first accesses the system, after which the necessary adjustments are made to

it. At the same time, the system services are configured by placing certain information, tips on them, and a significant amount of additional information stored in particular databases. Taking into account the level of training of users and their personal differences implies an emphasis on differences in the level of their information competence, which is expressed in the difference in skills in handling computer equipment. In addition, a system of tests for determining user competence is provided, which involves determining differences in the training of users in the field of knowledge of hardware and software computer software (Mistrik et al., 2017). The need to adjust the model's functionality at each user login to the system is determined based on information obtained by clarifying the level of information competence of a particular user, the basis for which is the analysis of the actions performed by him when entering the system. Similarly, there is a test assessment of his psychophysical characteristics at a particular time.

Improving the user's skills in the development of his interaction with the system, including its direct adaptation to various aspects of system software management, is achieved through the introduction of a system of assessment tests, training events, and a system for explaining complex aspects of using information stored in the system's knowledge bases. Analysis of the results of passing tests by users is the basis for making decisions on changing the structure of user access to the system, as well as supplementing and expanding, if necessary, the information array contained in the knowledge base of the multi-scenario system (Dong and Nguang, 2020). Ensuring many options for user access to the architecture of a multi-scenario system is implemented by constantly monitoring user access levels, with the provision of rights to a specific system user that provides access to information arrays of various levels

(Boucher and Yalcin, 2006). In this case, the level of user access is determined depending on the level of his general training in computer skills and the level of mastery of the software disciplines included in the online learning system. All changes in the level of user competence are tracked within

the system. As the user's competence increases, the level of his user access to individual nodes and elements of the system increases. Figure 1 shows a schematic representation of a multi-scenario e-learning system model allowing distance learning programs to be implemented.



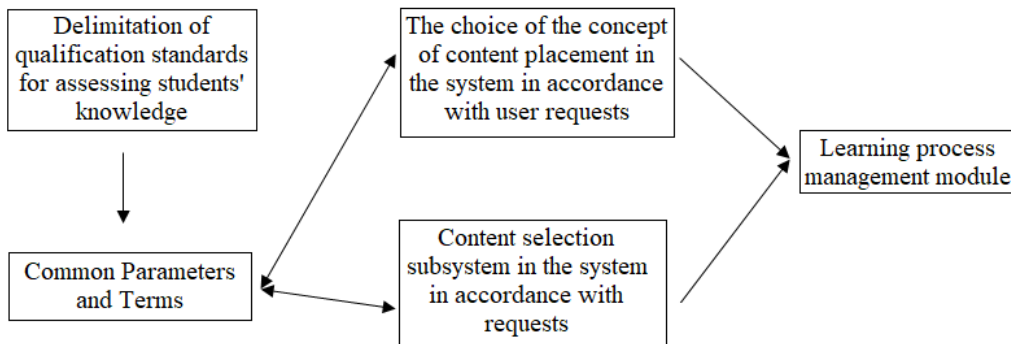
**Figure 1.** Model of a multi-scenario system of distance e-learning

In order to provide a multi-level system of access to a multi-scenario distance learning system and to adapt the system itself to the requests and needs of users, this model provided:

- subsystem for choosing widely used and most frequently used concepts and terms;

- content selection subsystem.

These elements are presented in Figure 2, which shows the interconnection diagram of the central nodes of the multi-scenario distance learning system.



**Figure 2.** The central nodes of the multi-scenario distance learning system

The module for distinguishing qualification standards for assessing students' knowledge is designed to determine differences in the level of computer training of users and create the necessary basis for the subsequent assessment of the level of their knowledge after completing a training program within the system itself. In this module, systems of tests are formed to test students' knowledge of the material presented and the main directions and volumes of providing advisory information to improve system users' skills.

The module of the most widely used terms and concepts includes the placement of the most frequently encountered user queries to create conditions for a quick search for information on given queries. This simplifies the process of searching for information and reduces the time it takes to provide it, which positively affects the organization of the learning process as a whole, increasing its final efficiency.

The module for selecting the concept of content placement by user requests is designed to speed up the search for the necessary information. It acts as a link between the content selection subsystem and the subsystem for matching between user requests. The concept of content placement may undergo changes depending on the change in the frequency and nature of search queries.

The content selection module, by the most common search queries, provides the selection of information that is most relevant to user queries. The choice of content occurs automatically, to the need of users for information of one kind or another.

The learning process management module is responsible for coordinating the interaction of all subsystems in a single distance learning system. The functions of this module include receiving information on changes like user requests, making decisions regarding changes in the structure of the

distribution of information related to the educational process and the supply of educational materials, as well as making managerial decisions regarding other aspects of building the educational process.

Modeling the operation of a multi-scenario system implies the need to break it down into several separate services that perform specific functions within the framework of the functioning of a single system. The system management function is assigned to a particular module that performs coordinating functions (Li et al., 2021). In case of problems in the functioning of one of the modules, measures should be taken to ensure the reliability of the functioning of the entire system as a whole and to resolve the situation.

Creating a multi-scenario system model implies the development of an interface that is maximally adapted to the qualifications of various categories of users. The maximum possible adaptation of the interface to the different qualifications of users allows you to solve several issues effectively:

- achieving ease of system management by users of different levels of preparedness;
- provide access to the system to users with low qualifications in the field of handling computer equipment and software;
- ensuring the choice of the display scenario when changing the system parameters;
- the possibility of improving the skills of users, as well as studying the capabilities of the system by directly entering it;
- the possibility of increasing the options for system management scenarios by adding new functionality.

Changing a multi-scenario system's operation is possible at any stage of its functioning, depending on changes in the

external environment's parameters that directly affect the system and its functioning. For this reason, a multi-scenario system's component must be able to handle all possible failure scenarios correctly. At the same time, they should be able to ensure long-term waiting for orders on system management issues, as well as be able to return to regular operation promptly as a result of the restoration of the counterparty in the case of limited centralization of functionality (with a large number of databases, an excessive number of contexts, which implies the impossibility of achieving synchronous interaction of several microservices) (Rouwet, 2022). Problems of this kind can be solved by abandoning the constant data consistency, where probable errors are either handled by more complex system architecture or by using data obtained from monitoring the current state of the multi-scenario system. The functioning of a multi-scenario distance learning system implies the presence of three main blocks of the system around which all its work is built:

1. Lecture presentation of training material.
2. Independent work of students.
3. Final check of the level of knowledge and assessment of students' competence (qualification).

At the same time, providing the possibility of multiple access to the system implies the presence of a large number of interfaces for users of various categories: students, teachers, and system administrators. To implement this kind of capabilities, various microservices are used, in particular:

- personal account of the system user;
- online training courses in specific disciplines or areas of knowledge;
- systems of tests and verification of knowledge in certain sections.

Each of these microservices has its own features of providing information and providing users with access to them,

depending on the level of access. For each of these microservices, a separately located virtual server is programmatically provided, for which a particular resource is allocated, the volume of which is maintained in strict accordance with the fundamental principles of distributing the load on the system as a whole and its individual nodes in particular, as well as maintaining the necessary systems of tests and verification of knowledge in certain sections of the load balance in the system (Somerville, 2015). At the same time, the adjustment of the module for maintaining the balance of the allowable load is carried out at the server core level and involves the practical use of software decision-making algorithms based on the received data describing the system's current state. The category of data of this kind should include the following: the type of protocols used, the total amount of system memory and the average parameter of the used RAM, the average server response time, the average response time of the information database, and the average page load time.

The solution of possible problems of the microservice architecture of a multi-scenario system is achieved by synchronizing the functioning of individual nodes of the system, as well as by a consistent transition from monolithic system architecture to a distributed microservice architecture, the functioning of which is based on more minor constituent elements consisting in continuous structural interaction. Eliminating problematic situations that arise in operating individual elements of a multi-scenario system contributes to its efficient functioning for a long time and the highest quality satisfaction of user requests.

## 4. Discussion

The topic of modeling the operation of multi-scenario systems is discussed in the scientific study by V.R. Barinov (2016) on using use case programs to develop modern

software use cases. The scientist notes that a use case should be understood as a particular approach to describing the interaction of a system with the external environment. According to the scientist, in the practical application of a multi-scenario system, the parameter of the frequency of its use is of crucial importance from the point of view of the prospects for subsequent improvement in the quality of the final result of the entire project. The researcher's conclusions correlate with this scientific study's results in evaluating the use case concept. In contrast, the conclusion regarding the frequency of use of the model seems controversial since the final results of the entire project depending on several other parameters besides the specified one.

In turn, A. Garces (2021), in his scientific study of modeling, operation, and analysis of DC networks, touches upon the issues of modeling the operation of multi-scenario systems. The scientist concluded that effective management of a multi-scenario system is possible under the condition of effective and coordinated functioning of all elements included in the system. The author notes that testing of the software used has shown that the introduction of hardware and software in the process of creating a model of a multi-scenario system implies the need to monitor at each stage the accuracy of the execution of commands by the elements of the system, which ultimately results in the achievement of the high final quality of the functioning of the entire system. In general. The researcher's conclusions directly correlate with the results obtained in this scientific work, expanding them in the context of software testing issues. This opens up prospects for further scientific research in this direction.

The topic was developed by a team of authors represented by R. Bansal, J.J. Justo, F. Mwasilu (2022) in a collaborative scientific study of modeling and dynamics control features in renewable energy

microgrid systems. The team of scientists draws attention to the fact that the use of the multi-scenario approach allows for generalizing and clarifying the results obtained during the diagnostics of microgrid systems through the use of the logical input method. According to the authors, the practical application of fuzzy logic methods makes it possible to form certain systems for assessing the actual state of the microgrid system with renewable energy sources and build a system of cause-and-effect relationships based solely on data obtained during diagnostic measures. The conclusions of the research team are controversial because the assessment of the actual state of the microgrid system is possible only when using a sufficiently large amount of initial data that is not always available.

T. Noergaard (2012), in a scientific study of the fundamental principles of creating an embedded systems architecture, touches upon the problems of building multi-scenario systems and monitoring the quality of their functioning. The scientist concluded that using many options for the placement of embedded equipment, in particular, in e-learning systems, increases the variability of using the system and obtains a significant number of results that are not directly related to each other. The scientist draws attention to the fact that the coordination of the distribution of the load on all elements of the e-learning system can significantly improve the quality of its functioning while greatly complicating the whole process. The researcher's conclusions do not directly contradict the results of this scientific work. At the same time, the assertion that load coordination improves the system's quality requires additional verification in natural conditions.

At the same time, a team of researchers represented by A. Puder, K. Romer, F. Pihofer (2005), in joint research work, considered several problematic aspects of building an architecture of distributed

systems. According to scientists, the development and implementation of middleware allow you to effectively connect distributed applications with hardware-type platforms, operating systems, and network data distribution technologies. Scientists note that the operation of multi-scenario systems provides the ability to manage large amounts of data and use them to solve the problems of developing data distribution systems with many access options. The scientists' conclusions coincide with this scientific study's results in using multi-scenario systems to manage large amounts of information. In contrast, the conclusion regarding the combination of different software types seems controversial since the realities of each specific situation determine this.

A similar topic is considered in the scientific work of the research team J. Wang, C. Wang, M. Xin, Z. Ding, J. Shan (2020), devoted to studying the principles of joint control of multi-agent systems. In the course of the scientific research, the authors concluded that the functioning of systems formed by ensuring the effective interaction of several intelligent agents should be organized with a wide variability of decisions made. This will allow serving a significantly more significant number of users in a given unit of time, as well as achieving higher rates of satisfaction of user requests. The opinion of the researchers does not fundamentally conflict with the results obtained in this scientific work.

S. Batley (2007) conducted an independent scientific study of the fundamental principles of data architecture for information professionals. The scientist concluded that the design of modern information systems must necessarily include the creation of adaptive interfaces that are intuitive to users, as well as maintaining the performance of relevant information tasks at the proper level that meets the most common user requests. According to the researcher, this can be fully

implemented through the creation of effective models of the functioning of multi-scenario systems, including large amounts of data and tools for their recognition and timely practical application for a qualitative solution of the entire range of tasks assigned to systems at the stage of their design and development. . The conclusions of the researcher supplement and expand the results of this scientific work, while attention should be paid to the issues of using a large amount of data in the development of multi-scenario systems, as fundamental in this context.

A team of authors represented by I. Mistrik, R. Bahsson, P. Eeles, R. Roshandel, M. Stal (2014) conducted a joint scientific study of the basic principles of software architecture for cloud use of big data. Scientists note that the effective functioning of multi-scenario system models can effectively solve the issues of cloud storage of large amounts of data and increase the speed of operations performed. The authors concluded that rethinking specific software architectural solutions can speed up the data processing process and increase the volume of operations performed, which will satisfy several functional and non-functional requirements for the system directly related to the amount of data and the speed of their processing. The researchers' conclusions correlate with this scientific study's results in resolving data storage issues using multi-scenario systems. In contrast, the problems of accelerating data processing require additional study.

The issues of system architecture modeling were considered in a scientific study by P. Roques (2020). In the course of research work, the author concluded that a simple and understandable user interface provides ease of use of computer programs and is extremely important in ensuring that information is communicated to users with varying degrees of training. According to the researcher, intuitive model editing and significantly increased user interface

browsing capabilities improve modeling quality and productivity, enabling system engineers to focus on designing improvements to the system and its architectural solutions. The researcher's conclusions are entirely consistent with the results obtained during this research work.

## 5. Conclusion

The process of building a model of a multi-scenario system implies the need to consider several factors that affect the efficiency of the functioning of individual subsystems, individually and within a single system, in the context of searching and processing information, as well as satisfying key user requests. In addition, the functioning of subsystems within a single multi-scenario system involves control in the system of processes for distinguishing qualification standards for assessing the knowledge of students using this system, accounting and saving terms and parameters that are important in terms of system speed as a whole and the level of satisfaction of user requests, and also the choice of the concept of content placement in the system by user requests and its provision. Modeling a multi-scenario system allows one to substantiate the choice of the main scenarios of its behavior under changing external conditions. These conditions include a

change in the user's qualifications in the case of a multi-scenario online learning system, as well as changes in the volume of information entering the system and processing by the system. In addition, the change in the frequency and nature of user requests is essential, which, in turn, implies the need to adjust the information stored in the databases.

The effective functioning of a multi-scenario system is facilitated by developing a software interface that is maximally adapted to users of various levels of training. Such an interface ensures the efficiency of use, allowing users with different skill levels to access the necessary information. The use of the principle of multi-scenario in the development of the system proves its practical effectiveness in developing software systems and multi-interface systems intended for the broadest user audience. In particular, the model of a multi-scenario learning system can be applied in practice when developing learning systems with many possible scenarios for learning in a wide variety of areas. In contrast, the principle of interaction and information exchange between the individual modules of the system remains unchanged. However, the aspect of verification of data entered into the system needs additional research

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## A STUDY ON IMPORTANCE OF ENTREPRENEURSHIP SKILL DEVELOPMENT PROGRAMME (ESDP) FOR SUSTAINABLE GROWTH OF MSMEs IN INDIA

**Abstract:** *The Entrepreneurship and Skill Development Program (ESDP) was launched by the Ministry of Micro, Small and Medium Enterprises (MSME) to build the capacities and skills of Indian entrepreneurs, both current and future ones. One of the many initiatives offered by the Ministry of MSME, it aims to increase the capacity of young people to take on challenges and create successful businesses across the nation. There are various activities under the plan that are coordinated in Industrial Training Institutes (ITIs), Polytechnics, and other specialized institutions/business colleges where there is talent available to influence teenagers toward self-employment. One of the essential elements for the development of any area is having an adequate supply of skilled human resources. The lack of skilled resources in the case of the Indian MSME area has undoubtedly prevented the region's development in a satisfactory manner. It is obvious that there are skill gaps, and they require special attention. The area has a lot of employment potential, but it isn't ready to act in that way because there aren't enough skilled workers, which is a big problem. It is often claimed that India has a segment profit and that, unlike other developed nations where reliance proportion is significantly high, India's is low. This substantial benefit needs to be converted into skilled labour so that the market demand can be met. Today, the problem is fundamentally linked to the employability problem rather than the lack of employment opportunities. This is a major problem in many developing countries where young children are taught, but they need skills that will help them become prepared for the workforce. Hence, the current study has been done with a view to give an analytical outline of the importance of ESDP for the sustainable growth of MSMEs in India and it includes both primary and secondary sources of data.*

**Keywords:** *Entrepreneurial Skill, Skill Development, Sustainable Growth, ESDP, Employment Opportunities, Programmes & Schemes and Government Initiatives*

## 1. Introduction

Entrepreneurs are essential to any economy because they have the knowledge and tenacity to anticipate needs and present brilliant, novel ideas to the public for purchase. Entrepreneurship that succeeds in building a startup despite the risks and difficulties is rewarded with benefits, notoriety, and continues to gain knowledge. Failure in entrepreneurship results in bad luck and less ubiquity in the business sectors for those involved. The Micro, Small and Medium Enterprises (MSME) sector is extremely important to home owners and plays a crucial role in the economic development of most countries around the world. In this way, it is a well-known undeniable fact that MSMEs significantly advance the growth of the overall economy. This commitment will accelerate the growth of the GDP, improve living standards, and slow down the pace of state formation. As a result of these facts, every economy should increase the benefit that such an endeavor provides. Skills are the facts that can only be verified through actions or a unique performance. Teaching is how skills are created and acquired. However, achieving sustainable business development may be a task requiring special abilities. Given the aforementioned circumstances, business owners who possess additional entrepreneurial skills are more likely to see their company succeed.

The most popular method for improving an entrepreneur's abilities to create, manage, and organize a business venture while taking into account the risks involved is through entrepreneur development. The goal of entrepreneur development is to increase the number of business owners. The Ministry of MSME has been organizing a few entrepreneurial and skill development programmes for current and potential entrepreneurs in order to create successful ventures. The MSME Service has sent out several programs, one of which is the

Entrepreneurship Skill Development Program (ESDP). In a nation like India, where the population is more than 45% between the ages of 20 and 35. India, which accounts for 1.224 billion people, or 17% of the global population, is evolving into a "youth reservoir." According to United Nations estimates from 2009, India will overtake the People's Republic of China as the world's most populous nation by 2050. Although India has a well-established system of vocational education, its youth are not properly equipped with the skills that the modern economy demands. The relevant government has stated that by 2022, the MSME sector is expected to require roughly 150 million qualified workers. Small and medium-sized businesses (SMEs) play a key role in economies, contributing to poverty reduction and employment, as well as sustainable development. In order to address the demand for skilled labour, India has developed a method of entrepreneurial development initiatives. The information for this study was gathered through secondary sources. The micro, small, and medium-sized business sector has developed a number of programmes in the areas of lending, marketing, infrastructure, and skill development in order to foster the growth of entrepreneurial activity. These regulations place a lot of emphasis on skill development because it's a need for launching a micro, small, or medium business.

## 2. OBJECTIVES OF THE STUDY

The present study has been associated with following objectives:

- To study the MSMEs in India and Entrepreneurship Skill Development Programme (ESDP).
- To analyze the various factors associated with current study and summarize the major findings.

- To recommend some suggestions for better reach of ESDP to all its beneficiaries.

### 3. REVIEWS OF RELATED LITERATURE

RajamohanS, Rajamohan and Sathish A (2019) conducted a study and investigated the topic as the primary goal that is typically pertinent to either evolved or emerging nation like India. To support entrepreneurship in MSME sectors like Khadi, Town, and Coir businesses, the Ministry of Micro, Small, and Medium Enterprises (M/o MSME) offers a variety of aids. The goal of this study was to pinpoint the strategies and encourage support offered by MSME to boost entrepreneurship in India.

According to NadafRajahusainS, et al. (2018)in this research, Micro, Small, and Medium-Sized Enterprises (MSMEs) have become a significant and active sector of the Indian economy. The government has launched numerous initiatives in this area, but the problem still persists because 79 MSME's are regularly affected by funding problems. The paper looks at MSME performance records, as well as the potential role they could play in the economy and other initiatives taken by various parties to advance MSME development in India.

According to Sen(2011),in this paper(The Key to Entrepreneurship Development in India) reported that the terms MSME, SME, and MSE all refer to micro, small, and medium-sized enterprises. MSME also refers to small and medium-sized enterprises. MSMEs are defined by India's Micro, Small, and Medium Enterprises Development (MSMED) Act of 2006. As countries promote horticulture's role in providing employment and as its contribution to GDP declines, the primary need is to create enormous amounts of employment. The MSME sector in India is heterogeneous, dispersed, and largely

disordered. It includes a range of artistic production units, from traditional artworks to cutting-edge businesses.

A study by Ravi and Shamika (2010)in this article (Entrepreneurship Development in the Micro Small and Medium Enterprise Sector in India) revealed that the MSME sector has frequently been referred to as the "driving force of development" for building economies. They begin with an overview of this region in India before looking at some recent trends that highlight the growth and significance of this region in contrast to the Indian economy. The main findings are that while more general development arrangements, such as consumption of framework and admission to funding, emphatically affect development of the MSME area across states in India over the course of recent years, even though explicit strategies that are focused on the MSME area essentially affect the development of this area.

### 4. STATEMENT OF THE PROBLEM

The Government of India has approved a variety of current and long-term professional courses at various levels of instruction so that students can receive both a broad education and specialized training. Since the government may not be able to implement this framework on its own, it has established the National Skill Development Chamber (NSDC), an organization that will work with other private players who are skilled in the relevant field to carry out skill development drives. As demands of the business may change, various other area skill gatherings are likewise evolving. Giving instruction to the students will undoubtedly help to reduce the dropout rate, which is a serious problem for the Indian educational system. Development and advancement of entrepreneurship projects are continuously being coordinated to support the talent of youth by educating

them on various aspects of modern or business action anticipated for establishing MSMEs. It is being a mandatory factor for the author to conduct a study entitled on 'A Study On Importance Of Entrepreneurship Skill Development Programme (ESDP) For Sustainable Growth Of Msmes In India'.

## **5. ENTREPRENEURIAL DEVELOPMENT PROGRAMMES (EDP/ESDP) IN INDIA**

The Entrepreneurship and Skill Development Programme (ESDP) was introduced by the Ministry of Micro, Small, and Medium Enterprises (MSME) to help existing and aspiring Indian entrepreneurs develop their entrepreneurial capabilities. It is one of many initiatives launched by the M/o MSME with the goal of enhancing young people's abilities to take calculated risks and establish prosperous businesses across the country. In order to encourage youth to pursue self-employment, the programme is planned to include a variety of activities in Industrial Training Institutes (ITIs), Polytechnics, and other technical institutions/business schools. The ESDP programme, a crucial component of the "Development of MSMEs," was modified in 2019 by the ministry to reflect the dynamic environment of entrepreneurship and MSME in India. The Enterprise Facilitation Centre (EFC), which aims to broaden the program's scope and deepen the enterprise facilitation process, is what distinguishes the up-scaled ESDP. The following list includes ESDP's primary goals in India:

- To educate/train people on an entrepreneurial culture.
- To encourage young people (men and women) from various societal groups, such as SC, ST, Women, and Physically Handicapped individuals,

Ex-Servicemen, and BPL individuals, to think about entrepreneurship or self-employment as one of their career possibilities.

- In order to encourage the target population to consider entrepreneurship as a career option and to help them succeed in any field, it is important to provide them with the technical and business skills necessary to think and act entrepreneurially from an early age.
- In order to help entrepreneurs implement their ideas, bring about an attitude and behavioural change in the target audience, and develop their own entrepreneurial abilities, fundamental entrepreneurship training will be provided.
- To provide high end/advanced training in the fields of e-commerce, BPO, Soft Ware, Biotech, Modern Agricultural & Animal Husbandry and Processing, Drug Discovery, Genomics, Tech. acquisition from premier labs like BARC/CSIR/DRDO, etc. with the aid of prestigious institutions like IIMs/IITs/ICAR/CSIR/NIT/Administrative Training Institutes (ATIs), post harvesting and food production.
- To assist the establishment of new MSMEs and enhance the growth of existing ones, which will lead to improved productivity and the creation of jobs. To develop technical and vocational skills or upgrade current capabilities of the target group. The responsibility for Udyam Registration of ESDP Beneficiaries shall fall under the purview of the Implementing Agencies (IAs).
- Support MBA/Engineering students by giving them the chance for vocational training, analysing the

results of a few typical ESDP programmes, compiling a list of available technology, setting up a top-notch lab for technology diffusion to MSMEs, etc. Additionally, students will be given other tasks, giving them a chance to work in a government setting. The hired students will receive a salary and an experience certificate.

ESDP includes the following modules:

1. Industrial Motivational Campaign (IMC): One-day or two-day Industrial Motivation Campaigns are held to find and inspire traditional and non-traditional business owners with the potential to found MSEs and Cluster SPVs, Industry Associations, and Chambers that will help spread MSMEs' promotion programmes.
2. Entrepreneurship Awareness Programmes (EAPs): These programmes are periodically held in order to develop young people's potential by educating them on many facets of the industrial activity necessary to establish MSEs. Typically, these EAPs are offered in ITIs, Polytechnics, and other technical institutions where there are resources to encourage students to pursue self-employment.
3. Entrepreneurship-cum-skill Development Programmes (E-SDP): By organising a variety of technical cum skill development training programmes, comprehensive training programmes are organised to upgrade the skills of potential entrepreneurs, the current workforce, and also develop skills of new workers and technicians of MSEs.
4. Management Development Programmes (MDP) and Mega Events: The goal of providing

training in this area is to enhance the ability of current and potential entrepreneurs to make decisions, which will lead to increased productivity and profitability.

The aforementioned activities/programmes will be carried out by various field officers of the DC (MSME) office who have been given the go-ahead by the empowered committee, which is chaired by AS&DC, MSME. The targeted recipients of EDPs and E-SDPs must comprise 40% members of the socially and economically disadvantaged groups (SC/ST/women/physically challenged). SC, ST, physically disabled, Below Poverty Line (BPL) and female participants are exempt from paying a participation fee. Up until November 2020, more than a million MSMEs were registered through the Udyam registration site, according to IBEF. Nevertheless, more than 93% of all registrations were for micro-businesses, highlighting the lopsided structure of the entrepreneurship process. Furthermore, according to the annual report issued by the M/o MSME, just 7% SC and 2% ST held businesses. The fact that the programme is meant to inspire people from underprivileged groups, particularly women, to pursue entrepreneurship just adds to the seriousness of the situation. Only 14%, or 8.05 million, of the 58.2 million MSMEs operating in India, according to the "Moving the Needle" report published by the NITI Aayog in March 2021, were owned by women. Women also agreed that businesses were even more skewed towards smaller ones, with almost 98% of firms falling into the micro-enterprise category.

## 6. MSMEs IN INDIA AND ENTREPRENEURSHIP SKILL DEVELOPMENT PROGRAMME (ESDP)

The most popular method for improving an

entrepreneur's abilities to start, run, and manage a business while keeping in mind the risks involved is called "entrepreneurship development." The "Entrepreneurship and Skill Development Program (ESDP)" has been launched by the O/o DC-MSME under the "Development of MSMEs" vertical. The program's goal is to inspire young people (both men and women) who represent various demographic groups. A clear objective is to promote new businesses, increase the number of MSMEs already in existence, and spread an entrepreneurial culture throughout the nation. The ESDP is implemented throughout the entire nation, both north and south. In total, 315 projects funded by the ESDP were completed during the years 2021–2022, and the recipients totaled 15,599 in total. The asset allocated and received is worth Rs. 10 crore, while the consumption that resulted costs Rs. 1.83 crore.

In order to eliminate unemployment and further contribute to the financial development of the nation, the Ministry of Micro, Small and Medium Enterprises (MSME) has planned a variety of strategies and projects for the development of entrepreneurs. The Service and its associations with entrepreneurs benefit from and collaborate with:

1. Adequate progression of credit from financial institutions/banks;
2. Support innovation up level and modernization;
3. Integrated infrastructural offices;
4. Contemporary testing facilities and quality assurance;
5. Access to rehearsals of the current management;
6. The development of entrepreneurship and the leveling up of skills through appropriate preparation offices;
7. Assistance with product development, plan intervention, and bundling;
8. Welfare of artisans and labourers;

9. Assistance with better entry into domestic and international business sectors and
10. Cluster-savvy actions to promote aggregate and unit empowerment and limit building

To create and strengthen the framework and support for entrepreneurship development and skill development preparation programmes, support is provided to national level preparation organizations working under the Ministry of MSME, specifically NIMSME, KVIC, Coir Board, Apparatus Rooms, NSIC, and MGIRI as a capital award. The main objectives of EDPs are to develop and strengthen the nature of entrepreneurship, choose reasonable products and plan various practical undertakings, familiarize people with the cycle and methodology involved in starting and operating a small business, train and prepare the entrepreneurs to face the challenges of business risk, broaden the perspective about business, and support its growth within the parameters of regulation.

## **7. SKILL DEVELOPMENT INITIATIVES BY MSMEs IN INDIA**

The Ministry of Micro, Small, and Medium Enterprises (MSME) and its field institutes have launched a number of programmes, including entrepreneurship skill development programmes (ESDP) and entrepreneurship development programmes, which provide training (EDP). These programmes, which are run by MSME-DIs, concentrate on developing trade skills in areas like electrical work, food processing, and electronics, among others. With the basic goal of upgrading the abilities of potential entrepreneurs and providing them with better and enhanced technological production skills, numerous extensive training programmes have been developed for the current workforce. Entrepreneurship development



and training, particularly for first-generation business start-ups, is one of the critical components for the promotion of micro, small, and medium enterprises (MSMEs). Three national level entrepreneurial development institutions have been established by the government to instill this entrepreneurial spirit in the next generation;

1. Hyderabad, India, opened the National Institute for Micro, Small, and Medium Enterprises (ni-msme) in 1960.
2. The establishment in 1983 of the Noida-based National Institute for Entrepreneurship and Small Business Development (NIESBUD) (UP)
3. Guwahati, India, hosted the Indian Institute of Entrepreneurship (IIE) in 1993. These were established with the intention of creating training modules, carrying out research, conducting training, and offering consulting services for the improvement of skill, entrepreneurship, and competitiveness.

The government has launched a number of programmes to support entrepreneurship and help those with it get skills. One of these is the Assistance to Training Institute (ATI) programme. The major goals of this programme are to promote indigenous entrepreneurship for micro, small, and medium-sized businesses, broaden the entrepreneurial base, and promote self-employment in rural and urban regions by offering training and helping people start businesses (Skill development report 2014-15). The government has launched a few more programmes to encourage skill development around the nation. They are as follows:

1. "Indian Institute for Skills" first ever Indian institute for skills.
2. "Skill India"

3. "PradhanMantriKaushalVikasYojana" (PMKVY)
4. "PradhanMantriKaushalVikasKendras" under skill India mission

## **8. IMPORTANCE OF ENTREPRENEURIAL DEVELOPMENT PROGRAMMES IN INDIA**

An entrepreneurship programme is currently more important than ever in India. As a result, it is crucial to present pupils with the proper information. The economy can grow significantly and potential of young brains can be realized through entrepreneurship. It is also true, though, that despite students' initial fascination with this field, it is frequently challenging for them to continue in it. It is due to the lack of appropriate mentoring and advice to get over obstacles in their way. One of the main reasons we advise you to enroll in courses like the WE NEN. The program's main objective is to instruct college students using case studies on the when, why, and how of starting a business. After talking about the possibilities of entrepreneurship, it is essential to examine what makes its growth so critical. The following are some important justifications for why entrepreneurship development is urgently needed:

**Better Job Possibilities:** The fact that entrepreneurship programmes in India provide to better job opportunities is one of the most crucial reasons for their promotion. Since most companies require a wide range of people to work under varied profiles, entrepreneurs produce a large number of employments. As a result, the job market has greatly improved. However, it can only be a direct result of an effective programme for entrepreneurial development.

**Independent Working Environment:** Increasing the independent working environment is another promising component of entrepreneurship programmes. Because

there is no requirement that one work for a specific boss, there is a great deal of flexibility. Consequently, a programme for entrepreneurial development is helpful in this area as well. As entrepreneurial development programmes aid in helping people envisage their lives and careers, this is perhaps one of their most important features. Entrepreneurs frequently have a lot of ideas but lack the knowledge necessary to put them into practice. The development programmes come into play here and are quite beneficial for aspiring business owners. In order for any entrepreneur to flourish, financial planning is also a skill that the curriculum assists in developing.

**Solve Issues Facing the Masses:** For his business to be successful, an entrepreneur must concentrate on addressing issues that affect the vast majority of people. An entrepreneurship programme can assist in developing this vision, which can support the creation of sustainable businesses. It is essential for entrepreneurs to have a strong vision because it helps them make better judgments when they are uncertain.

**Boost the Nation's Economy:** Entrepreneurship programmes are essential to the nation's economic development. Promoting entrepreneurship can be a step in the correct direction given that our economy needs a boost and that development programmes concentrate on generating jobs, which improve cash flow. Additionally, entrepreneurial programmes aid in raising the standard of life, which is necessary to raise the nation's existing economic stratification.

**Consider Local Resources:** State-level economic growth is important for a nation's GDP as well. Additionally, using local resources enables a state's progress. Most entrepreneurial initiatives emphasize using local resources, which increases demand for them, helps with money generation, and in turn encourages economic jurisprudence.

Challenges in ESD

The ESDP programme is one of the many skill-development initiatives the government has put in place to strengthen entrepreneurship in the nation and promote the creation of MSMEs. The development of MSMEs' capabilities, however, is being hampered by a number of issues.

**Infrastructure bottlenecks:** As was already said, the majority of MSME firms fall under the umbrella of microenterprises. Better infrastructure is required for the move from micro to small or medium enterprises, including a cost-effective location, reliable electricity and water connections, etc.

**Access to Technology:** MSMEs' ability to compete on the global market is severely limited by low technology levels. A fundamental issue impeding the development of the MSME sector's capability is technological obsolescence.

**Weak industry-academic interface:** Students' chances of becoming entrepreneurs are negatively influenced by the nation's weak connectivity between businesses and educational institutions.

**Scale and Cost:** Extending these measures and extending the reach of programmes remain a cause for worry, notwithstanding the financial support given by the government for the sustainability of various initiatives.

**Mismatch between Supply and Demand:** The supply and demand of skilled workers are very different. It is essential to align skill-development programmes with the potential skills that are in demand around the world.

## **9. INSTITUTIONAL SUPPORT FOR ENTREPRENEURIAL DEVELOPMENT**

Bankers and government organizations typically think that the borrower needs to have the necessary entrepreneurial skills. The truth is that no school or college curriculum ever takes this subject seriously. Because of

this, practically all graduates (including engineering grads) rush to get employment after finishing their studies and hold off on starting their own businesses. In fact, to improve their entrepreneurial competencies, both new and seasoned business owners need ongoing education and training. The Government of India, several State Governments, and the major financial institutions have established entrepreneurship training institutions in response to this need. These organizations offer ED trainings as well as need-based support and other services. The following is a list of these organizations:

**EDII:**The apex financial institutions support the EDII, which was established in 1983. Through teaching, training, research, consulting, and institution building, the institute has been promoting the growth of entrepreneurship. Additionally, the institute has been offering a DEC-approved open and remote learning programme in addition to two post-graduate diploma programmes with AICTE approval. Every year, EDII develops more than 10,000 aspiring entrepreneurs across all teaching and training programmes.

**Indian Institute of Entrepreneurship (IIE):**The IIE was founded in 1993 at Guwahati by the Ministry of MSME, Government of India, with the intention of conducting training, research, and consultancy activities in the small industry sector with an emphasis on ED. The North East Council (NEC), the Government of Assam, Arunachal Pradesh, Nagaland, and SIDBI were among the main partners when the institute began operations in April 1994. It has a presence in Uttarakhand and mostly runs programmes for the north-eastern region. Currently, the Institute is offering a number of Entrepreneurship and Skill Development Programmes (ESDPs) on topics such as food processing, jute diversified products, electrical wire manufacturing, bamboo products manufacturing, tailoring and embroidery, customer service, manufacturing

beauty products, steel fabrication, etc.

**National Institute for Micro, Small and Medium Enterprises (NIMSME):**In Delhi, India, in October 1960, the Central Industrial Training Institute was established as a division of the Central Government under the Ministry of Commerce and Industry. CIETI was relocated to Hyderabad in 1962, where it was renamed the Small Industry Extension Training Institute. It was given the new name NIMSME. The Institute's goal is to influence the expansion and development of MSMEs by providing services in the fields of management, entrepreneurship, technology, information, education, and policy. In the current age of globalization, NIMSMEs programmes are made to be applicable to everyone. Through all these special training programmes, the Institute has been effective in preparing business owners to meet problems, assist small businesses in surviving the competitive environment, and achieve the crucial competitive advantage in a worldwide context. The institute has also been hosting international training programmes financed by ITEC. It has run specialized programmes for the MSME officials at the national level. In the course of the year (2010–2011), the institute collaborated with 25 institutions and provided training to 10,000 FGEs, the majority of whom were from rural areas and members of vulnerable groups including SC, ST, women, and so on. In the southern and central states of the nation, NIMSME plans to collaborate with more than 30 partner institutions over the 2011–2012 year.

**Rural Development and Self-Employment Training Institute (RUDSETI):**The RUDSETI has been working very hard to promote entrepreneurship and self-employment. RUDSETI was founded in 1982 in Ujire, Karnataka, and has now grown to include 24 locations throughout 14 states. It has trained 2.41 lakh adolescents, of whom 1.69 lakh have found employment through their own businesses, making up 70% of the settlement rate. In order to accomplish the

shared goals, RUDSETI has collaborated with government departments, nonprofit organizations, and institutions such as NABARD, SIDBI, DICs, DRDAs, and NBCFDC.

The National Institute for Entrepreneurship and Small Business Development (NIESBUD): NIESBUD was established in 1983 as an apex body for coordinating and supervising the activities of various institutions/agencies engaged in ED specifically in the area of small industry and small business by the then Ministry of Industry (renamed as Ministry of Micro, Small and Medium Enterprises), Government of India. From 1986 to 2006, NIESBUD ran 680 different programmes with over 13,600 participants. Approximately 2,000 people have participated in the institute's primary foreign programmes, which are supported by ITEC. The institute offers ESDP programmes in security guards, computerized design for brass clusters, and hospitality.

The National Science & Technology Entrepreneurship Development Board (NSTEDB): The Department of Science and Technology (DST) and the Government of India formed the NSTEDB in 1982 as an institutional mechanism to support the promotion of knowledge-driven and technology-intensive businesses. The Board, which has representatives from socioeconomic and scientific ministries/departments, seeks to use Science & Technology (S&T) interventions to change "job-seekers" into "job-generators." The NSTEDB's programmes have encouraged more S&T professionals to pursue entrepreneurship as a vocation. TBI, STED, STEP, EDC/IEDC, FDP, STST, EDP, TEDB, WEDP, and EAC are a few of the NSTEDB's extremely effective programmes. Academics and researchers have begun to show a strong interest in such socially significant jobs and have joined a number of NSTEDB programmes. About 100 organizations, the majority of which are academic institutions

and nonprofit organizations have benefited from the NSTEDB's assistance with the goal of creating ED and jobs.

## **10. EDUCATIONAL INSTITUTIONS' ROLE IN ESDP**

A few incubation centres have also opened on educational campuses over the past ten years with the help of DST and other organizations, with the aim of developing entrepreneurs who are focused on technology.

AII, the Amity Innovation Incubator: AII's goal is to promote an entrepreneurial mentality. To support budding entrepreneurs, AII provides a variety of incubation services, including business development, company creation, legal and IPR support, venture capital investment, networking, partnerships, and alliances.

The DST and NSTEDB sponsor the Amrita Technical Business Incubator (ATBI), which is situated on the Amritapuri Campus in Kollam. Amrita TBI provides funds, services, and infrastructure to early stage start-ups and innovators to aid in the successful commercialization of their unique company ideas.

Technology Business Incubator (TBI) at Birla Institute of Technology and Science (BITS): In the fields of embedded systems and VLSI design, TBI has been formed by the BITS, Pilani in collaboration with the DST. The Center for Entrepreneurial Leadership (CEL) at BITS has been supporting entrepreneurial leadership throughout all disciplines in collaboration with TBI.

Innovation Incubation and Entrepreneurship Center (CIIE): With assistance from the Gujarat Government and DST, the Indian Institute of Management Ahmadabad (IIMA) established the Center for Innovation, Incubation, and Entrepreneurship. The Center has taken the initiative to strengthen India's entrepreneurial ecosystem and offer

mentoring, networking opportunities, and seed money to the nation's top ideas. The ICT, energy, and healthcare incubation centre promotes new ideas.

The Indian Institute of Technology Mumbai (IIT Mumbai) Society for Innovation and Entrepreneurship (SINE) was established in 2004 to promote entrepreneurship at IIT Bombay. SINE is in charge of a company incubator that supports entrepreneurship in the technology sector. Since its creation, the society has acted as a model for other academic business incubators around the nation. It finds ideas and technology that could lead to profitable business initiatives.

Indian Institute of Technology-Madras Rural Technology & Business Incubator (IITMs RTBI): IITMs RTBI claims to be the only incubator concentrating on rural technologies and businesses in India at the moment and has the unique distinction of having been funded both by the World Bank's Info-Development Project and the Government of India's Department of Science and Technology.

The Trivandrum India Techno-Innovation Park's Lab (Extension Center): This facility delivers fantastic opportunities for unique ideas to blossom and provides the ideal setting for innovative thinkers to launch their products. The Innovation Lab Fund, in addition to providing technical and infrastructure support, also acts as a catalyst to encourage technological advancement for aspiring entrepreneurs.

Communication Institute Mudra Ahmadabad's MICA-EDC (Entrepreneurship Development Center) since its founding, MICA-EDC has aimed to provide business support services in order to foster innovative concepts with the potential to alter this industry. A pioneering Communications Technology-Based Business Incubator (Comcubator), an Incubation Center exclusively for the Communications Sector, has been established by MICA-EDC to foster and commercialize ideas and breakthroughs.

National Design Business Incubation (NDBI): NID has pledged to build on India's design talents through NDBI. To encourage the invention abilities of individual innovators, NDBI is developing a novel programme called the "Technopreneur Promotion Program" (TePP) with the assistance of the Department of Scientific and Industrial Research (DSIR).

Science & Technology Entrepreneurs' Park: NITK-STEP (previously KREC-STEP) was founded in 1994 on the campus of KREC (Mangalore) with the goal of providing benefits to all participating agencies through business incubation, innovation, training, and skill enhancement in a value-driven and service-focused environment.

SIDBI Innovation & Incubation Center (SIIC): IIT Kanpur and the Small Industries Development Bank of India together established the SIIC (SIDBI). SIIC offers start-ups and potential entrepreneurs and entrepreneurs a platform on which to transform their ground-breaking ideas into marketable goods. In addition to other activities, the institution runs virtual incubation, giving entrepreneurs the chance to use SIIC/IITK as a platform for creating breakthrough commercial products without physically being at IITK.

Science and Technology Entrepreneurs Park at Tiruchirappalli Regional Engineering College (TREC-STEP): The national strategy to expand knowledge-based businesses in our society includes TREC-STEP. It has consistently worked to support numerous innovative initiatives for bringing about technology-based growth as well as a new breed of entrepreneurs.

Technological Business Incubator (VIT-TBI) at the Vellore Institute of Technology VIT University and DST, the Indian government, collaborated to create VIT-TBI. In its ecosystem of company incubation, VIT has excellent relationships with a number of key companies. As a result of network benefits,

incubates receive services that are significantly more valuable.

**11. ANALYSIS PART OF THE STUDY**

100 respondents (MSME Entrepreneurs) have

been selected randomly and collected the primary data through questionnaire. The questionnaire covered the questions which clear the importance and role of ESDP for the sustainable growth of MSMEs in India. Summary of major analysis and its findings were given below:

**Table 1.** Opinion of the Respondents on ESDP Training (SA – Strongly Agree; A – Agree; N – Neutral; DA – Disagree and SDA – Strongly Disagree)

<i>Statements</i>	<i>SA</i>	<i>A</i>	<i>N</i>	<i>DA</i>	<i>SDA</i>
A sufficient level of government support for the growth of entrepreneurship	30	27	29	10	4
Ample infrastructure support for aspiring business owners	29	38	24	6	3
Adequate Entrepreneur Training and Retraining for Current and Future Entrepreneurs	27	35	28	8	2
It is better for entrepreneurs to have access to reliable information systems	31	29	27	9	4
Better regular classes	23	39	20	10	8
Lack of energy availability and high costs are obstacles to entrepreneurs' success	26	29	32	8	5
The contribution of entrepreneurs to the source of government revenue	36	39	20	3	2
The growth and success of small business enterprises are significantly impacted by the development of entrepreneurship	18	37	29	9	7
Increase the training's duration	28	35	30	5	2
Provide more post-training handholding from MSME	26	34	25	10	5
Require refresher training in the newest techniques and technologies	28	38	24	7	3
Readily accessible financial assistance for aspiring businesspeople	30	29	33	6	2
Unpredictable social, political, and economic factors to take into account that may impede the growth of entrepreneurship	22	31	28	14	5

It is clear from the table out of 100 respondents the majority of the respondents (30 percent) have strongly agreed for the statement 'A sufficient level of government support for the growth of entrepreneurship', 38 percent of the respondents have agreed the statement 'Ample infrastructure support for aspiring business owners', 35 percent of the respondents have agreed the statement 'Adequate Entrepreneur Training and Retraining for Current and Future Entrepreneurs', 31 percent of the respondents have strongly agreed the statement 'It is better for entrepreneurs to have access to reliable

information systems', 39 percent of the respondents have agreed the statement 'Better regular classes', 32 percent of the respondents are neutral for the statement 'Lack of energy availability and high costs are obstacles to entrepreneurs' success', 39 percent of the respondents have agreed the statement 'The contribution of entrepreneurs to the source of government revenue', 37 percent of the respondents have agreed the statement 'The growth and success of small business enterprises are significantly impacted by the development of entrepreneurship', 35 percent of the respondents have agreed the statement 'Increase the training's duration', 34 percent

of the respondents have agreed the statement 'Provide more post-training handholding from MSME', 38 percent of the respondents have agreed the statement 'Require refresher training in the newest techniques and technologies', 33 percent of the respondents are neutral for the statement 'Readily

accessible financial assistance for aspiring businesspeople' and 31 percent of the respondents have agreed the statement 'Unpredictable social, political, and economic factors to take into account that may impede the growth of entrepreneurship'.

**Table 2.** Satisfaction Level of the Respondents on ESDP Training by the M/o MSME (HS – Highly Satisfied; S – Satisfied; N – Neutral; DS – Dissatisfied and HDS – Highly Dissatisfied)

<i>Training and Supportive Programmes</i>	<i>HS</i>	<i>S</i>	<i>N</i>	<i>DS</i>	<i>HDS</i>
Credit Facilities	24	28	<b>30</b>	11	7
ESDP Training	22	20	<b>33</b>	15	10
Financial Support	21	25	<b>30</b>	14	10
Linkages	25	28	<b>32</b>	9	6
Premises on work place	19	23	<b>38</b>	16	4
Project Preparation	18	25	<b>34</b>	18	5
Schemes and Programmes	19	<b>32</b>	25	18	4
Support and Development Services	24	<b>32</b>	30	11	3
Technical Training	24	26	<b>32</b>	12	6

It is inferred from the table 2, out of 100 respondents the majority of the respondents' satisfaction level is neutral for the training and supportive programmes 'Credit facilities', 'ESDP Training', 'Financial support', 'Linkages', 'Premises on work

place', 'Project preparation' and 'technical training', and for two training and supportive programmes i.e. 'schemes and programme' and 'support and development services' the majority of the respondents' satisfaction level is satisfied.

**Table 3.** Ranking Analysis on the Respondents' Opinion on the steps to be taken for ESDP in India (based on weight score)

<i>Options for Order Preferred</i>	<i>Weight Score</i>	<i>Rank</i>
Constructing training facilities	867	4
<b>Construction of industrial parks</b>	<b>932</b>	<b>1</b>
Creation of an entrepreneurial support unit	798	5
Creation of technology and science parks	880	3
Establishment of institutions for development	596	10
Fiscally liberal policies	720	7
Industrial regulations	896	2
Simple licensing process	693	8
Technical and vocational education advancement	750	6
The planning of workshops and seminars	627	9

The above table 3 shows that, out of given on the preference by the respondents on ESDP by M/o MSME, the option 'construction of industrial parks' secured first rank, followed by 'industrial relations', 'creation of technology and science parks', 'constructing training facilities', 'creation of an entrepreneurial support unit', 'technical and vocational education advancement', 'fiscally liberal policies', 'simple licensing process', 'the planning of workshops and seminars' and 'establishment of institutions for the development' have secured second, third, fourth, fifth, sixth, seventh, eighth, ninth and tenth ranks respectively.

## **12. DISCUSSION AND RECOMMENDATIONS**

One of the key sectors contributing to the expansion of the Indian economy is the MSME sector. The government has tried a variety of initiatives and strategies over the past few years to increase the number of MSMEs in the country and support entrepreneurship. ESDP, one of the numerous programmes run by the Ministry of MSME, has unquestionably helped the nation's skill development. However, a closer look at the programmes reveals that most ESDP recipients come from the overall classification, and only 10% belong to the SC/ST in reverse. Additionally, female entrepreneurs are still incredibly unimportant, and their businesses tend to focus on microbusinesses. Given this, significant efforts should be made to encourage entrepreneurship among the underprivileged and disadvantaged classes of society. As a result of the pandemic, ESDP exercises were discontinued, and the business environment was severely damaged. The government should support skill development that is in line with global demand as the economy recovers and revive the MSME sector.

The following suggestions are made to help the ESDP reach each recipient more effectively:

- When granting credit to business owners for the launch of their specialty units, credit-giving institutions like banks and other monetary organizations should reduce the administrative burden and other practices.
- Entrepreneurs should seize market opportunities as they present themselves, and various critical methodologies should be adopted to advance and support MSMEs.
- The ESDP must have a reliable system in place to follow up on the learners' situation at predetermined intervals, ideally for a period of a year following the training.
- It is important to develop and make available innovations that are appropriate for the MSME sector.
- Learn essential skills to keep up with global developments.
- Government should lessen the influence that entrepreneurs have when they first launch their businesses.
- The government should implement plans and initiatives that will foster an entrepreneur-friendly environment in business.
- The government should keep entrepreneurship development in mind as a subject for educational programmes at optional schools and at institutions of higher education in order to impart crucial fundamental knowledge and develop sufficient entrepreneur skill and demeanor among young people from a fundamental level.
- Government in general and society in particular should support and empower entrepreneurs.



- Mechanical progress and steering. A board of experts and advisors should be prepared to assist MSMEs.
- At the regional level, new and expanded sections of the Entrepreneurship Development Foundations should be opened in order to provide more eager entrepreneurs with the necessary training and knowledge to become more successful businesspeople.
- MSMEs should be given practical planning and development projects and mindfulness initiatives. Furthermore, there should be enough credit offices available.
- The government and the MSME-DI will place more emphasis on this preparation and work to include more students in the programme because the more vulnerable segments are the most hampered group with the highest rate of unemployment.
- There should be clear reviews to examine the financial and technical needs of the MSME.
- The dismantling of red tape and the relaxation of labour laws. For creative strategy for creation, management, delivery, and marketing, legitimate exploration and development should be developed.
- Optimal use of restricted resources (financial and human). It should receive instruction and information on the most recent events taking place around the globe.

### 13. CONCLUSION

For India's practical development, the Ministry of MSME tries to play a crucial role in entrepreneurship development. It embraces a broad and enormous commitment to

providing significant financial and other support to the small- and medium-sized businesses. It increased their reach into every sector of Indian business in order to open doors for employment and encourages entrepreneurship, which in turn helped to develop the neighborhood. India can generate additional financial growth by promoting entrepreneurial activities throughout its country, particularly among its growing working class. In addition to the fact that entrepreneurship has been shown to have significant financial benefits in a wide range of nations, India has specifically reached a stage of development where it can achieve comparable results through entrepreneurial endeavors. India is prepared to launch new businesses in the high-innovation sector, among other things, to help it become a significant competitor on the global economy. It has significant areas of strength for a base fit to entrepreneurial activities, increased inflows of foreign capital concentrated on its developing data innovation administrations area, and a sizable number of successful new business new companies, for example. India should now provide beneficial access to training targeted specifically at developing entrepreneurial skills, funding entrepreneurial endeavors and systems administration among potential entrepreneurs and their experienced partners in order to further the entrepreneurial approach to managing financial development. It is obvious that the government can contribute significantly to helping to provide these kinds of opportunities. Additionally, it can provide the necessary administrative frameworks and duties and aid Indian citizens in understanding how successful business ventures relate to financial prosperity.

One of the key sectors driving the expansion of the Indian economy is the MSME sector. The Government has implemented numerous programmes and initiatives over the past few years to support entrepreneurship and grow the nation's MSMEs. Unquestionably, the ESDP, one of the numerous programmes run

by the M/o MSME, has helped the nation's skill development. However, a closer examination of the programmes reveals that 90% of ESDP recipients fall within the general group, while only 10% are SC/ST backward. Additionally, there are still very few women who own businesses, and most of them are microbusinesses (Salini and Venkateswaran, 2020) In light of this,

significant effort needs to be made to promote entrepreneurship among the underprivileged and backward segments of society. Due to the pandemic, ESDP programme operations were suspended, and the entrepreneurial ecosystem was very dysfunctional. The government must support skill development that is in line with global demand as the economy recovers and revitalize the MSME sector.

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## **MSME BUSINESS STRATEGY: ELECTRONIC BUSINESS SUSTAINABILITY DURING THE COVID-19 PANDEMIC**

***Abstract:** Indonesia has been hit by the coronavirus disease 2019 (COVID-19) pandemic since March 2020, but not only in Indonesia; some countries in the world are also experiencing the COVID-19 pandemic. This causes the economy to be unstable, which affects business people, including MSME players. The purpose of writing this article is how MSME actors are able to adapt during the COVID-19 pandemic in maintaining the sustainability of their business. The approach to writing this article uses qualitative and explained descriptively. The findings of this study are that the Government in its strategy can offer financial incentives based on advantages on financial technology (fintech) lending platforms, namely tax incentives, for fintech platforms that can provide direct access to funding for MSMEs, as well as MSME players in Indonesia in maintaining their business adapting by utilizing online media, such as twitter, facebook, instagram, gofood, gopay, wa group. This finding indicates the need for MSME actors to increase their strategies to adapt to the sustainability of their electronic business during this pandemic.*

***Keywords:** MSMEs, Electronic Business Sustainability, Adaptation*

### **1. Introduction**

MSMEs are one of the most important types of businesses in Indonesia, with important implications for economic growth. MSMEs also have an important role in the field of employment and equitable distribution of development results. In addition, it is also often called a sector that focuses on important issues of smoking. This is because most of the population has a poor education and their lives rely on small businesses that they have traditionally or modernly (Wijaya et al., 2021; Wagiono et al., 2022).

MSMEs are a strong economic pillar in Indonesia, which is able to survive various economic crises and stable growth. However,

after the world experienced the COVID-19 pandemic in 2020, the majority of MSMEs in Indonesia are estimated to be still turbulent, especially MSMEs in cities and villages as well as their businesses are volatile and even some of the benches (Mahfuzah et al., 2021; Wanidison&Shaddiq, 2021; Surti et al., 2022).

The COVID-19 problem in Indonesia has not been resolved; however, the economic turmoil is expected to get worse in the third and fourth quarters of 2020. According to the latest data dated December 20, 2020, the number of Indonesians exposed to COVID-19 is 664,930 people (Maulaa, 2020; <https://www.pikiran-rakyat.com/>; Shaddiq et al., 2021). The existence of a pandemic that is

quite long for up to 10 months (March – December 2020), and is expected to cause various problems in all aspects of life. One of them has a significant impact on the community's economy which tends to deteriorate (Wagiono et al., 2020; Shaddiq&Wanidison, 2021).

According to the Organisation for Economic Cooperation and Development, the world economy can be affected by the COVID-19 pandemic, seen from a policy point of view as well as demand and supply (Shaddiq&Haryano, 2020). Researchers are trying to better understand the current condition of society, one of which is the economic aspect that has an impact on MSME actors due to the decline in people's purchasing power (Saputra et al., 2020). Thus, many MSME actors are pursuing alternative economic activities (Hasan, at al., 2021; Rizani et al., 2022) while still working for the sustainability of their business (Rahman, at al., 2021; Rizal et al., 2020).

Since the outbreak of the COVID-19 pandemic in 2020, the number of MSMEs in Indonesia has decreased, because the results have been unable to finance certain services, such as electricity, water, building rents and others. In addition, many micro-enterprises whose products were not sold so they suffered damage and they closed their businesses. Currently, the economic crisis affects economic policy because many businesses that perform poorly even close, so unemployment increases (Lutfi et al., 2020). This is a critical issue that must be addressed in order to improve the economic condition of MSMEs, which is currently in a downturn (Arizal et al., 2021; Ramadhani et al., 2021). If you look at the economic sector as a whole, it will be seen that the most important factor in economic growth is MSMEs, which have been affected by the COVID-19 pandemic (Sugiri, 2020; Rahmadani et al., 2022). Therefore, the government must focus its attention on MSMEs to protect them from the economic downturn that occurred in the era of

the COVID-19 pandemic. The government must have new methods and procedures in place. The generation and development of MSMEs in Indonesia will regulate the economy again (Habibah et al., 2021; Putera et al., 2022).

Stabilizing the economy must start from special attention from the government to the people affected by COVID-19, one of which is MSMEs. Many bankruptcies have occurred, inspiring microenterprises to return to operation. This is a motivator for the government to continue to support MSMEs in increasing the income of MSME actors. For this reason, special methods and procedures used by the government are needed in the development of MSMEs in Indonesia (Shaddiq&Handayani., 2021; Norrahmiati et al., 2022).

In addition to losses due to COVID 19, business people must also have a strategy that focuses on growing and developing, which can be done by selling goods through online systems (twitter, facebook, istagram, gofood, gopay, group WA) or transferring goods to market places in Indonesia. This will help entrepreneurs in strengthening and developing their businesses because their products can be seen by potential buyers around the world (Hidayat et al., 2021; Norrahmi et al., 2021).

## 2. Literature review

The definition of "MSMEs according to LawNumber 20 of 2008" concerning MSMEs is:

1. Micro enterprises are productive businesses owned by individuals and/or individual business entities that meet the criteria for Micro Enterprises as regulated in thisLaw.
2. Small Business is a productive economic business that stands alone, which is carried out by an individual or business entity that is not a subsidiary or not a branch of a company that is owned, controlled, or is part either

directly or indirectly of a Medium Enterprise or Large Business that meets the criteria for Small Business as referred to in this Law.

3. Medium Enterprises are productive economic businesses that stand alone, which are carried out by individuals or business entities that are not subsidiaries or branches of companies that are owned, controlled, or part of either directly or indirectly. "

MSMEs are the main and vital force that can encourage the economy and job opportunities (Supardi et al., 2021) and are important in national development (Sugiyanto et al., 2021; Kurniawan et al., 2021), not only reflected in economic growth in the city, but also in economic growth in general (Hamid & Ikbal, 2017; Joko et al., 2022) as well as an increase in GDP in the State of Indonesia (Jefri & Ibrohim, 2021; Iyansyah et al., 2021). Events that occurred in 1998 to 2012 MSMEs showed that they were able to overcome the economic crisis, as evidenced by positive economic growth (Jefri & Ibrohim, 2021). This proves MSMEs are resilient from the economic crisis (Handayani et al., 2022).

Since the company's goal is to increase productivity, such as shortening business processes by moving them to automated processes, or to reduce the number of workers, the company's productivity can be increased through digitization (Chae et al., 2018; Irpan et al., 2022). Benitez, et al. (2018) found that digital transformation in business can increase revenue and productivity, for example, implementing digital business applications that enable more efficient operations. Bouman, et al., (2019) conducted an exploratory research on 321 MSMEs in Europe, by utilizing digital media and information technology (IT) to innovate their businesses. In today's digital era, it makes it easier for people to maximize their business and needs to have a business strategy (Hilmiana & Kirana, 2021). For this reason, along with the acceleration of digitalization, which is the main focus of every business (Sia et al., 2016; Hidayat et al., 2021), it must be

integrated into its business strategy (El Sawy et al., 2016; Irpan et al., 2021), the latest innovations are needed in order to increase the competitiveness of MSMEs (Suci, 2017).

### 3. Research method

A qualitative approach is used in this writing, to interpret in obtaining the meaning that is being studied (Raco, 2010). The qualitative approach aims to find the problem and develop in detail the details of a phenomenon, as well as analyze data to explain the description of the problem (Creswell, 2015).

This writing uses second-level (secondary) data, which the author took in the form of ready-made data, (Sekaran & Bougie, 2016). Sekaran & Bougie (2016) also explains secondary data sources sourced from published government documentation/records (reports), companies, the internet, industrial analysis / information carried out by the media, and soon.

This writing is categorized as a literature approach. Sari & Asmendri (2020) explained that research is carried out in a sequence or systematic manner in order to collect data and process data, as well as conclude data based on the appropriate method to answer existing problems is literature research.

### 4. Discussion

#### 4.1. Economy Affected by COVID-19 Pandemic

The health crisis that occurred had implications for the economy caused by the COVID19 pandemic (Nicola et al., 2020). This crisis has made the government quick to carry out policy strategies in inhibiting the acceleration of the health crisis, one of which is by maintaining social distancing. The most serious impact of COVID-19 on the economy is a decrease in output as a result of social distancing and the absence of employees infected with the coronavirus (Wren-Lewis,

2020). McKibbin& Fernando (2020) explain the consequences of affecting the smooth running of global supply chains. This inaction is due to a decline in transport and delivery, which has hampered global economic planning.

McKibbin& Fernando (2020), stated that the existence of unrest among producers and consumers also resulted in a shift in the variety of consumption and the emergence of market abnormalities. Furthermore, the implementation of Large-Scale Social Restrictions (PSBB) in several areas infected with the virus resulted in an increase in consumption of community residents for several periods (BKF, 2020). Since the announcement in March 2020 by the government that there is COVID-19 in Indonesia, there has been a significant increase in the growth rate of domestic consumption (BPS, 2021). Household consumption growth was around 5.44 percent in the second quarter of 2020.

Susilawati et al., (2020) said that national economic activity has decreased markedly as a result of the COVID-19 pandemic. Disruptions in demand and supply were felt by various business groups (services, trade, industry). Among them, sectors that provide food and drink accommodation, trade, transportation, hospitality and warehousing as well as MSME groups, bear the brunt of the consequences. Due to the decline in the activity of economic activity, the sector suffers greatly.

In addition to having an impact on the economic sector, the handling of COVID-19 has also accelerated the pace of the online / digital economy (ITU, 2020). The economy experienced improving changes during the COVID-19 pandemic, marked by an increase in the volume of e-commerce transactions and an increase in nominal value, fintech lending and digital banking in the fourth quarter of 2020. (BI, 2021). In terms of volume, it increased by 104.9 percent and nominally e-commerce transactions increased by 49.5

percent, when compared to the third quarter, the fourth quarter was higher. Digital banking is gaining popularity because it has become the preferred transaction method for the general public during the COVID-19 pandemic. This can be seen from the increasing transaction costs. Digital banking grew 12.5 percent nominally and by volume 41.9 percent.

#### **4.2. MsME's Contribution to the Economy**

MSMEs do not specifically have a broadly acceptable terminology (Agyapong, 2010). However, according to Henschel& Durst (2016) &Ekwere (2016) MSMEs have characteristics, namely:

- relatively small marketshare
- owned by an individual/family/group
- formal organizational structure is not owned
- the resources it has are limited
- limited access to capital markets
- management vagueness
- less clear investment and financing decisions

Each country has terms, definitions and measures about MSMEs (Ayyagari et al., 2007), according to the conditions of their respective countries. According to Agyapong (2010), MSMEs are a key sector with important implications for economic growth. This is because MSMEs contribute to the progress of developing the provision of job opportunities through creativity and innovation. The long-term impact of business from the MSME sector will be the increase in the income of a country, which in turn can contribute to programs to reduce unemployment and poverty.

The role of MSME peting on the economy of ASEAN member countries (ADB, 2020) is that MSMEs are able to create new job opportunities, business competencies and new ideas in innovation to maintain the sustainability of their business. Furthermore,



according to the Asian Development Bank, that of the total existing companies, MSMEs in Southeast Asia accounted for 97.2%, and amounted to 69.4% of the total workforce, as well as Broto Domestic Product 41.1% during the 2010-2019 period in a country. With the average contribution of MSMEs from the export value of a country in 2010–2018, it is around 20.4%.

MSMEs in Indonesia can absorb up to 97.04% or as many as 112,709,244 national workers (Suhaili and Sugiharsono, 2019). The proportion of each business to the absorption of the total MSME workforce by business group: (a) medium enterprises 3 percent, (b) small businesses 5 percent, (c) micro enterprises 92 percent. In 2012 – 2017, Indonesia's GDP was contributed from the MSME sector by 59.74 percent or worth Rp 5,928,934.98 billion. The contribution of MSMEs to the largest total GDP was given by micro-enterprises at 61.05 percent, followed by small businesses at 16.20 percent, and large businesses at 22.75 percent.

### 4.3. Strategy Concept

A business strategy is a long-term plan that considers every possible alternative option that can be used to achieve a goal in the future (Susanto & Sukarno, 2022). It is intended, during business activities, as an entrepreneur to be a must to have the ability to continuously improve business management and look for various strategic options. Entrepreneurs in managing their business can also make extensive adjustments to the surrounding environment, so that there is an increase in business performance.

In order for the MSME business to succeed in its goal of expanding its market share and increasing its income, a strategy is needed that can easily adapt to the ever-changing environmental conditions in which it operates, so as to be able to win the market. Thus a good strategy is a strategy that is able to adapt to its operational environment in

winning the market.

Effective sustainability of the MSME business in the face of increasingly broad and heavy competition requires the development of a business strategy that is able to answer this, namely: determining prices according to quality, choosing products that are in accordance with market demand, choosing human resources who have the best skills and the best, making the right promotion choices, determining and choosing a strategic location. This strategy can also be called the 5P strategy (product, price, place, promotion, people) or marketing mix. (Safa'atin, et al, 2022).

Marketing is a series of steps to create, communicate and add value to customer relationships in a way that increases customer satisfaction. For a good marketing strategy, business actors can carry out their marketing mix. The marketing mix is important because consumers take it into account when buying products and. (Amiroh, et al., 2022). If the business actor does not know what the customer wants, then the customer will turn to a new option.

### 4.4. Business Sustainability Strategy for MSMEs

The government plays a key role in the recovery phase of the COVID19 pandemic. According to the 1945 Constitution, the Indonesian government is responsible for proving that all its citizens have access to civil liberties and basic security, especially in the economic field. The government's responsibilities include maintaining MSMEs as an economic buffer during the COVID19 pandemic with various economic stimulus measures.

The government obtains tax payment receipts from "fintech lending", MSMEs and investors based on their income. PP Number 23 of 2018 concerning income tax from business results received with a certain minimum value, subject to 0.5% of the final income tax for

MSMEs (Kartiko, 2020; Fadilurrahman et al., 2021).

The problem of MSME access to banking that is difficult to obtain must be assisted by the government. In fact, MSMEs really need access to capital to maintain their business continuity. One alternative is a partnership between the government and a "fintech lending platform" to provide financing to MSMEs. In the era of the COVID-19 pandemic, the government can use its authority to encourage the growth and economy of MSMEs. The government can offer financial incentives based on a percentage of the profits earned. Incentives can be offered to "fintech lending platforms" that help finance MSMEs.

According to Kartiko&Rachmi, (2021) that the strategy to overcome the problem of sustainability of MSMEs is to provide a stimulus for the economy through the PEN (National Economic Recovery) program. Based on Article 1 paragraph (1) of PP 23 of 2020, the PEN Program is "a series of activities for the recovery of the national economy which are part of the state financial policy implemented by the government" to accelerate the handling of the COVID-19 pandemic.

Another strategy that can also be implemented by MSMEs in maintaining their

business is to adapt by utilizing online media, such as twitter, facebook, instagram, gofood, gopay, wa group, to increase their sales turnover. This strategy is very likely to be carried out by MSME players, considering the large number of "market places", which are available that can help bring customers (consumers) closer to the choice of products provided by MSME players. The use of online media can also speed up transactions and reduce costs incurred by both customers and MSME players.

## **5. Conclusion**

The government's policy strategy related to the absence of MSME access to banking includes providing stimulation to the economy. To implement this stimulus, it is possible to cooperate with "fintech lending", which can provide direct access to funding for MSMEs. The government in its strategy can offer financial incentives based on profits on fintech lending platforms, namely tax incentives. The strategy that can be implemented by MSMEs in maintaining their business is to adapt by utilizing online media, such as twitter, facebook, instagram, gofood, gopay, wa group, to increase their sale turnover.

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## QUALITY OF TOP FOUR ERITREAN SUSTAINABLE BIO-RESOURCES FOR THE FUEL APPLICATIONS

**Abstract:** Worldwide 208% of increase in CO<sub>2</sub> emissions reported during 1965-2020, from 11.32 to 34.81 billion tonnes per year which has led to the contemplative global warming issues. However, transformation of non-renewable fuels into renewable alternatives enhance sustainable energy supply with a significant contribution in the energy mix. Since fire wood is commonly used in traditional mogogo (adhanet) for making daily bread (injera), approximately 2 million tonnes per year of biomass are consumed in Eritrea, primarily for household usage at 61% of total energy consumption in 2019. The net primary production of biomass in Eritrea measured at a rate of 12.5-16.67 % despite of 4% local consumption rate when compared with global production and consumes rates. Moreover, variance between the groups and within the groups analyzed to cognize the effect of different varieties of bio-resources in fuel applications. Further, mathematical models were constructed using Excel® and POLYMATH® tools to derive heating values from proximate parameters and validated with qualified former reports. Calorific values of forest wood species, temri musa (*Prosopis juliflora*) and seraw (*Acacia etbaica*) in conjunction with major crop residues of sorghum and wheat straws are assessed at 19.27, 19.38, 16.7 and 18.06 MJ/kg respectively as a function of proximate variables. Briefly, comparison of local samples with international species revealed that they are competitive in terms of energy content.

**Keywords:** *Prosopis juliflora*, *Acacia etbaica*, Wheat Straw, Sorghum Stalk, Biomass energy, HHV Prediction Models

### 1. Introduction

Globally there is a perpetual need of clean and sustainable energy sources due to rapid urbanization, persistent growth in population and consistent industrialization. In the past five decades, static 80% share of fossil fuels have maintained in the energy mix and there was threefold increase in energy demand despite the gains of energy efficiency. Worldwide 208% of increase in CO<sub>2</sub> emissions have reported during 1965-2020,

from 11.32 to 34.81 billion tonnes per year (Simmonds D 2022). The transformation of non-renewable energy resources to renewable resources could create sustainable energy supply and significant contribution in the energy mix. Thus the renewable energy options such as solar, wind, hydro power, geothermal, tidal, ocean thermal energy and biomass energy have gained prominence in the recent years. Of all energy sources, biomass is the third largest energy resource in the world. It is also the most dominant source

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of cooking and heating energy for three-quarters of all people in developing countries, and accounts for about 14% of the total global energy use (Kpalo S. Y. et al., 2020).

The overlapping crises are affecting many parts of Africa's energy systems, including reversing positive trends in improving access to modern energy, with 4% more people living without electricity in 2021 than in 2019 (WEO Report 2022). They are also deepening financial difficulties of utilities, increasing risks of blackouts and rationing. These problems are contributing to a sharp increase in extreme poverty in sub-Saharan Africa, with the number of people affected by food crises quadrupling in some areas. With nearly one-fifth of the world's population today, Africa accounts for less than 3% of the world's energy-related carbon dioxide (CO<sub>2</sub>) emissions to date and has the lowest emissions per capita of any region. As of May 2022, countries representing more than 70% of global CO<sub>2</sub> emissions have committed to reach net zero emissions by around mid-century which include 12 African countries that contribute 40% of the continent's total emissions. At present, 600 million people, or 43% of the total population, lack access to electricity, most of them in sub-Saharan Africa. Today, 970 million Africans lack access to clean cooking. Countries are re-evaluating clean fuel subsidy schemes and exploring alternatives such as improved biomass cook stoves, electric cooking and biodigesters (WEO Report 2022).

Despite of the rapid depletion of fossil fuel reserves, excessive use of fossil fuels is posing serious environmental issues. In pursuit of alternative fuels, today renewable energy resources are paid of great interest in the world. Similar to many other countries in sub-Saharan Africa, the energy-development relationship has numerous social and political implications in Eritrea, where the national access to modern energy services is still very low although the government of Eritrea has given priority to the energy sector

immediately after independence in May 1991. About 70% of the Eritrean population, who lives in rural areas, has little or no access to modern energy services. At national level, access to electricity is about 32%, but only 3% of the rural population has access to it compared to 78% in urban areas (Zemenfes T 2015).

At present 52% of population has the accessibility to electricity majorly in the urban areas and 9% of total Eritrean people has accessibility for clean cooking and the rest depend on fire wood or locally made charcoal (IRENA 2022). At national level 72% of total energy supply in 2019 contributed by renewable sources primarily biomass despite of 11% share of solar energy, whereas 28% of energy supplied by non-renewable energy sources (IRENA 2022). Biomass is still the primary energy source in Eritrea despite of less biomass production. Net primary production (NPP) is the amount of carbon fixed by plants and accumulated as biomass each year and it is a measure of biomass productivity which is estimated as 0.5 tC/ha/yr substantially low when compared with global production of 3-4 tC/ha/yr (IRENA 2022). But unfortunately, fire wood and charcoal remained as major energy sources for cooking despite of social and environmental issues that are alarming globally. In the context of that development of sustainable and cleaner energy sources made significant field of study in Eritrea.

Biomass represents the biodegradable part of products, waste and residues from agriculture, forestry and, implicitly, from industrial and urban waste. Biomass, which represents around 15% of the primary energy sources used worldwide (Tumuluru J.S. et al., 2011), does not contribute to the increase of CO<sub>2</sub> concentration in the atmosphere, but it contributes to the reduction of the greenhouse effect and does not produce acid rains, thanks to sulfur content lower than to one existing in the structure of fossil fuels. In another report biomass is defined as the ensemble of non-

fossil organic matter in which are inscribed: wood residues, agricultural residues, plant residues from the forestry sector, but also cereals and fruits (Repsa E 2012). The main difference between the energy obtained from classic fuels and respectively biomass is the following one: fossil fuels can only be transformed into usable energy after thousands of years, whereas the energy from biomass is renewable and it can be used every year. Biomass in its original form is difficult to be used successfully as fuel in Compaction technologies are used for converting biomass (agricultural and forestry residues) into fossil fuels. These technologies are also known under the name of briquetting, pelleting, granulation, molding, packing, etc. (Adapa P.K et al., 2009). Lignocellulosic materials could provide up to 50 billion tons of dry matter on a global scale. Approximately 2 million tons per year of biomass are consumed in Eritrea, primarily in the household sector. About 80% of the energy use in Eritrea is from biomass resources such as fuel wood, dung and crop residue. Burning or disposal of biomass materials in the form of wastes or as a fuel creates more carbon dioxide emissions and other health and environmental problems.

Biomass is a primary renewable and sustainable energy source in Eritrea for many years particularly for cooking. Charcoal also placed as an essential fuel stock in house hold usage especially for homemade coffee as a tradition in Eritrea. Thus, biomass has become primary energy component in the country but unfortunately NPP rate is very less comparable with global NPP. Further, in most of the rural areas of Eritrea, injera (the baked bread) prepared on traditional fire wood stoves (mogogo) and their daily household coffee tradition include homemade coffee, consumes locally made charcoal which is inefficient and insufficient. Therefore, this work aimed to identify potential biomass resources in the country and assessing their quality attributes for fuel

usage purposes. Further, the development of models for the prediction of calorific values using proximate variables might serve as a database for the future relevant studies.

## 2. Potential Biomass Resources from Eritrea

As per the information from the Ministry of Agriculture (MoA), agricultural crop residues from the dominantly cultivated crops such as sorghum straw, wheat stalk and millets. Sorghum, wheat and millets were cultivated in 239700 ha, 34760 and 27434 ha respectively and their production rates of 112080 tons, 29486 tonne and 31836 tonne were measured respectively in 2021. Other vegetation in Eritrea varies based on the rainfall received and it has shown in Table 1. Bushland and shrub land covered majorly in the country with 43.19% of total land area followed by woody grasslands occupied about 18.93% of total land in Eritrea.

All woody species found in Eritrea can be used for charcoal and fire wood most commonly used species include *Balanites aegyptiaca* (Mekie), *Prosopis juliflora* (Temri musa), *Ziziphus spina-christi* (Gaba), *Albiza amara* (Chigono), *Terminalia browni* (Weyba), *Diospyros mespiliformis* and *Acacia* species.

### 2.1 *Prosopis Juliflora* (PJ) wood

Amongst the wide range of biomass species, *Prosopis juliflora* has been proposed as energy source by different researchers. It is a tropical and subtropical shrub tree, mainly found in the arid and semi-arid regions of the world (Africa, Asia and Australia) during the last 100-150 years. The species are now spreadover in the Africa; including Eritrea, Kenya, Ethiopia and Sudan (Nick P et al., 2001, Demissei E 2019).

Out of commonly used charcoal making species in Eritrea that are shown in fig.1, *Acacia etbaica* and *Prosopis juliflora* have

been selected as potential forest wood sources because of abundant existence and invasive attributes. According to the informants of MOA, PJ found in all zones except zoba Maekel and Dehub. It covers a vast area and

there is no quantifiable information on the extent of its invasion. But it is known to be covered in fertile crop lands, grazing lands, wood lands, river banks, water points, irrigation schemes and other areas.

**Table 1.** Variety of vegetation in Eritrea and their available areas in ha (MOA, Eritrea 2022)

Vegetation type	Area (ha)	Percentage of total land area
Closed to medium closed forest	51,520	0.42
Closed forest	40,790	0.33
Closed to medium closed woodland	452,730	3.68
Open woodland	1,112,760	9.05
Riverine forest	185,480	1.51
Mangrove	11,330	0.09
Bushland and shrub land	5,309,560	43.19
Grassland and wooded grassland	2,326,260	18.93
Bare land	1,879,190	15.28
Arable/cropped land	685,040	5.57
Other and non-classified land	240,320	1.95
Total	12,294,980	100



**Figure 1.** (a) *Acacia oregana* (b) *Albiza amara* (c) *Prosopis juliflora* (d) *Terminalia brownii* (e) *Ziziphus spina-Christi* (f) *Diospyros mespiliformis* (g) *Balanites aegyptiaca* (h) *Acacia etbaica*

Factors or Traits that makes PJ, a highly competitive and invasive, enabling it to spread at the cost of native species includes deep tap root system that can reach up to 50 meters deep, high potential of seed production and germination and long dormancy period (40 kg of pods/tree/yr, 60,000 seed 2-10 years), the ability to survive very low rainfall and lengthy dry periods, availability of mature trees with high photosynthetic productivity even in hot-arid climates and allelopathic potential

Invasive species such as *Prosopis* can have major negative impacts on food security and livelihoods if local communities are not mobilized and supported to adopt appropriate management practices to prevent further spread and restore invaded areas. There is a potential to control *Prosopis* spread and invasion by promoting its utilization in planned and regulated ways that provide economic incentives to local people. By this reason cutting of this woody plant would not lead to deforestation and the violation of the prohibited charcoal making law in Eritrea.

## 2.2 Acacia Etbaica (AE) wood

In a study of Ethiopia, the neighboring country to Eritrea targeting to know the most preferred fuel wood by the practitioners 88% of the frequency of the preference recorded for the *Acacia Etbaica* (Desta and Ambaye 2020). The green belt zone on the Eastern Escarpment is one of the natural woody forests in upland Eritrea dominated by *Acacia etbaica* (Seraw), a bushy wood plant used in this study to survey its potential for bioethanol production. The category “bush” is the dominant vegetation in Eritrea covering 63% of the total area. *Acacia etbaica* has a wide occurrence, from semi-desert shrub to wooded grassland at altitudes that extend from 1200 to 2000 m. *Acacia etbaica* is a tree or shrub (min. 2m) 2.5-12 m tall, survive with a mean annual rainfall of 200 -1400mm, and mean annual temperature of 22.3 °C and

native to Eritrea, Ethiopia, Kenya, Somalia, Sudan, Tanzania and Uganda.

Tree biomass of *Acacia etbaica* was estimated approximately as 4.5ton ha-1yr-1 by using allometry equations with tree height and canopy area as parameters in structure from motion(SfM) method. *Acacia etbaica* has a composition of 48.87 % cellulose, 21.37 % hemicellulose, 29.77 % lignin, and 2.35 % of ash contents and possessing a heating value of 19.14 MJ/kg which are prominent features of the plant in the selection as a feed stock for biobriquettes production (Aremanda et al., 2021).

## 2.3 Sorghum Stalk (SS)

Sorghum is the dominant crop variety cultivated in 35% of total arable lands of Eritrea. Sorghum biomass is an alternative energy source that offers producers a quick way to obtain biomass and it is easily available in Eritrea as it produced more. Sorghum cultivated in 239700 ha in 2021 at a production rate of 0.468 ton/ha. Ferreira et al.,I have tested sorghum waste for pellet production in Brazil. Pure sorghum biomass wastes have shown higher calorific values when compared with other additives that include steam and starch. Fixed carbon content of sorghum stalk measured as 14.45 % and a net calorific value of 3605 kcal/kg and their derived pellets have estimated as 3660 kcal/kg, which was comparatively higher than the other cases when they used starch and steam.

## 2.4 Wheat Straw (WS)

With the constant growth of the energy price, the interest for the energetic exploitation of the vegetal biomass, especially the straws, increased as well. From the specialty literature the burn heat values for different types of biomass are: wood, 18.5-19.5 MJ/kg, *myscanthus*, 17.6 MJ/kg, wheat straws, 17.2

MJ/kg, corn stems, 16 MJ/kg, rapeseed stems 16.5 MJ/kg, energetic coal 25 MJ/kg. From the qualitative point of view, the annual plants are comparable to the wood, as follows: wheat straws have a celluloses content comprised between 30-40%, lignin 16-21%, the average length of fibers is 1.50 mm.

### 3. Materials and Methodology

Based on the information provided by the Ministry of Agriculture, Eritrea following Agrocrop residue samples and forest wood samples collected for the thermochemical property analysis.

#### 3.1 Sample Collection and Preparation

Agrocrop residues and forest wood samples collected from the different parts of Eritrea. Sorghum stalk of 20 kg approximately collected from nearby farms to Barentu in Gash Barka region and transferred to Mainefhi and wheat straw of 20 kg collected from Himbrti farms in the form that they were left in the fields from the farmers. Later 100 g of each stalk reduced to the size range of 1-10mm using a cutters and grinder available in Chemical Reaction Engineering (CRE) laboratory, MCOETEC. *Prosopis juliflora* (locally known as Temri musa) wood logs about 20 kg were collected from Barentu subzone and transported to CRE laboratory, MCOETEC. In addition, locally available *Acacia etbaica* (locally known as seraw) plant wood of 20 kg were cut from MCOTEC premises with special permission from MOA and brought to CRE lab. Wood samples were cut into chips initially using axes and then grinded to 1-10mm of particle size for further analysis.

#### 3.2 Proximate Analysis

**Moisture Content:** The moisture content determined for the pulverized samples. 1g of each sample taken into a silica crucible and

placed inside an electric oven set at 105°C for 24 hours. It was then removed with the aid of tong and placed immediately in the desiccators to cool. The weight was then taken using a digital weighing balance. The procedure was repeated for all the samples and the moisture content was evaluated using the following Equation (Aliyu et al., 2016),

$$\text{Moisture content, } M (\%) = ((w_2 - w_3)/(w_2 - w_1)) \times 100$$

where,  $w_1$  = weight of crucible, (g)  
 $w_2$  = weight of crucible with the sample before heating (g)  
 $w_3$  = weight of crucible with the sample after heating (g)

**Volatile Matter:** The volatile matter (V) of all biomass species determined for the pulverized samples of 1 g each taken in to a crucible, covered and oven-dried until a constant weight was attained. It was then heated further in a muffle furnace at 600°C for 6 minutes then at 900°C for another 6 minutes as per method described in ASTM-3275. The difference in the weight as a result of loss of volatile matter was taken as the total volatile matter in the sample on percentage basis (Aliyu et al., 2016),

$$\text{Volatile matter, } V (\%) = ((w_3 - w_4)/(w_2 - w_1)) \times 100$$

where,  $w_1$  = weight of the crucible (g)  
 $w_2$  = weight of crucible with the sample before oven drying (g)  
 $w_3$  = weight of crucible with the sample after oven drying (g)  
 $w_4$  = weight of crucible with the sample after heating in muffle furnace (g) at 900 °C

**Ash Content:** The ash content was determined for the ground samples of 1 g each taken into a crucible and heated without lid in the muffle furnace at 750 °C for 90 minutes. The crucible was taken out and placed in a desiccator for cooling. The sample was then weighed. The procedure was repeated until a constant weight was attained. According to ASTM-

3174, the residue was reported as the ash content on percentage-basis (Aliyu et al., 2016), *Ash content, A (%)*

$$= ((w_3 - w_4)/(w_2 - w_1)) \times 100$$

where,  $w_1$  = weight of the crucible (g)

$w_2$  = weight of crucible with the sample before oven drying (g)

$w_3$  = weight of crucible with the sample after oven drying (g)

$w_4$  = weight of crucible with the sample after heating in muffle furnace (g)

**Fixed Carbon:** The fixed carbon content of coal was determined by subtracting the percentages of moisture, volatile matter and ash from the original mass of the biomass sample and it can be written as follows (Sipahutar et al., 2016),

*Fixed Carbon, F (%)*

$$= 100 - (M + V + A)$$

where,  $F$  is the weight percentage of fixed carbon,  $M$  is the percentage of moisture content,  $V$  is the percentage of volatile matter and  $A$  is the percentage of ash in the sample analyzed.

### 3.3 Statistical Analysis of Local and International Data Sets

Proximate parameters of all biomass resource samples were analyzed in one-way ANOVA study using Excel®, corresponding mean and variances were recorded for the comparison of deviations among the selected species. In general, statistical mean of  $n$  samples is given by,

$$\bar{X} = \frac{\sum X_i}{n} = \frac{X_1 + X_2 + X_3 \dots + X_n}{n}$$

and the standard deviation ( $\sigma$ ) or variance is given by,

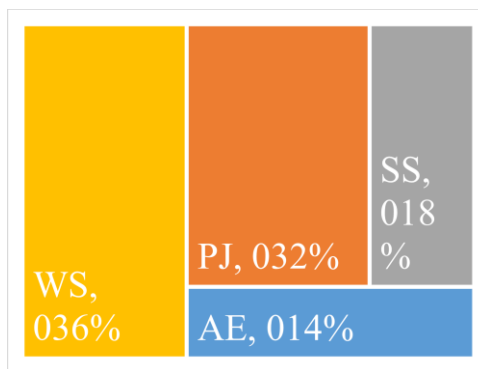
$$\sigma = \sqrt{\frac{\sum (X_i - \bar{X})^2}{n}}$$

In addition, different sets of relative proximate parameters of prosopis juliflora

and acacia etbaica wood species, sorghum and wheat straw materials were considered from the open sources provided in the table 2 and determined the corresponding mean and variances among the international groups. The degree of correlation between two populations can be analyzed using the Pearson correlation coefficient, which is expressed in the following equation (Sunyong et al., 2023),

$$r = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum (X_i - \bar{X})^2} \sqrt{\sum (Y_i - \bar{Y})^2}}$$

The collected data was stratified as shown in figure 2. Highest data samples of wheat stalk (WS) and prosopis juliflora (PJ) have utilized in the statistical analysis and for further development of HHV prediction models.



**Figure 2.** Stratification of biomass data used in Statistical Analysis

### 3.4 Model Constructions for HHV determination and their validation

Many different statistical linear, single and multivariate models constructed in Excel® and POLYMATH® and verified for the better comprehensive statistical parameter  $R^2$  and to understand the precision of the proposed model. A simple single variant linear regression can be arranged as,

$$y = \beta_0 + \beta_1 x$$

and a multiple linear regression can be

described by,

$$y = \beta_0 + \beta_1x_1 + \beta_2x_2 + \dots + \beta_kx_k + \varepsilon$$

where  $y$  is the dependent variable and  $X = \{x_1, x_2, \dots, x_k\}$  are the independent variables and  $\varepsilon$  is the corresponding residual error.

**Table 2.** Data Sets of PJ, AE, WS and SS Biomass for the Statistical analysis and HHV Model Construction

S.No	Source	Prosopis juliflora wood				
		M (%)	V (%)	F (%)	A (%)	HHV (MJ/kg)
1	This Work (Eritrea)	5.1563	74.01	18.5022	2.3315	19.27
2	Arunkumar et al., 2017 (India)	7.85	69.8	19.1	3.24	16.9
3	Demessie 2019 (Ethiopia)	7	75.81	14.82	2.37	17.02
4	Nellie & Joseph 2013 (Kenya)	7.30	76.75	14.82	1.13	20.72
5	Zebene et al., 2021 (Ethiopia)	7.16	75.81	15.82	1.21	15.82
6	Patel and Gani (India)	7.7	78.9	12.9	0.5	17.73
7	Sisay (Ethiopia)	7.95	63.05	12.28	1.665	20.53
S.No	Source	Acacia etbaica wood				
		M (%)	V (%)	F (%)	A (%)	HHV (MJ/kg)
1	This Work	6.1027	69.9234	22.7956	1.1786	19.38
2	Ramesh et al., 2021 (Eritrea)	8.90	65.03	23.62	2.45	18.80
3	Hailu and Cherinet 2020 (Ethiopia)	7.819	73.644	15.796	2.741	19.42
S.No	Source	Wheat Straw				
		M (%)	V (%)	F (%)	A (%)	HHV (MJ/kg)
1	This Work	4.821	70.53	15.1924	9.4536	16.7
2	Anezka et al., 2020	8.4	62.4	23.30	6.00	15.6
3	Phyllis Database	6.4	71.37	9.67	12.59	16.73
4	W.R Livingston (Phyllis)	12.9	66.02	14.98	6.1	15.4
5	NREL (Phyllis Database)	9.19	68.6	14.73	7.48	16.05
6	Phyllis Database	7.04	69.97	16.46	6.53	16.68
7	Phyllis Database	11.1	66.59	15.91	6.4	16.43
8	Phyllis Database	10.25	69.74	15.79	4.23	17.0
S.No	Source	Sorghum Straw				
		M (%)	V (%)	F (%)	A (%)	HHV (MJ/kg)
1	This Work	5.4384	68.75	21.2116	4.6	18.06
2	Lori et al., 2007 (Nigeria)	6.73	66.65	23.02	3.6	18.35
3	ECN Phyllis 2006 (China)	5.97	69.11	18.45	6.47	16.80
4	Vaibhav et al., 2017 (India)	7.72	65.38	19.77	7.13	20.58

If the expected error,  $\varepsilon$  assumed as zero, the set of arbitrary coefficients ( $b$ ) can be

described as,  $b = \{\beta_0, \beta_1, \beta_2, \dots, \beta_k\}$  and it can be evaluated by the least square



method as,

$$b = (X^T X)^{-1} X^T y$$

Thus the developed linear and non-linear multivariate models are compared with earlier reported models (Ayse et al., 2019, Ayse and Serdar 2016) for the determination HHV as a function of proximate variables.

## 4. Results and Discussion

Prudent utilization of biomass resources in sub-Saharan African countries such as Eritrea is pertinent as the rain fall seasons are highly uncertain and unpredictable. In Eritrea, most of the forest wood and agricultural crop residues consumed as firewood for cooking applications without any scientific analysis of their aptness. However, the calorific value of a fuel substance is defined as the amount of energy released per kg of substance during its combustion and it is the most significant fuel character. Experimentally, higher heating values (HHV) of fuel substances are measured using Bomb calorimeter. Instead, HHV can also be determined using proximate analysis by developing the relevant and reliable models.

Although a model is preferable to develop when the plentiful data is available, in certain conditions a limited data facilitate the basic prediction of unknown and inaccessible parameters as a function of well-known and easily accessible variables. A total data set of 18 experimental proximate values of top-four biomass species as listed in the table 2 from the open sources and 4 additional results of locally performed experiments are considered for the ANOVA study and model construction.

### 4.1 Statistical Analysis Results

As given in the Table 4, ANOVA study of selected data sets of the top-four biomass species revealed that, amongst the tested species as received WS has highest range of

**Table 3.** Range, Mean and Variances of Proximate and HHV parameters for the selected biomass

moisture content and then followed by SS while PJ possess the least. Removal of moisture in the wood species consume more time in sun drying process and thus the variation among the forest wood species is minimum. Other words, PJ contain highest range and associated deviation of volatiles than others whereas SS has the minimum range and variance. Further, fixed carbon content is an indicator for the better fuel attributes and found in WS with a large range of 13.63 while SS acquire the lowest range of 4.57. Additionally, higher fixed carbon content favors in higher char yields which can be burned as fuel. AE and SS possess higher mean fixed carbon contents and thus they can generate value added charcoal or biochar through torrefaction or pyrolysis processes. Further, the deviation of fixed carbon content in the SS is very less as it accompanying relatively higher contents. Moreover, the ash content in the organic substances indicate the presence inorganic and trace elemental compositions. As silica found as the dominant component in agro-crop residues, WS and SS were identified with as high as 12.59 and 7.13% of silica respectively. The variations in the HHV were also analyzed and noted that PJ possess slightly higher range than the others whereas AE has the least variation, but the PJ and SS observed with maximum calorific values.

Pearson correlations between the proximate variables and HHV of selected biomass species are provided in the table 4. It was observed that the HHV correlated significantly with ash content (A) comparative with all other proximate variables. Additionally, M (moisture content) has shown better negative linear relation with volatile matter (V) and HHV. Further, comparatively a strong negative relation also ascertained between ash (A) and volatiles (V). Otherwise, the rest have shown very weak relations amongst them and deviated far from the goodness.

species

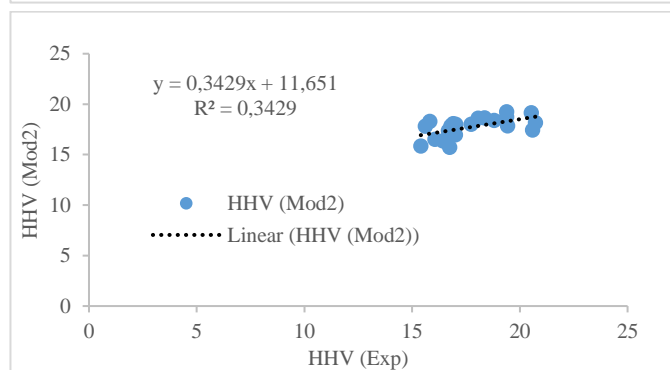
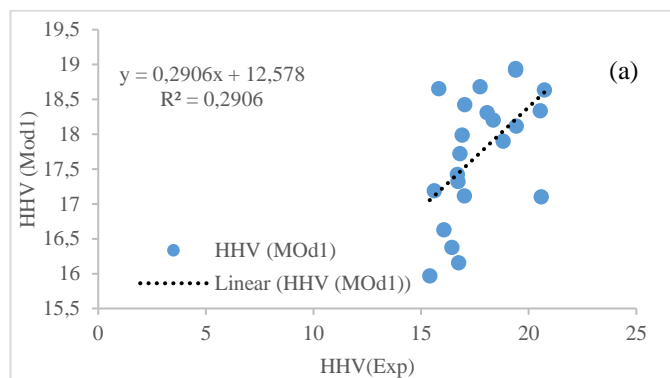
Biomass Species	Statistical Parameter	Moisture Content (M) %	Volatile Matter (V) %	Fixed Carbon (F) %	Ash Content (A) %	HHV MJ/kg
Acacia etbaica (Seraw)	Minimum	6.1027	65.03	15.796	1.1786	18.8
	Maximum	8.900	73.644	23.62	2.741	19.42
	Range	2.797	8.614	7.824	1.5624	0.62
	Mean	7.607	69.532	20.7372	2.1232	19.2
	Variance	1.989	18.665	18.481	0.690372	0.1204
Prosopis juliflora (Temri musa)	Minimum	5.1563	63.05	12.28	0.5	15.82
	Maximum	7.95	78.9	19.1	3.24	20.72
	Range	2.7937	15.85	6.82	2.74	4.9
	Mean	7.159471	73.59	15.32031	1.778071	18.3
	Variance	0.908635	29.25177	5.816399	0.863809	3.678233
Wheat straw (Sernay)	Minimum	4.821	62.4	9.67	4.23	15.4
	Maximum	12.9	71.37	23.3	12.59	17
	Range	8.079	8.97	13.63	8.36	1.6
	Mean	8.762625	68.1525	15.75405	7.34795	16.32375
	Variance	7.027638	8.872679	13.77776	6.656271	0.336313
Sorghum stalk (meshella)	Minimum	5.4384	65.38	18.45	3.6	16.8
	Maximum	7.72	69.11	23.02	7.13	20.58
	Range	2.2816	3.73	4.57	3.53	3.78
	Mean	6.4646	67.4725	20.6129	5.45	18.4475
	Variance	0.981394	3.122825	3.847063	2.669267	2.473825
Aggregated Biomass Samples	Minimum	4.821	62.4	9.67	0.5	15.4
	Maximum	12.9	78.9	23.62	12.59	20.72
	Range	8.079	16.5	13.95	12.09	5.32
	Mean	7.677155	69.94715	17.17899	4.518168	17.73091
	Variance	3.750806	20.38037	14.54394	9.450685	2.796304

**Table 4.** Pearson's Correlations among Proximate and HHV variables of Chosen Biomass Species

Variable	M	V	F	A	HHV
M	1				
V	-0.35932	1			
F	-0.12553	-0.12553	1		
A	0.021065	-0.35138	-0.22482	1	
HHV	-0.31693	0.065418	0.123873	-0.44264	1

**Table 5.** Predicted HHV models and their corresponding statistical comprehensive parameters

S.No	Model	R <sup>2</sup>	Variance
1	$HHV = 20.84276 - 0.26571M - 0.23725A$	0.290	2.192
2	$HHV = 28.51115 - 0.09765V - 0.28657A - 0.34585M$	0.343	2.144
3	$HHV = 37.65919 - 0.18001V - 0.36467A - 0.44494M - 0.13236F$	0.391	2.104



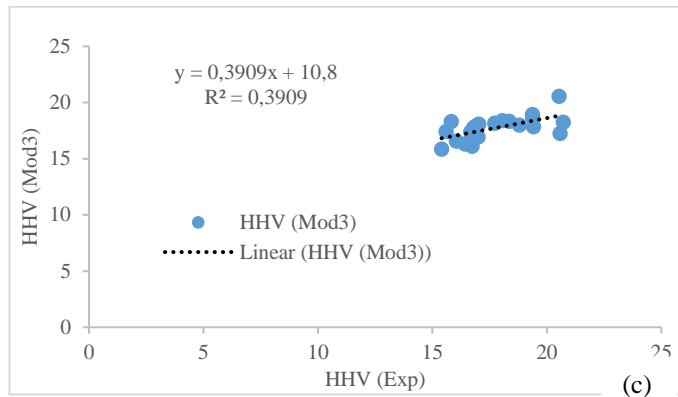


Figure 3(a-c). Multivariate linear regressions for the experimental and calculated HHV

Table 6. HHV Model fittings according to earlier reported models of biomass species

S.No	Model	R <sup>2</sup>	Variance	Reference
4	$HHV = -857.09 + 7.90M + 8.80VM + 8.90FC + 8.62A$	0.391	2.104	Ayse et al., 2019
5	$HHV = 27.2 - 0.880M - 0.021VM - 0.196A - \frac{18.4}{FC}$	0.367	2.323	Ayse et al., 2019
6	$HHV = 13.60 - 0.655M + 0.171VM - \frac{61.1}{FC}$	0.353	2.234	Ayse et al., 2019
7	$HHV = 5.21 - 0.701M + 0.175VM + 0.276FC$	0.343	2.144	Ayse et al., 2019
8	$HHV = -1.89 + 0.3357VM + 0.0553A - \frac{94.12}{FC}$	0.223	2.684	Ayse et al., 2019
9	$HHV = 167.2 - 1.449VM - 1.562FC - 1.846A$	0.206	2.589	Ayse and Serdar 2016
10	$HHV = 25.19 - 0.0503VM - 0.044FC$	0.2064	2.589	Ayse et al., 2019
11	$HHV = 55.87 + 0.6279FC + 0.3282A - \frac{3840.99}{VM}$	0.206	2.742	Ayse et al., 2019
12	$HHV = 42.60 - 0.448M + 0.527FC + 0.245A - \frac{2280}{VM}$	0.206	2.742	Ayse et al., 2019
13	$HHV = -18.37 - 0.8469FC - 1.1251A + \frac{4420}{VM}$	0.206	2.743	Ayse and Serdar 2016
14	$HHV = -17.507 + 0.3985VM + 0.2875FC$	0.205	2.456	Ayse and Serdar 2016
15	$HHV = -8.847 + 0.2901VM + 0.2956FC$	0.205	2.456	Ayse et al., 2019
16	$HHV = 44.336 + 0.286FC - \frac{2394.7}{VM}$	0.205	2.594	Ayse and Serdar 2016

17	$HHV = 18.297 - 0.4128A + \frac{35.8}{FC}$	0.201	2.607	Ayşe and Serdar 2016
18	$HHV = 22.3418 - 0.1136FC - 0.3983A$	0.196	2.483	Ayşe and Serdar 2016
19	$HHV = 18.30 - 0.968M - 0.2713A + \frac{512}{VM}$	0.109	3.075	Ayşe et al., 2019
20	$HHV = 32.77 - 0.976M - 0.101VM - 0.276A$	0.108	2.911	Ayşe et al., 2019
21	$HHV = 19.63 - 0.894M + 0.0538VM$	0.103	2.772	Ayşe et al., 2019
22	$HHV = 20.72 - 0.0056VM - 0.2956A$	0.0328	2.989	Ayşe et al., 2019
23	$HHV = 44.336 + 0.286FC - \frac{2394.7}{VM}$	0.030	3.163	Ayşe and Serdar 2016s
24	$HHV = 20.15 - 0.2927A + \frac{9.48}{VM}$	0.029	3.167	Ayşe et al., 2019
25	$HHV = 1.63 + 0.2834VM - \frac{80.26}{FC}$	0.005	3.245	Ayşe et al., 2019
26	$HHV = 5.63 + 0.1679VM$	0.004	2.923	Ayşe et al., 2019

#### 4.2 Prediction of HHV using Proximate Parameters

Proximate analysis used for the prediction of gross calorific values (HHV) of potential biomass species in Eritrea such as AE, PJ, SS and WS. Equations (1) to (3) provided in the table 5 are the comparatively better linear multivariate regression models for HHV prediction by considering proximate variables as independent parameters. Model precision coefficient  $R^2$  has ensured that the model equation (3), which has constructed based on HHV dependence on all proximate variables (A, V, F, and M) provides comparatively better prediction than others.

Several other earlier reported models from the literature tested for the prediction of an optimized model as shown in table 6 and their corresponding coefficient of model goodness ( $R^2$ ) along with variances are also reported. (Ayşe et al., 2019) has developed HHV prediction models considering proximate analysis of 39 different biomass samples that include locust bean, ash, peanut husk and sour

cherry stem etc., This work has considered 22 different samples of forest wood of PJ and AE along with agro-crop residues of SS and WS and tested with Ayşe proposed models and found with similar accuracy coefficient  $R^2$  of 0.391 which is the highest amongst the other proposed models. The functions that includes moisture content have shown better predictions in similar with conclusions made by Ayşe et al.,, while HHV holds a very poor dependence on volatiles in contrast to the earlier reports (Ayşe et al., 2019).

#### 5. Conclusion

Being the third largest source of energy in the world, biomass contributes about 61 % of total energy consumption in Eritrea despite of its substantially lower biomass production rate of 0.5 tC/ha/year. In other words, lignocellulosic materials could provide up to 50 billion tons of dry matter on a global scale whereas in Eritrea approximately 2 million tons per year of biomass are consumed, particularly in the household sector. Bushland and shrub lands spread over 43% of total land

in Eritrea, subsequently the dominant and invasive forest wood species such as acacia etbaica and prosopis juliflora have recognized as potential biomass resources for fuels applications together with major agro-crop residues from sorghum and wheat cultivations. Proximate parameters such as moisture content, volatile matter, fixed carbon amount and ash quantity are analyzed for the top four biomass resources to understand their effect on fuel attributes. Statistical analysis of proximate results has revealed that prosopis juliflora wood found with higher volatile of 73.59% while the wood of acacia etbaica contains the highest fixed carbon content of 20.73%. In addition, from the selected agro-crop residues, sorghum straw exhibited good amounts of fixed carbon of 20.61% on average. Pearson's correlation between the HHV and proximate variables showed that HHV has relatively better linear relations with ash and moisture contents. Further, the calorific values of bioenergy sources modeled as the functions of proximate variables using multivariate linear regressions and their validation proven

that they coincide with formerly reported models. Calorific values of forest wood species, temri musa (*Prosopis juliflora*) and seraw (*Acacia etbaica*) in conjunction with major crop residues of sorghum and wheat straws are assessed at 19.27, 19.38, 16.7 and 18.06 MJ/kg respectively as a function of proximate variables. Thus, acacia etbaica wood from the forest species and sorghum stalk of the agro-crop residues are proven to be the best bioenergy sources for Eritrea.

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## EVALUATING THE SUSTAINABILITY OF SUGAR VALUE CHAIN: EVIDENCE FROM VIETNAM

**Abstract:** *This paper investigates the sugar value chain in Vietnam and evaluates its sustainability using integrative indicators based on the Triple Bottom Line (TBL) approach. A set of 27 indicators were used in our survey of key stakeholders in the sugar value chain of Vietnam. After 2 months, we received 482 questionnaires and retained 473 valid responses. Our findings show that there are still many challenges for the Vietnamese sugar value chain to grow sustainably. Thus, we proposed some suggestions to enhance the sustainability of the Vietnamese sugar value chain.*

**Keywords:** *Sugar value chain, Sustainable development, Triple Bottom Line, Vietnam*

### 1. Introduction

In recent decades, increased worldwide competitiveness and decreased commodity prices have led to agriculture sectors pursuing value chain possibilities to boost profitability and sustainability (Martin, 2001; Boehlje, 1999). Martin (2001) highlights other drivers, including the industrialisation of agriculture as farming shifts from a rural lifestyle to an agribusiness sector with a value chain mentality. Sugar industries around the world are no exception. The long-term sugar price trend has been downwards despite the costs of production generally has been increasing. Increased competition from new potent sweeteners as sugar substitutes may put more pressure on sugar pricing (Higgins et al., 2007). Furthermore, sugar production (per hectare) has stayed stable or decreased in many established sugarcane-growing regions during the last three to five decades (Meyer and Van Antwerpen, 2001; Garside et al., 2001). These challenges have resulted in a greater emphasis on value chain solutions to boost profitability.

In Vietnam, the sugar industry is essential and plays a vital role in agriculture-based industries. In the last 5 years, the Vietnamese sugar industry has suffered severe losses due to the impact of the unequal business environment. Over the years, the devaluation of sugar from Thailand has found many ways to enter the Vietnamese market, causing the domestic sugar price to drop below production costs. As a result, the local sugar factories are forced to sell sugar below the production cost, leading to severe damage to the sugar industry in Vietnam. In addition, climate change is also causing difficulties for the Vietnamese sugar industry. Prolonged drought, and quick drying of sugarcane lead to reduced weight and quality of sugarcane in the last months of harvest and high transportation costs. Processing and taking advantage of by-products after processing sugar are not much. In other words, the Vietnamese sugar industry is in a precarious stage.

As a result, there is a quest to maintain the sustainability of the Vietnamese sugar

industry. In this regard, it is essential to explore and evaluate the sustainability of the sugar value chain in Vietnam and raise some suggestions to improve the value chain.

## **2. Literature review**

### **2.1. Value chain and sugar value chain**

The value chain concept was developed and popularized in 1985 by Michael Porter, in “Competitive Advantage,” a seminal work on the implementation of competitive strategy to achieve superior business performance. Porter (1985) defined value as the amount buyers are willing to pay for what a firm provides. He conceived the “value chain” as the combination of nine generic value-added activities operating within a firm – activities that work together to provide value to customers. Porter linked up the value chains between firms to form a Value System. However, in the present era of greater outsourcing and collaboration, the linkage between multiple firms’ value-creating processes has more commonly become called the “value chain.” As this name implies, the primary focus in value chains is on the benefits that accrue to customers, the interdependent processes that generate value, and the resulting demand and funds flow that are created. Effective value chains generate profits.

In the agriculture sector, the value chain approach provides a systematic process to improve market linkage for farmers (Ferris et al., 2014). It provides a framework for identifying key constraints and considering appropriate solutions (Orozco-Romero et al., 2020). These constraints and solutions require a coordinated response by different stakeholders in the chain, which necessitates trust and a willingness to collaborate (USAID, 2012). Through the value chain approach, one can understand the farmer-trader relationship, power dynamics, and the distribution of benefits. According to Rota and Sperandini (2010), value chain analysis is essential to an understanding of markets, their

relationships, the participation of different actors, and the critical constraints that limit the growth of agricultural production and, consequently the competitiveness of smallholder farmers. These farmers currently receive only a small fraction of the ultimate value of their output.

Sugar industries worldwide are primarily “push chains”, where sugarcane is pushed through the chain to produce raw sugar with minimal product differentiation and sold at market value as a bulk commodity. A general sugar value chain consists of growing, harvesting, cane transport, mill processing, sugar transport, and storage/shipping/marketing sectors.

### **2.2. Sustainability of the sugar value chain**

The sustainability of the sugar value chain has been of primary concern for researchers and practitioners in recent decades. As a result, various issues related to the value chain have been discussed. For example, Higgins and Laredo (2006) explored the Australian sugar industry and proposed an analytical framework to model the components involved in the harvesting and transportation of sugar cane products in the value chain. Research by Higgins and Laredo (2006) showed that there are several key points for improvement, such as rearranging the harvesting process or streamlining the transportation infrastructure that will help increase the return value for stakeholders.

Similarly, Archer et al. (2008) conducted a review of the studies on the sugar value chain and elucidated the challenges in this research topic. These authors compared the sugar industry of Australia and South Africa, thereby pointing out solutions to develop the sugarcane value chain that not only include technical solutions but also need collaborative participation throughout the chain, and regularly change in a disruptive way. Accordingly, the sugar value chain should be developed in a lean and flexible

direction.

Kalinda and Chisanga (2014) studied the sugar value chain in Zambia and pointed out the opportunities and challenges for the development of the sugar industry. The specialty of the Zambian sugar industry is that it is a monopolistic industry with only one business, contributing 4% of the country's GDP and 6% of the country's total exports.

Perlata and Navarrete (2017) researched the problem of creating shared value in the sugar industry and offers a model that proposes 6 steps to choose a strategy to create shared value in the enterprise's value chain. According to these two authors, shared values are reinforced through supplier development. In another study, Manda et al. (2020) explores the factors influencing the participation of farmers in the sugarcane value chain and examines the preconditions required to secure the benefits and forms of participation, suitable for local groups in the chain.

Srichanthamit and Tipayawong (2018) designed and developed a set of criteria for evaluating value chain performance for the sugar industry based on value chain management theory and case studies. In this study, Srichanthamit and Tipayawong (2018) use a quality function development (QFD) tool to integrate with value chain activities and find success factors with different evaluation weights, together. This set of indicators is applied to the case study of a sugar factory to assess its relevance to practice. Research results show that this set of criteria can be used by sugar mills for internal evaluation.

In general, researches on the value chain in the sugar industry in the world have focused mainly on value chain tools to assess the current situation of the value chain and find solutions to improve the performance of the sugar industry. A few studies have addressed the value chain evaluation criteria, but none have directly addressed the sustainability of the sugar value chain. Similarly, in Vietnam, studies on the sugar industry have been

conducted, but in-depth studies on the sugar value chain and its sustainability are not available.

### **2.3. Evaluating sustainability of a value chain**

The sustainability of the value chain can be expressed simultaneously along three dimensions: economic, social and environmental or triple bottom line (profit, people and planet) (Gebre & Rik, 2016). On the economic dimension, an existing or proposed upgraded value chain is considered sustainable if the required activities at the level of each actor or support provider are commercially profitable. On the social dimension, sustainability refers to socially acceptable outcomes in terms of the distribution of the benefits and costs associated with increased value creation. On the environmental dimension, sustainability is determined largely by the ability of value chain actors to show little or no negative impact on the natural environment from their value-adding activities; where possible, they should show a positive impact (Neven, 2014). Sustainability indicators are particularly hard to define and measure. The basic problem is that sustainability only occurs in the future while the indicators are measured in the present (USAID, 2012). Although the three sustainability dimensions (social, environmental, and economic) are treated individually here for clarity, in practice they overlap (USAID, 2012). Once the core processes of the value chain are mapped, indicators must be associated with each chain, for the three sustainability dimensions. The indicator selection depends on the level of the organization and the type of activities (Moreno & Salgado, 2012).

Previous conventional life cycle assessment models in the past often focused on sustainability indicators such as raw materials, energy, emissions, etc. These indicators are chosen because they are directly related to all stages in the value chain

and can be quantified. However, it is not simple to assess the socioeconomic impact of the value chain of a specific product. In such a context, we propose that there is a need for multiple methods of measuring socioeconomic criteria to describe the relationship between products and socioeconomic impacts, which can be successfully integrated into the traditional analysis framework. In our classification, economic and social indicators are divided into two categories: additive and descriptive. The additive indicators must meet two criteria: (1) they can be measured quantitatively, and (2) they are related to production volume so that they can be cumulative throughout the value chain. For example, production cost, labor cost, and value added per unit. In addition, some socioeconomic indicators to measure sustainability that is widely considered fail to meet the requirement to be additives because they are not directly related to production. This classification is suitable for measuring social and environmental aspects (Kruse et al., 2009). Descriptive indicators can be divided into general and specific indicators based on the viewpoints or the different social contexts. The general indicators are often used to describe widely accepted social values, such as working conditions in relation to the minimum wage, social benefits, number of working hours per week, the gender ratio, etc. On the other hand, specific indicators are those factors that cannot be widely applied in any industry. These indicators focus on measuring the economic, social, and environmental impact of a specific product or procedure. They are qualitatively or quantitatively measured, but their comparison ability of these indicators are limited to similar production system. For example, the impact of pesticide use on workers can become a major concern in the sugar industry but not in the fishery industry. From a sustainability viewpoint, specific descriptive indicators allow us to focus on

sustainability issues related to a particular product.

### **3. Methodology**

#### **3.1. Sample and procedures**

The primary data collection process is divided into two phases. At the first stage, we asked 57 experts and researchers who have grasp of knowledge of Nghe An sugar value chain to assess the suitability and feasibility of 51 triple-bottom-line-based indicators that were gathered from previous research including Balkau and Sonnemann (2021), Petit et al. (2019), Yakovleva (2007), Fearn and Garcia (2012), Warhust (2002), Hassini (2015), Tarekn et al. (2020). The sample consisted of 50% women and 46.4% men. The age of survey participants ranged from 28 to 60 years, with 91% of an age between 28 to 57. University or higher education accounted for 73.2% participants. This percentage would improve the quality of the evaluation results. Moreover, the percentage of respondents who know the value chain accounts for 83.9%, which is also another indicator of the quality of the responses.

27 out of 51 indicators are judged to be relevant and feasibility, with the percentage of raters agreeing or completely agreeing over 75%. For example, the item “Sugarcane farmers take part in training programs on planting and managing arable land” was assessed by 83.6% of experts as an appropriate indicator. The Krippendorff’s Alpha index of all the 27 indicators is greater than 0.667 (Landis & Koch, 1977), indicating consensus in the expert responses about the relevance and feasibility of the criteria. 24 indicators were excluded because they are not relevant to the condition of Nghe An sugarcane industry or not feasible to measure their impact. For example, the indicator “Discrimination between men and women in the sugarcane industry” may be not a suitable criterion for measuring sustainability. Particularly, the topographical condition for sugarcane cultivation are sloping and

scattered in Nghe An, which does not create favorable conditions for mechanization in sugarcane planting and harvesting activities. As a result, the disproportion between male and female labor is inevitable.

In the second stage, the questionnaires which consist of the 27 selected indicators in the first stage were sent out to a broader range of stakeholders, such as farmers, sugar mills, cooperatives, suppliers, distributors and public administrators to measure the sustainability of Nghe An sugarcane value chain

With the goal of evaluating the sustainability of sugar value chain in Vietnam, we decided to chose Nghe An province as an representative sample because the province demonstrates the average typical features of various sugar chain regions in Vietnam. In the crop year 2021-2022, the total area of raw sugarcane in Nghe An reaches 19,223 hectares, concentrated in the following districts: Quy Hop 4,961 hectares; Tan Ky 3,171 hectares; Nghia Dan 7,600 hectares; Quy Chau 1,158 hectares; Quynh Luu 936 hectares; Anh Son 449 hectares. The average yield of sugarcane is nearly 61.0 tons/ha; output reached 1,173,000 tons, serving 3 sugar processing factories with a total designed capacity of 15,500 tons of sugarcane/day.

To identify the target population, we gathered contact information of the sugar value chain's stakeholders through the support of officials from Nghe An Department of Agriculture and Rural Development. We randomly selected 987 stakeholders, including farmers, employees in sugar mills, cooperatives, suppliers, distributors and public administrators, and invited them to participate in both our web-based survey via email and paper-pencil-based survey. We received 482 questionnaires, which corresponds to a 48.8% response rate. After dropping questionnaires with incomplete data (missing data greater than 5%) and reckless responses, we retained

473 responses in total. Our sample consists of ten groups, including cooperative farmers (N=101), individual farmers (N=55), dealers (N=21), retailers (N=10), cooperative leaders (N=98), sugar mill employees (N=112), transport, local government officials (N=20), agricultural advisors (N=20), transporters (N=26), material and tool suppliers (N=10). The proportion of the sample represents the true proportion of the stakeholders in Nghe An sugar value chain. The education of survey respondents were primarily high school and vocational degree (66.6%). Age mostly ranges from 28 to 47 years old (72.1%) and the majority of respondents were males (71.7%).

### 3.2. Measures

Measures used in this study were adapted from established scales. We used multi-item scales based on 5-point Likert scales from "1" (strongly disagree) to "5" (strongly agree), unless otherwise stated.

We captured the economic dimension through eight items from Yakovleva (2007), and Hassini (2015). The items of the scale ask respondents to evaluate how sustainable the economic indicators are. A sample item is "Income from the value chain ensures essential needs" with a five-point Likert scale ("1" = "Strongly disagree", "5" = "Strongly agree"). Cronbach's alpha of the scale is 0.86. The social aspect was measured using twelve items taken from Mayer (2008), Labuschagne and Van Erck (2005). The items indicate how sustainable the social criteria of the sugarcane value chain are, and they are coded on a five-point Likert scale ("1" = "Strongly disagree" to "5" = "Strongly agree"). A sample item, for example, is "workers are guaranteed safety in the workplace". The scale has a Cronbach's alpha of 0.90. The environmental aspect was measured using seven items collected from Darmawan et al. (2014), Gebre and Rik (2016). The items indicate how sustainable the environmental criteria of the sugarcane value chain are. A sample item is

“Stakeholders in the value chain using renewable energy sources”. The scale has a Cronbach’s alpha of 0.76.

## **4. Results and discussions**

### **4.1. Preliminary analysis**

We conducted confirmatory factor analysis (CFA) on all multi-item scales using R to validate the scales. We conceptualised ‘economic’, ‘social’, ‘environmental’ as first-order factors, which can be freely correlated. We used Chi-square statistics and practical fit indices to evaluate model fit. In particular, standardized root-mean-square residual (SRMR) with a cut-off value of 0.08, root-mean-square error of approximation (RMSEA) with a cut-off value of .06, and comparative fit index (CFI) with a cut-off value of 0.95 were used as evidence of good model fit (Hu & Bentler, 1998). After deleting 6 items with a modification index greater than 30, the results of this analysis indicate good model fit:  $\chi^2 (186) = 567.556$ ; CFI = .951; SRMR = .0049; RMSEA = .061 (see Table 1 in the Appendix). Furthermore, all standardized loading estimates are higher than 0.50 (Hair et al. 2010) (see Table 2 in the Appendix), average variance extracted (AVE) and composite reliability (C.R) of all the factors in the model greater than 0.50 and 0.70 respectively are indicators of convergent validity. Discriminant validity was tested by a more rigorous test which requires the AVE of each of the latent constructs to be higher than the highest squared correlation with any other latent variable in the model (Fornell & Larcker 1981). These conditions were met suggesting discriminant validity (see Table 3 in the Appendix).

### **4.2. Analysis of sustainability indicators**

To evaluate the sustainability of the sugar value chain in Vietnam, we calculate the mean value of each indicator by 10 groups of respondents and sum up in total of 473 respondents ( see Table 4 in the Appendix).

As shown in Table 4, the mean values of 6 economic indicators range from 3.19 to 3.55 (higher than 3.00). Thus, we might conclude that the sugar value chain is not sustainable in terms of economic aspects. Among the 6 economic indicators, logistics cost (Q15) has the highest mean value of 3.55 and labor cost (Q13) has the lowest mean value of 3.19. Other economic indicators have a mean value of around 3.50. Thus, it is implied that the Vietnamese sugar value chain is facing many challenges to be economically sustainable. This finding is attributed to the fact that the Vietnamese sugar industry has been severely impacted by fierce competition from illegally imported sugar from Thailand and other issues such as drought, flood, and diseases. As a result, sugar companies have to sell sugar at an extremely low price, even lower than the production cost. In turn, they pay very little to farmers who grow the sugarcane. Therefore, farmers are disappointed and do not want to commit to the sugar mills to grow sugarcane and maintain the long-term input supply. This finding is typical for the case of Vietnam.

Regarding the social aspect, 11 indicators are retained in our measurement to evaluate the sustainability of the sugar value chain. Table 4 reveals that the mean values of social indicators range from 3.66 to 3.92. Notably, 8 out of 11 indicators have mean values higher than 3.80, indicating that all respondents agree that the sugar value chain is socially sustainable. Some indicators in this measurement achieve quite a high mean value (over 3.80), such as “tax payment to the government budget” (Q21), “clear regulations for recalling defective products” (Q35), “participating in training farmers on sugarcane planting and relevant skills” (Q36). The mentioned activities are taken by the sugar mills and are related to different stakeholders in the value chain, including the government, consumers, and the local community. Therefore, it is implied that sugar mills play a critical role in socially improving

the value chain's sustainability. In the case of our study, Nghe An province is a big area where the living condition and average income of the civils are still low. Thus, the appearance of big and modern sugar mills is very critical to the sustainable growth of the industry and the region.

In terms of the environmental aspect, we have 4 indicators in the measurement, of which the issue related to "improving the fertility of the soil" (Q56) achieves the highest mean value of 3.91. The lowest mean value of the environmental indicator is 3.66 (Q40), which is "using recycling packaging". These findings are in line with some previous studies of the food value chain, such as Yakovleva (2007), or the banana value chain of Gebre et al. (2020).

In addition, it is notable in our study that among the 10 groups of respondents, dealers and retailers tend to rate most indicators at a higher value than other groups, showing that they are very optimistic about the sustainability of the Vietnamese sugar value chain. On the contrary, agricultural advisors and cooperative farmers always give lower scores to all indicators than other groups. This finding implies that agricultural advisors and collective farmers are less optimistic about the sustainability of the Vietnamese sugar value chain than the remaining respondents. The doubt of these two groups regarding the sustainability of the sugar value chain might be explained by their deep engagement in the value chain and their daily exposure to the activities of sugarcane growing. Furthermore, these two groups are believed to be more knowledgeable of the sugar value chain than the dealers and retailers.

## 5. Recommendations and conclusion

In the present study, we evaluate the sustainability of the Vietnamese sugar value chain from the stakholder perspective. We

## References:

found that the sugar value chain seems to be more sustainable in terms of social and environmental aspects than economic aspect. From our findings, we suggest that some key stakeholders should be more active in promoting the sustainability of the value chain, who are the sugar mills, the local government and the supporting organizations in the industry. For example, financial shortage is one problem for farmers to maintain their growing and harvesting process. Thus, to enhance the economic sustainability of the value chain, it is essential to prioritize the loan for poor farmers so that they can invest in sugarcane growing. Banks and sugar mills should joint hand to support farmers access the loan. In addition, we strongly recommend sugar companies should also take their responsibility in promoting the sustainability of the sugar value chain. Sugar companies participate in many phases of the value chain so they have wide sphere of influences on the farmers, the input suppliers, the distributors. Thus, they will be able to guide farmers and encourage them to grow sugarcane and commit a to buy sugarcane from farmers at a stable and profitable price. Furthermore, local government should admend the policies to strengthen the relationship among farmers, sugar mills, dealers, retailers and other stakeholders. This study has some limitations. Sample size is small so that the research results might not be generalized for the whole sugar industry in Vietnam. Moreover, we have not yet applied in-depth interview method to further explore the reasons for unsustainable issues. Thus, we suggest that future study should expand the survey to other provinces in Vietnam and employ more qualitative methods.

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**Appendix**

**Table 1.** Results of CFA for Model Comparison (N=473)

N	Model	$\chi^2$	df	SRMR	CFI	RMSEA	C.I. 90
473	Single factor model	1001.40	189	.11	.79	.12	.110 - .130
473	Two factor model	787.73	188	.09	.87	.09	.081 - .099
473	Three factor model	567.56	186	.05	.95	.06	.054 - .066

**Table 2.** Results of CFA for Triple-bottom-line Sustainability Model (N=473)

Items				Factor Loading
...production cost	Q10	<---	Economic	.77
...labor cost	Q11	<---	Economic	.79
...added value	Q12	<---	Economic	.78
...production hours	Q13	<---	Economic	.73
...logistic costs	Q15	<---	Economic	.75
...main income comes from the value chain	Q16	<---	Economic	.71
...tax payment to local government budget	Q21	<---	Social	.74
...transparency of product information	Q23	<---	Social	.78
...clear instruction for workplace safety	Q28	<---	Social	.79
...clear regulation for recalling defective product	Q35	<---	Social	.85
...participate in training on planting and relevant skills	Q36	<---	Social	.77
...participation in charitable activities	Q37	<---	Social	.83
...support for harvesting sugarcane	Q42	<---	Social	.75

Items				Factor Loading
...support for improving financial capital accessibility	Q45	<---	Social	.70
...gain support for improving arable land management	Q49	<---	Social	.70
...join cooperatives gains more benefits	Q50	<---	Social	.77
...support for planting effective sugarcane varieties	Q58	<---	Social	.73
...reduce environmental impact by technology and science	Q38	<---	Environmental	.82
...use renewable energy sources	Q39	<---	Environmental	.77
...use recyclable packaging	Q40	<---	Environmental	.70
...implement measures to improve the fertility of the soil	Q56	<---	Environmental	.83

**Table 3.** Factor Correlation Matrix with squared root of AVE on the diagonal

	CR	AVE	1	2	3
1. Economic	0.86	0.69	(0.83)		
2. Social	0.90	0.69	0.71	(0.83)	
3. Environmental	0.76	0.62	0.68	0.75	(0.79)

CR: Construct reliability

AVE: Average variance extracted

**Table 4.** Mean and SD of sustainability indicators (N = 473)

	Criteria	Mean	SD	Agricultural advisors	Cooperative farmers	Government staff	Dealers	Retailers	Transporters	Material & tool suppliers	Cooperative leaders	Individual farmers	Sugar mill employees
<b>Economic</b>	Q10	<b>3.36</b>	0.84	2.90	3.05	3.2	4.38	4.10	3.42	4.10	3.07	3.69	3.52
	Q11	<b>3.44</b>	0.91	2.95	2.98	3.40	4.33	4.10	3.46	4.00	3.44	3.53	3.63
	Q12	<b>3.54</b>	0.81	3.35	3.09	3.70	4.29	4.00	3.50	4.20	3.66	3.58	3.58
	Q13	<b>3.19</b>	0.88	3.10	2.88	3.45	4.24	3.90	3.38	3.80	2.85	3.51	3.23
	Q15	<b>3.55</b>	0.81	3.20	3.26	3.40	4.23	4.10	3.65	3.90	3.40	3.69	3.71
	Q16	<b>3.53</b>	0.89	3.45	3.39	2.45	3.76	3.50	3.46	3.60	3.42	3.76	3.83
<b>Social</b>	Q21	<b>3.83</b>	0.73	3.65	3.66	4.40	4.33	3.60	3.46	4.20	3.72	3.78	4.00
	Q23	<b>3.78</b>	0.74	3.85	3.59	3.90	4.28	3.60	3.50	4.10	3.66	3.74	3.99
	Q28	<b>3.92</b>	0.66	4.00	3.76	3.75	4.33	4.30	3.88	4.10	3.84	3.96	4.01
	Q35	<b>3.83</b>	0.66	3.95	3.68	3.50	4.29	3.90	3.69	4.20	3.75	3.90	3.93
	Q36	<b>3.85</b>	0.67	3.85	3.68	3.75	4.28	4.00	3.69	4.30	3.76	3.93	3.95
	Q37	<b>3.85</b>	0.67	3.75	3.71	3.80	4.33	4.00	3.77	4.30	3.72	3.84	3.97
Q42	<b>3.83</b>	0.67	3.90	3.77	3.40	4.14	3.90	3.58	3.80	3.87	3.84	3.90	

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	Q45	<b>3.74</b>	0.71	3.60	3.71	3.40	3.81	4.00	3.65	4.00	3.79	3.93	3.69
	Q49	<b>3.80</b>	0.66	3.85	3.87	3.30	4.33	4.20	3.42	4.00	3.65	3.80	3.87
	Q50	<b>3.84</b>	0.72	3.55	3.72	3.45	4.38	4.20	3.61	3.80	3.72	3.94	4.02
	Q58	<b>3.66</b>	0.69	3.60	3.78	3.90	4.57	4.50	3.54	4.00	3.68	3.93	4.02
<b>Environment</b>	Q38	<b>3.77</b>	0.66	3.75	3.61	3.55	4.29	4.10	3.73	4.30	3.73	3.84	3.77
	Q39	<b>3.74</b>	0.69	3.85	3.66	3.45	4.43	3.80	3.50	4.10	3.62	3.78	3.83
	Q40	<b>3.66</b>	0.71	3.80	3.58	3.35	4.43	3.80	3.46	3.80	3.64	3.71	3.62
	Q56	<b>3.91</b>	0.60	3.90	3.82	3.60	4.43	4.30	3.65	3.80	3.88	4.04	3.95

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# **14. International Quality Conference**



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## STUDING THE INTERRELATIONSHIP BETWEEN QUALITY MANAGEMENT SYSTEM AND INTELLECTUAL CAPITAL

**Abstract:** *The aim of this study is to analyse the relationship between the quality management system (QMS) and the intellectual capital (IC) of a company. The importance of IC results from its potential to generate value, especially in the knowledge-based economy. It reflects unique organizational resources which are hard to acquire, imitate and replace. Such resources are most often grouped using trichotomous categorization into human, structural, and relational capital. As there is scarce literature examining the interrelationship between QMS and IC, this study aims to explore the way QMS enhances IC, but also how IC impacts QMS. The role of motivation for implementing a formal QMS is examined in light of IC efficiency and value-added based on IC. The results indicate a mutually reinforcing role of QMS and IC, leading to superior company performance.*

**Keywords:** *intellectual capital, quality management system, knowledge, performance*

### 1. Introduction

Quality management system (QMS) is oriented towards improvement of business performance through reducing customer complaints, costs and errors, increasing efficiency and employee motivation, as well as through exceeding customer expectations.

Research has shown that QMS can improve business performance, while the focus was on measuring the past performance. Given that the current business environment is very dynamic, looking at the rearview mirror while driving forward is not the best option. Thus, it is necessary to analyse whether QMS helps companies to create value in the future. Intellectual capital (IC) represents a set of a company's immaterial resources, which are rather hard and time-consuming to be acquired, but as such they are hard to be

replaced or imitated by competition, thus providing the base for competitive advantage. According to the Resource Based View (RBV), companies gain competitive advantage if they possess resources which are rare, valuable, unspstiuable, and imperfectly imitable. Unlike material assets which can be easily acquired, immaterial assets need development within the company. Consequently, such assets are context-dependent and create value only in that specific environment. IC represents a company's unique capabilities and an invisible infrastructure for value creation. It is dynamic by its nature, enabling a company to evolve in a changing context.

Ruiz et al. (2018) studied the influence of total quality management (TQM) on firms' intellectual capital, finding a strong positive causal effect. Milovanović et al. (2021)

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assert that “IC provides key support to the QM process”, while, at the same time “through the QM process, companies exploit and increase the value of its IC”. The authors proposed further examination of IC contribution to improving the QM process.

In order to examine the contribution of QMS adjusted to the requirements of ISO 9001:2015 to the company’s ability to create value in the future, this study employs the concept of IC. Moreover, it examines the two-way relationship between QMS and IC, following the suggestions of the previous research. The results support a mutual reinforcing effect of QM and IC, leading to improved business performance on the sustainable basis. Additionally, it is found that motives for employing a formal QMS, such as ISO 9001, impact IC efficiency and value-added based on IC.

## 2. Quality management system

Oakland (2004, p. 270) defines quality management system (QMS) “as an assembly of components, such as the management structure, responsibilities, processes and resources for implementing quality management”. The author asserts that interactions between components of QMS are as important as the components themselves, and that it is important to understand the functioning of the system, instead of analyzing the individual components. QMS begins with identification of customer needs, and finishes with their satisfaction, involving all activities grouped in four major areas: management responsibility, resource management, product realization, and measurement, analysis and improvement.

According to Purushothama (2010), the concept of QMS originated from the Second World War but was kept as a military secret until 1976, when the British Standards Institution published BS 5750. It was accepted by the International Organization for Standardization (ISO) in Geneva as a

series of ISO 9000 standards, published in 1987 amended in 1994, 2000, 2008 and 2015. The amendments are a consequence of the mechanism of reviewing the adaptability of the management system to the changing business environment. The number of companies that align their management system with the requirements of the ISO 9001 standard is growing. As of December 31, 2021 the total number of valid ISO 9001:2015 certificates was 1,077,884. The reasons for the great popularity of the ISO 9001 certificate are numerous. Unlike regional or national quality awards that can be used as a framework for achieving business excellence, these standards are much more widespread. The formation of free trade zones such as EC, EFTA, NAFTA and others, imposes the need for certification according to the ISO 9001 standard. Certification can help companies to build a system that will minimize the risk of injuries and harmful effects of products, which can result in high fines for the company. Companies use ISO 9001 certificates as a basis for choosing business partners, and public tenders in many countries today are difficult to win without an ISO 9001 certificate.

ISO 9000:2015 describes contemporary business environment as profoundly different from recent decades. The family of standards for quality management recognises the role of knowledge as a principal resource in a changing environment where stakeholders are becoming more demanding. For the first time this amendment presents quality management as a strategic process, and includes risk-based thinking. The idea is to drive companies towards sustainable development, instead of concentrating on customer satisfaction and efficiency only. In earlier editions of the ISO 9001 standard, the concept of risk-based thinking was implicit and expressed through guidelines for preventive action. QMS is defined by ISO 9000:2015 as a dynamic system that evolves



through improvements. It is a set of activities by which the organization identifies its goals and determines the processes and resources required to achieve the desired results. A QMS is supposed to be “flexible and adaptable within the complexities of the organizational context” (ISO 9000:2015). It is highlighted that each organisation’s QMS is unique, and it has to be compliant to the organisational needs. The standards specify seven quality management principles as the basis for QMS: customer focus, leadership, engagement of people, process approach, improvement, evidence-based decision making, and relationship management. A cohesive QMS is a formal program of managing quality activities in order to improve business performance. Some of the benefits are reflected in customer loyalty, market share, operational efficiency, flexibility, use of resources, cost reduction, competitive advantage, employee motivation, reputation and control of all processes (Purushothama, 2010).

Besides ISO 9000 standards, there are several alternatives that can serve as guidelines for building an effective QMS, such as quality awards (Deming Prize, Malcolm Baldrige National Quality Award, European Quality Award etc.) and the European Foundation for Quality Management Excellence Model – EFQM. The awards promote performance excellence and guide businesses towards improvement of competitiveness through criteria used to evaluate organizations. Fernández Pérez and Gutiérrez Gutiérrez (2013) find that different alternatives have a different impact on the network of relationships that management achieves with the external environment, through which it accesses information and knowledge, and which has a positive impact on the company's strategic flexibility and organizational learning. Companies that do not adhere to quality management guidelines face a negative impact of the diversity of external relations networks on strategic

flexibility and organizational learning, while the aforementioned negative impact is absent if companies have implemented ISO standards.

### 3. Intellectual capital

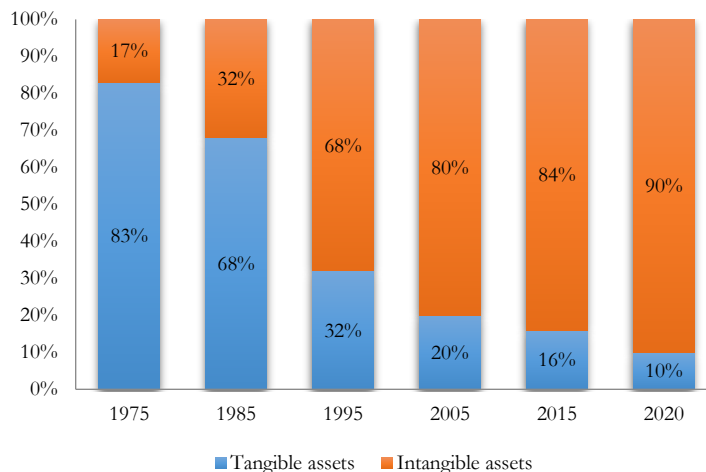
According to Janošević (2019), IC represents a set of different types of intangible resources, which significantly contributes to the creation of value and improvement of the company's competitive position in today's knowledge-based economy or information era. The reason is that intangible resources have a greater potential for value creation because, compared to tangible resources, they are harder to imitate and unsuitable for substitution. According to this author, the key characteristics of IC are: (1) IC generates future benefits, (2) IC potency is based on intangible resources, (3) IC can be input and output of the value creation process, (4) value created by using IC is indirect, (5) IC components are connected to each other and to tangible assets (physical and financial), (6) IC is directly related to knowledge management process, (7) IC is difficult to imitate and substitute, (8) certain elements of IC can determine the competitive environment of the branch and sources of sustainable competitive advantage, (9) unlike material assets whose value decreases with use, the value of IC increases with use, and (10) IC changes the rules of competing, the process of strategy formulation and implementation, and the ways of measuring success.

The literature offers numerous definitions of IC. Stewart (1998) defines IC as the collective brain power that encompasses knowledge, information, intellectual property and experience that can be harnessed to create wealth. According to Rastogi (2003), IC can be seen as the holistic ability of a company to coordinate, manage and deploy its knowledge resources with the aim of creating value in the future. Similar to

conceptual determination of IC, there are also differences regarding its constituent elements. It has been perceived as a set of competencies of employees, internal structure and external structure (Sveiby, 1997); marketable assets, human capital, intellectual property and infrastructure (Brooking, 1997); human capital and organisational (structural) capital (Roos & Roos, 1997); human capital, organizational (structural) capital and customer capital (Stewart, 1998); research and development, advertising (brand support), capital expenditure, information systems and technology appropriation (Gu & Lev, 2001);

human capital, customer capital, structural capital, social capital, technological capital and spiritual capital (Khaliq et al., 2015); human capital, structural capital and relational capital (MERITUM, 2002).

The rising importance of IC can be best observed by looking at the components of market value of the S&P 500 in the USA over the years provided by Ocean Tomo (2020). Figure 1 illustrates this phenomenon, showing that participation of IC in total assets has grown enormously (73% for the period of 45 years). The most impressive fact is that the portion of IC is approaching the value of total assets.



**Figure 1.** Components of S&P 500 market value in the USA

Source: Ocean Tomo (2020). Study of Intangible Asset Market Value. Available at: <http://www.oceantomo.com/intangible-asset-market-value-study/>, Retrieved 13.04.2023

#### 4. Relationship between QMS and IC

Quality management by its definition is a broader concept than IC. It is a process aiming to assure a company's competitiveness, while IC is perceived as the

main resource that can be used for achieving competitive advantage. Nevertheless, it is assumed that QMS can help in developing IC, and that IC supports QMS, leading to superior business performance. Several researchers have recognized connection between the two concepts. For example, Kim et al. (2009) proposed a framework for

managing IC based on ISO 9001 QMS. Ruiz et al. (2018) examined the influence of total quality management (TQM) on IC and found a strong positive effect. By studying the impact of IC on the firm's performance, Yousaf (2022) found that EFQM model also enhances the firm's performance. Claver-Cortes et al. (2018) found that international quality standards lead to competitiveness, as they demand adaptations to infrastructure and processes, while trainings enabled transformation of tacit into explicit knowledge. Further, organizational culture was strengthened, headed by the management's commitment and followed by employees' involvement in decision-making and teamwork. Majority of companies experienced opening of new markets and establishing alliances. Therefore, quality standards led to improvement of human, structural and relational dimensions of IC in examined companies, which observed improved innovativeness and operational and market performance.

However, to date and according to the authors' knowledge, there are no studies examining the relationship between ISO 9001 QMS and IC. This study therefore attempts to fill this research gap by proposing a model for examination of such relationship. Figure 2 illustrates assumed relationship between QMS and IC. QMS is presented through its principles defined by ISO 9001, while IC is composed of human, structural and relational capital. Elements of each IC component are systematized based on previous research (Janošević, 2019; Janošević & Dženopoljac, 2015, Martin-de-Castro et al., 2011). When having a strong focus on customers, the organization is learning about their requirements, needs and expectations, thus generating a knowledge that will be used for improving products, services and processes in order to increase customers' satisfaction, market share and improve reputation. It is thus supposed that customer focus positively impacts human

capital (relationship a).

Leadership plays a pivotal role in the QM process through goals setting, strategy formulation, resources allocation, communication and leading by example, which is essential for employee motivation and enthusiasm (relationship b). Leaders are responsible for organizational structure and culture, business strategy and management process (relationship c).

Engagement of people is concerned with their involvement, training and empowerment, contributing to improving employees' knowledge, skills and motivation (relationship d). Procedures are created to direct employees and standardize their performance and are especially beneficial for the newly employed (relationship e).

The idea of process approach is to manage interrelated processes in order to improve effectiveness and efficiency of the system, and to exploit synergy as a source of competitive advantage. This principle leads to improved awareness of the customers' needs across the organization and to improved motivation and enthusiasm of employees, as they become aware of their role in the system, but also of the importance of other positions and interdependences (relationship f). This is very effective in breaking down inter-functional barriers.

Improvement demands continuous quest for possibilities to create value, either regarding customer satisfaction or lowering costs, increasing speed, efficiency, productivity and so on. This principle is extremely important in a high competitive environment, and it may determine survival of the company. A pursuit for improvement opportunities enhances creativity of employees (relationship g), while novelties may be protected by patent, license or trademark (relationship h).

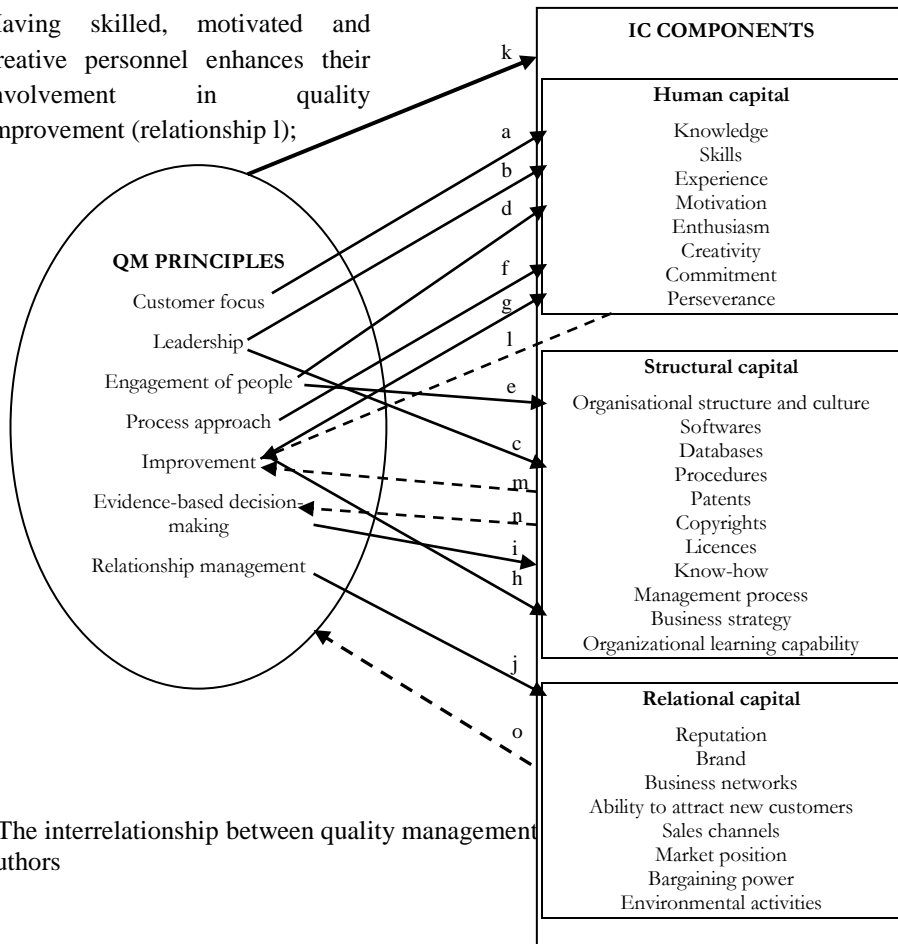
Evidence-based decision-making demands data gathering, storage and analysis in order to produce valuable facts upon which decisions will be made. For the purpose of

this principle databases are created and software developed or acquired to help managing the data (relationship i).

Relationship management aims to establish good cooperative connections with suppliers, distributors, customers and community. This principle is supposed to lead to good reputation, formation of business networks and sales channels, as well as to a higher level of corporate social responsibility. Moreover, having ISO 9001 certificate is positively reflected on the company's image (relationship j). All QM principles together are supposed to lead to increased organizational learning capability, employee commitment and market position (relationship k). On the other hand, IC is very important for the QM process:

- 2) Procedures limit errors (relationship m);
- 3) Databases and software enable analysis, finding room for improvement, but also an effective decision-making process (relationship n) and
- 4) Organisational structure and culture, and management process play an important role in enabling all of QM principles (relationship o).

- 1) Having skilled, motivated and creative personnel enhances their involvement in quality improvement (relationship l);



**Figure 2.** The interrelationship between quality management  
 Source: Authors

## 5. Motivation for ISO 9001 certificate and IC performance

There are two types of motives to certify QMS to ISO 9001 known as internal and external motives (Bravi et al., 2019). Internal certification motives refer to aspiration to improve the quality of business in order to achieve superior performance. External motives concern the pressure from customers or regulation, following the trend or using the certificate for accessing government funds, participate in bidding, as well as for marketing purposes. Certificate is useful for international cooperation to eliminate information asymmetry (Heras-Saizarbitoria & Boiral, 2013) and achieve confidence of stakeholders (Zhang et al., 2019), while it is supposed to help building QMS that will lead to improved operational efficiency, quality and productivity (Nair & Prajogo, 2009; Dias & Heras-Saizarbitoria, 2016). Chountalas et al. (2020) assert that the level of fidelity to ISO 9001 requirements vary among companies, leading to different outcomes in terms of improved performance. Some authors find that certification may not lead to improved performance if the management and employees are not committed to following the requirements in everyday operations (Oliveira et al. 2019, and others). Thus, the research documents that internal motives for ISO 9001 certification produce a greater impact on a company's performance than external ones (Chountalas et al. 2020, and others). On the other hand, Chountalas et al. (2020) find that even superficial implementation of ISO 9001 can to a certain extent initiate beneficial changes throughout the organizations and, consequently, lead to improved performance. In order to investigate the impact of motives for ISO 9001 certification on the company's efficiency in using the specific components of IC and its performance in terms of value added based on IC, the current research involves 44 ISO 9001 certified companies in

Serbia, divided into two groups, 22 companies with internal certification motives and 22 of those with external certification motives. The groups are homogenous concerning the size of companies (micro, small, medium and large) and sector (manufacturing, service and trade). The used method is Value-Added Intellectual Coefficient (VAIC), and data are gathered from the annual financial statements of ISO 9001 certified companies for the year 2021, and by interviewing quality managers from the companies that participated in the survey regarding the nature of motives for certification.

VAIC method includes two components of IC, human and structural capital, and demands calculation of human capital efficiency (HCE) and structural capital efficiency (SCE). The sum of these values is known as intellectual capital efficiency (ICE), and it shows how well a company uses these components of IC. Unfortunately, the method does not include relational capital as the third component of IC. The method also requires the calculation of capital employed efficiency (CEE) in order to finally show the value added based on IC. Table 1 presents descriptive statistics for VAIC and its components along with the Shapiro-Wilk test of normality. The Shapiro-Wilk test is significant ( $p < 0.01$ ) for most of the subsamples, indicating that the data is not normally distributed. Since the assumption of normality is necessary for parametric tests, the Mann-Whitney non-parametric test is used to establish whether there are significant differences in intellectual capital between internally and externally motivated companies. Table 2 shows the results of the Mann-Whitney test for VAIC and its components. The grouping variable is certification incentive: external vs. external.

The results indicate that there is a significant ( $p < 0.01$ ) difference in VAIC between internally and externally motivated

companies. Internally motivated companies (Mdn=2.98) have higher VAIC than externally motivated companies (Mdn=2.46), demonstrating that interest in improving the quality of processes compared to the pressure from the environment for certifying to ISO 9001, helps companies create higher value-added based on IC. The differences are also significant ( $p < 0.10$ ) for VAIC components such as HCE, SCE, and, consequently, ICE (as the sum of HCE and SCE). Internally motivated companies

(Mdn=1.74) have a higher HCE than externally motivated companies (Mdn=1.39). SCE is also higher for internally motivated companies (Mdn=0.42) than for externally motivated companies (Mdn=0.28). This means that internally motivated companies use IC more efficiently than externally motivated ones. On the other hand, CEE did not differ significantly ( $p > 0.10$ ) between internally and externally motivated companies.

**Table 1:** Descriptive statistics with the test of normality

Incentive		M	SD	Mdn	Shapiro-Wilk		
					Statistic	df	Sig.
HCE	Internal	2.01	1.30	1.74	0.72	22	0.00***
	External	1.49	0.42	1.39	0.95	21	0.39
SCE	Internal	0.23	0.94	0.42	0.41	22	0.00***
	External	0.28	0.18	0.28	0.95	21	0.41
CEE	Internal	0.80	0.72	0.58	0.73	22	0.00***
	External	1.67	3.99	0.49	0.39	21	0.00***
ICE	Internal	2.24	1.93	2.16	0.78	22	0.00***
	External	1.78	0.59	1.67	0.96	21	0.57
VAIC	Internal	3.04	1.99	2.98	0.74	22	0.00***
	External	3.37	3.79	2.46	0.40	21	0.00***

\* Results significant at the 10% level  
 Source: Author's research

**Table 2:** Mann-Whitney Test

Intellectual capital	HCE	SCE	CEE	ICE	VAIC
Mann-Whitney U	162.00	162.00	214.00	162.00	124.00
Wilcoxon W	415.00	415.00	445.00	415.00	355.00
Z	-1.88	-1.88	-0.41	-1.88	-2.60
Asymp. Sig. (2-tailed)	0.06*	0.06*	0.68	0.06*	0.01***

\* Results significant at the 10% level  
 \*\*\* Results significant at the 1% level  
 Grouping Variable: Incentive  
 Source: Author's research

## 6. Conclusion

The current study is an attempt to analyse the impact of QMS on a company's ability to create value in the future, measured by IC. Previous research has scrutinised the effects of QMS on past performance without providing insights into a company's potential to operate successfully in the long run. By indicating connections between QMS and IC, this study asserts that QMS strengthens IC as a dynamic system enabling a company to adjust to the changing environment and sustain competitive advantage. IC is company-specific, difficult to acquire, and imitate, which is why it is valuable for business success. Moreover, the study uncovers that motives for implementing a formal QMS, such as ISO 9001, have an impact on the company's efficiency in using IC, specifically human and structural capital. Namely, internally motivated companies for ISO 9001 certification, those that strive to improve the quality of processes in order to reduce errors, customer complaints and waste, to increase efficiency, employee motivation and customer satisfaction, show a higher efficiency of IC than externally motivated ones, who try to follow the trend, to have more effective marketing, or are

pressured by customers or regulation for certification to ISO 9001. Also, internally motivated companies show higher value-added based on IC, meaning that they produce superior performance by their IC compared to companies that are externally motivated for ISO 9001 certification.

Although QMS seems to contribute to IC and its efficiency, IC, on the other hand, supports the establishment of an effective QMS. It facilitates employee involvement, organizational learning, and improvement, as well as relationship management. Thus, these two concepts are mutually reinforcing, leading to a company's continuous evolution.

It is suggested for future research to empirically examine the nature and strength of relationships between specific components of QMS and IC, based on the model proposed in this study. Such examination should aim to determine the strongest predictors of yield created by the resources invested.

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**14<sup>th</sup> IQC**  
**QUALITY  
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## THE PECULIARITY OF PLANNING THE PRODUCTION OF INNOVATIVE PRODUCTS

**Abstract:** *Most companies understand that the only way to ensure continuous competitive advantage is the constant creation and launch of innovative products on the market. However, when implementing the processes of creating new products, companies face problems in forecasting and strategic planning, since the markets of innovative products are characterized by various kinds of risks, many of which are uncontrollable.*

*The purpose of this study is to study the impact of changing consumer requirements on the technical and economic parameters of the products being created.*

*The authors propose a mathematical model of cascade diffusion, taking into account the above relationship, as well as the degree of consumer involvement in the development process and the rate of change in the quality requirements of the product.*

*The model makes allow to increase the efficiency of planning the innovation process, using a formed strategy for developing new products.*

**Keywords:** *quality, management, innovation process, diffusion, mathematical model.*

### 1. Introduction

The basis of modern research in the field of planning the technical and economic new products parameters is the theory of Evert Rogers. In his theory, it is proposed to differentiate consumers of innovative products into five basic groups: innovators, early adopters, early majority, late majority, and laggards, which has received a modern understanding (E.M. Rogers, 2003, B. Lundvall, 2010, V. Mahajan & Wind, 1985).

Later, this theory formed the basis of the mathematical model proposed by F. Bass. Unlike Rogers, he proposed to distinguish only two categories of consumers according to the principle of attitude to new products - innovators and imitators. Among the factors

that determine the speed of bringing new products to the market, Bass attributed interpersonal communications and advertising. The Bass model (F.M. Bass, 1969) is universal in nature that is, regardless of the specifics of the product (product parameters), the sales volume versus time curve will always be «bell-shaped».

A further development of this theory (D.A. Moore, 2013, L. Leydesdorff, 2006) was the introduction of the concept of a gap in the adoption and dissemination of new technologies.

According to the results of the analysis of a number of empirical data on sales of new products related to the category of electronics, the authors (J. Goldenberg, 2002, J. Mejía, 2015) found that in almost half of all

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cases, the sales curve shows a moment of decline in volumes up to 20% from the initial peak, which in the short term are restored again. Up to previous volumes and even exceed it. This phenomenon is called «saddle». This study confirmed the presence of two large consumer markets: innovators and followers, the gap between which causes a decrease in sales, and also indicated the influence of two or more developments on each other, depending on their parameters.

A fairly large number of works have been devoted to the development of mathematical models for the commercialization of new products. Many of them aim to concretize and expand the Bass mathematical model by introducing new variables into it.

Thus, in (A.R. Khasanov, 2016), a modified Basses mathematical model is proposed, which makes it possible to reflect the spread of new products in the regions of Russia using the example of cellular communications. The resulting model led to the conclusion that the speed of entering the market is determined by the methods of information dissemination about new products and the maximum capacity of the market. However, as the authors note, the model gives good approximation results in the analysis of disruptive innovations, but using the model it is impossible to estimate the change in speed as a result of the introduction of improving innovations to the market. The proposed model does not allow using it for strategic planning of a product portfolio.

Modern modeling tools make it possible to build simulation models for the development of new products that best meet the real conditions. For example, in (S. Zemtsov & Baburin, 2017, M. Günther, 2016) a simulation model was built based on the Bass model in the AnyLogic software environment. The main parameters that determine the speed of entry into the market are the effectiveness of advertising and the power of the buyer persuasion, who has already used the product, when

communicating with another potential buyer. These parameters are set as constant values and are determined by an expert. This model allows you to explore the relationship between advertising costs and the speed of commercialization in order to optimize it further. However, this model also does not take into account the impact of entering the market of innovation modifications.

Similar problems are solved in (I.V. Penkovam 2018), where the main goal of the study is to obtain a mathematical model for estimating the expected discounted cash flow from the implementation of innovations over the entire life cycle. At the same time, the mutual influence of the basic and improving innovations is evaluated, which makes it possible to explain the processes of leaving the goods from the market as a result of the release of the modification. The model has a fairly generalized form and does not include important parameters that quantify the factors that stimulate innovation processes.

A different approach is proposed in (N.A. Tsvetkova & Tukkell 2017), where the simulation model is based on econophysical analogies, namely, on the analogy between the processes of innovation dissemination, which is described by Fick's laws. Based on this analogy, a mathematical model for the commercialization of innovations is obtained, in which the determining factor is the diffusion coefficient. This model allows taking into account the mutual influence of basic and improving innovations when bringing them to the market, as well as planning the moment of their launch, which makes it possible to use it in the strategic management of the company's project portfolio.

## **2. Method for determining the technical and economic parameters of products**

As shown earlier, most models for predicting

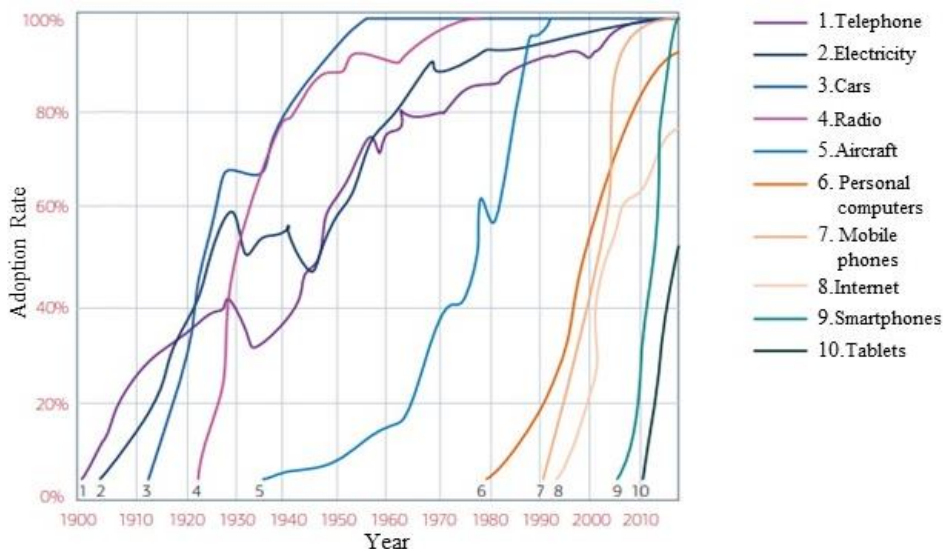
the volume of new products sales in the market differ in approaches that explain consumer behavior. The models where the adoption of a product by various consumers categories obeys an exponential law (the so-called S-curves) are most widely used. Evidence of such a generalized pattern is given in a significant number of publications, for example (A.I. Yakimov, 2010).

When forming a digital model of the innovation dissemination process, it is more expedient to talk about the information and diagnostic type of the model, which allows monitoring, sorting, adaptation, analysis of deviations, failures and abnormal behavior of the process, that is, the need to create a digital shadow for predictive analytics (Association «Technet», 2019). To build such models, it is required to use the methods of a systematic approach and optimization modeling (V.F. Minakov, 2012).

The implementation of products based on new technologies (Skolkovo, 2019) shows

that there are periods of decline against the background of sales growth. This change is in the form of a «saddle», such as that shown in Figure 1, indicates that the development of any technology has a similar nature, which is associated with several factors:

- Increasing the speed of information dissemination due to the development of IT technologies;
- Reducing the cost of technology;
- Increasing the degree of automation of production;
- The size of the develops new products company;
- The level of competition in the industry;
- Growth rate of the company;
- Intercompany partnership and cooperation;
- The cost of using the technology;
- Technical and economic indicators of products formed by technology;
- Human capital.



**Figure 1.** The degree of adoption of consumer technologies over the past 110 years [16]

Within the framework of the study, a method was proposed for determining the

requirements for technical and economic parameters of the new products quality being developed (A.K. Moskalev & Tsygankov, 2021). Its method is based on a mathematical model for estimating the cumulative sales volume of various modifications of new products depending on the time of their

$$Y_t = V_0 * \left(1 + \frac{e^{(p_0 - r_0 * t)}}{k_0}\right)^{-1} + \sum_{i=1}^n V_i * \left(1 + \frac{e^{(p_i - r_i * t)}}{k_i}\right)^{-1} \times \begin{cases} (1 + h_i), & (p_{i+1} - S > p_i + R \geq t \geq p_i) \\ (1 - h_i), & (p_{i+1} - S \leq t \leq p_{i+1}) \\ 1, & (p_{i+1} - S > t > p_i + R \text{ or } t > p_i) \end{cases}$$

where Y(t) – the cumulative sales volume of all product modifications at a certain point in time t (day, month, quarter, year),

V<sub>i</sub> – available share, taking into account the commercial model and competition of the i-th product model (SOM model), mln roubles or in kind,

p<sub>i</sub> – time period for the start of sales of the i-th model of the product (day, month, quarter, year),

r<sub>i</sub> – diffusion coefficient of the i-th model (derived from empirical data, in particular from the optimization model built in AnyLogic based on retrospective data). This indicator is a combination of the impact of advertising on product consumers and their interpersonal communication,

t – time period (day, month, quarter, year),

k<sub>i</sub> – constant characterising the curvature of the propa

gation velocity of the i-th model (day, month, quarter, year),

h<sub>i</sub> – coefficient describing the planned lag of the current product model compared to the next product model in terms of technical parameters and price. This indicator affects the decline in sales when the next model is announced,

S – date when the next product model will be announced with regard to the planned date (days, months, quarters, years),

release, the announcement of the release, as well as the technical characteristics of this product.

The model has the following form:

R – period of increased demand for the product according to the price-performance ratio (days, months, quarters, years). Determined on the basis of market characteristics and the niche of the product in question.

The block diagram of the algorithm of the method is shown in Figure 2.

At the first step, we determine the analyzer model of the 3D printer and its modifications, and then set a number of initial data:

- Planned market size for each modification (V<sub>i</sub>);
- start of sales of modifications (p<sub>i</sub>);
- Actual and planned diffusion coefficient (r<sub>i</sub>). Determined based on sales data. This indicator is a combination of the advertising impact of and interpersonal communications of product consumers;
- Actual and planned curvature of change in the growth rate of sales volume (k<sub>i</sub>).

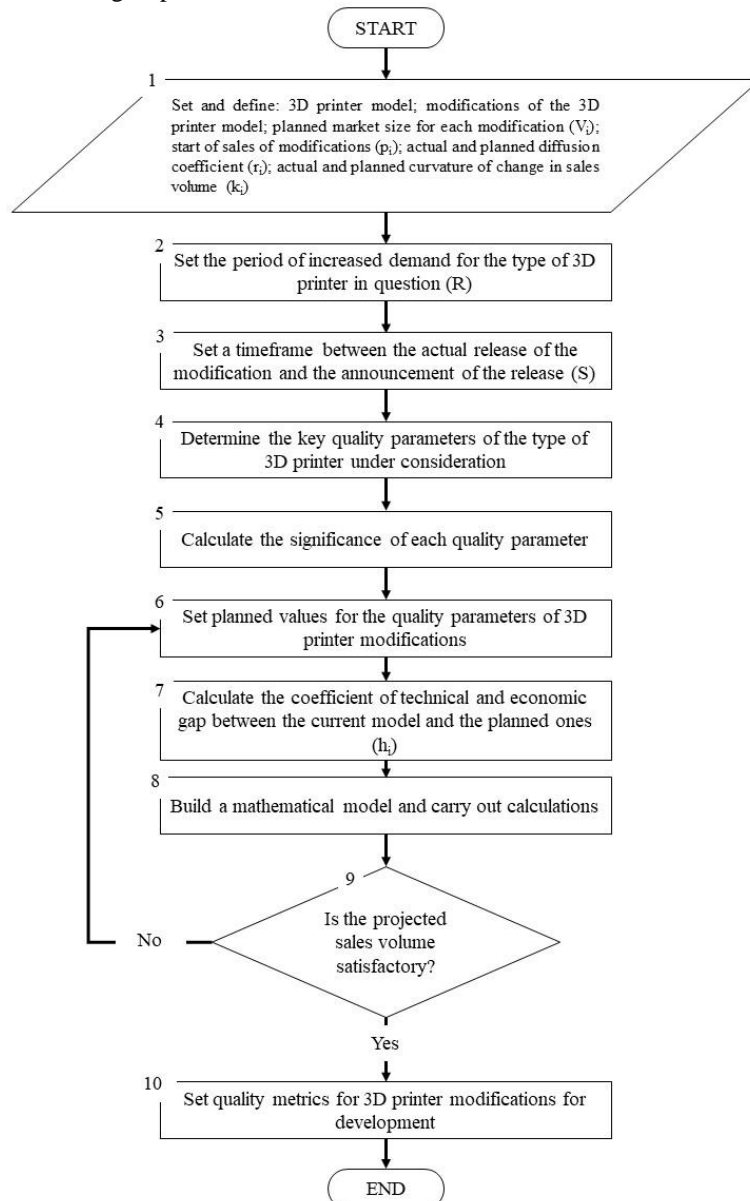
Then, based on the analysis of the enterprise's statistical data on sales of a certain type of 3D printer in the market, an average period is established during which the products are in high demand.

At the third step, the average period between the date of the announcement of the release of a new modification of the 3D printer and the

date of the actual start of sales is determined. During this period, in its first half, there is an active surge in demand for modification, which is associated with the activities of consumers from the group of «innovators»

(E.M. Rogers, 2003).

The next step is the selection of key quality parameters for the analyzed type of 3D printer.



**Figure 2.** Diagram of the method for determining the requirements for the technical and economic parameters of the quality of 3D printers

As part of the fifth step, the significance of each of the quality parameters selected in the previous step is calculated. For this purpose, an expert approach is used in the absence of statistical data, which is typical for most innovative products. If there is enough data, then the best solution is to use the methods of neural network analysis.

Then, for each modification of the 3D printer, planned indicators are set for all key quality parameters that are expected to be achieved as a result of their development.

$$h_i = \left( \frac{\sum_{j=1}^m \left( \frac{E_{j,i+1}}{E_{j,i}} - 1 \right) * g_j}{\left( \frac{C_{i+1}}{C_i} - 1 \right)} - 1 \right) * \frac{1}{(p_{i+1} - p_i)} * 100\%$$

where  $C_i$  is the market price of the  $i$ -th product modification, rubles;

$E_{j,i}$  – value of the  $j$ -th parameter of the  $i$ -th product modification. Each parameter is expressed in its own units of measurement. If there is a parameter that characterizes improvement when the value decreases, the inverse ratio should be used, i.e.  $E_{(j,i)}/E_{(j,i+1)}$ ;

$m$  – the number of parameters used to characterise the product;

$g_j$  – weighting coefficient for the  $j$ -th parameter of the product. It is recommended to use the results of market analysis (trends, customer requirements) or the Delphi method to calculate it.

At the eighth step, calculations are carried out in accordance for the entire period under consideration using automated tools with the possibility of subsequent analysis.

Then the results obtained and their compliance with the strategy and plans of the enterprise are evaluated. If necessary, a search is made for the optimal quality parameters of the 3D printer modifications planned for development. The goal of optimization may be to reduce requirements while maintaining the potential sales volume, taking into account the company's production capacity. Another goal is to conduct a

The sixth step, the coefficient of the technical and economic lag of the current modification of the 3D printer from the subsequent ones ( $h_i$ ) is calculated. This indicator affects the decrease in sales when the next model is announced.

To determine  $h_i$ , it is required to evaluate the ratio of price and quality of product modification relative to previous modifications, taking into account the interval between the outputs of modifications according to the following formula:

scenario analysis depending on the timing of the release of products, the price and quality of the products being developed.

At the last step, we obtain the final values of the required quality parameters of the products planned for development, as well as the required price ranges.

### 3. Research on the impact of consumer requirements

Consider the application of the proposed mathematical model on the example of sales of Hercules 3D printers for the period from 2014 to 2023, affecting 33 quarters based on the data on the cumulative sales volume received from the IMPRINTA company.

During the period under review, the company developed and commercialized 6 models of 3D printers from one line. The analysis considered products that are designed for one category of consumers and are similar or replacing each other. An analysis of the commercialization process for each individual 3D printer model made it possible to identify the main parameters for the model, which are presented in Table 1.



**Table 1.** Quality parameters of extrusion 3D printers

Printer modification	Parameters						R, quarter	S, quarter
	V <sub>i</sub> , pcs.	P <sub>i</sub> , quarter	r <sub>i</sub>	k <sub>i</sub>	h <sub>i</sub> , %			
First modification (i=1)	48	1	1	1,1	14%	3	3	
Second modification (i=2)	550	7	0,74	0,72	-8%			
Third modification (i=3)	900	13	0,72	0,85	-6%			
Fourth modification (i=4)	200	22	0,79	1,3	1%			
Fifth modification (i=5)	480	30	0,88	0,7	-17%			
Sixth modification (i=6)	250	31	0,826	0,934	-7%			
Seventh modification (i=7)	100	43	0,826	0,934				

As a result of studying existing desktop and professional extrusion 3D printers, feedback from users of this equipment, as well as based on the results of a survey conducted by IMPRINTA company, it was found that the following are the main product parameters:

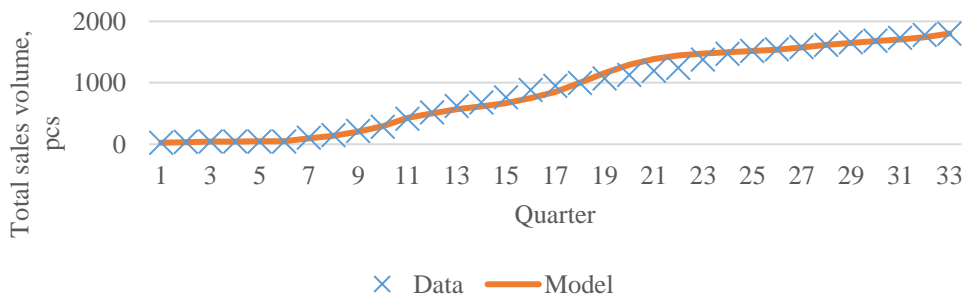
chamber volume; print speed; minimum layer thickness; printing temperature; the presence of a heated chamber; number of extruders. In addition, their significance coefficients were determined. The results are presented in Table 2.

**Table 2.** Quality parameters of extrusion 3D printers

Parameter	Coefficient	Model №1	Model №2	Model №3	Model №4	Model №5	Model №6	Model №7
Chamber volume, liters	0,2	5,832	8	8,4	8,4	18	72	216
Print speed, cm <sup>3</sup> /hour	0,2	40	50	50	100	162	162	162
Minimum layer thickness, microns	0,2	50	50	20	10	10	10	10
Printing	0,2	260	260	260	410	420	420	420

Parameter	Coefficient	Model №1	Model №2	Model №3	Model №4	Model №5	Model №6	Model №7
temperature, degrees Celsius								
The presence of a heated chamber (0 - no, 1 - yes)	0,1	0	0	0	0	0	1	1
Number of extruders, pcs.	0,1	1	1	1	1	1	1	1
Price, thousand rubles		60	64	104	219	289	499	1 590
Release quarter		1	7	13	22	30	31	43 (план)

The results of applying the model with the identified parameters are shown in Figure 3.



**Figure 3.** Results of applying the diffusion model

The model error was 5.12%, but one can observe a deviation from the actual data when the third and fourth models of the 3D printer are released, which is associated with external market factors, namely the lack of analogues in terms of price and quality among competitors compared to the third model of the 3D printer, which positively affected the sales of the model. There were some minor technical problems at the launch of the fourth model, which led to a simultaneous increase in sales of the previous model of the 3D printer.

Consider the impact of consumer preferences when they change significantly with the release of each model. To do this, we take two extreme situations:

- 1) All changes in 3D printer models do not coincide with consumer preferences;
- 2) The company's products are developed in full accordance with the requirements of consumers, at least in one of the most improved parameters.

The results of the changing significance coefficients are presented in Table 3.

**Table 3.** The value of preferences (coefficients) at the time of release of models

Parameter	Model №1	Model №2	Model №3	Model №4	Model №5	Model №6
<b>Case №1 - Preferences are completely out of alignment with product improvement direction</b>						
Chamber volume, liters	0	0	1	0	0	0
Print speed, cm <sup>3</sup> /hour	0	0	0	0	1	1
Minimum layer thickness, microns	1	0	0	1	0	0
Printing temperature, degrees Celsius	0	1	0	0	0	0
The presence of a heated chamber (0 - no, 1 - yes)	0	0	0	0	0	0
Number of extruders, pcs.	0	0	0	0	0	0
<b>Case №2 - Preferences fully coincide with the direction of product improvement</b>						
Chamber volume, liters	0,3	0	0	1	1	1
Print speed, cm <sup>3</sup> /hour	0,3	0	0	0	0	0
Minimum layer thickness, microns	0,3	1	0	0	0	0
Printing temperature, degrees Celsius	0	0	1	0	0	0
The presence of a heated chamber (0 - no, 1 - yes)	0	0	0	0	0	0
Number of extruders, pcs.	0	0	0	0	0	0

As a result of applying the modified coefficients for each product modification, we get 2 models, which are shown in Figure

4 together with the base model, where the base model is model №.1, the model in accordance with case 1 from table 3 is model

№ 2, the model in accordance with case 2 from table 3 - model №3.

As a result of the simulation, 3 areas were identified where the largest deviation is observed - with the release of 2, 3 and 5, 6 models of a 3D printer. At the same time, it can be seen that with full compliance of product improvements with consumer requirements, an accelerated diffusion process of up to 43% is observed.

However, with the release of models 5 and 6 of the 3D printer in the 30th and 31st quarter, there is a completely opposite situation associated with the almost simultaneous release of products and such a rapid change in consumer preferences. The forecast for the period of 8 quarters shows that, depending on the changing preferences of the consumer, an increase in the absolute amount of the cumulative sales volume up to 62 units of products is possible. When this event occurs, the enterprise should be able to increase production capacity to cover additional demand.

The analysis performed shows that companies, when releasing substitutes or analogues of products, the influence of

consumers can have a significant impact on the rate of commercialization, even without taking into account the impact on other external factors, for example, the possible size of the market, which is also confirmed in a number of other studies (Yu.V. Danilova & Polyakova, 2015, D. Antipov & Smagina, 2020). Which suggests that in the face of changing product requirements, enterprises should plan and organize the development process in such a way as to be able to:

- To improve all technical parameters of products to reduce the negative impact in the event of a change in preferences;
- Make changes to products at any stage of development without a significant increase in time and financial costs;
- Reduce uncertainty in understanding consumer preferences by embedding consumers in the development process (getting feedback, increasing the number of product testing stages, etc.).

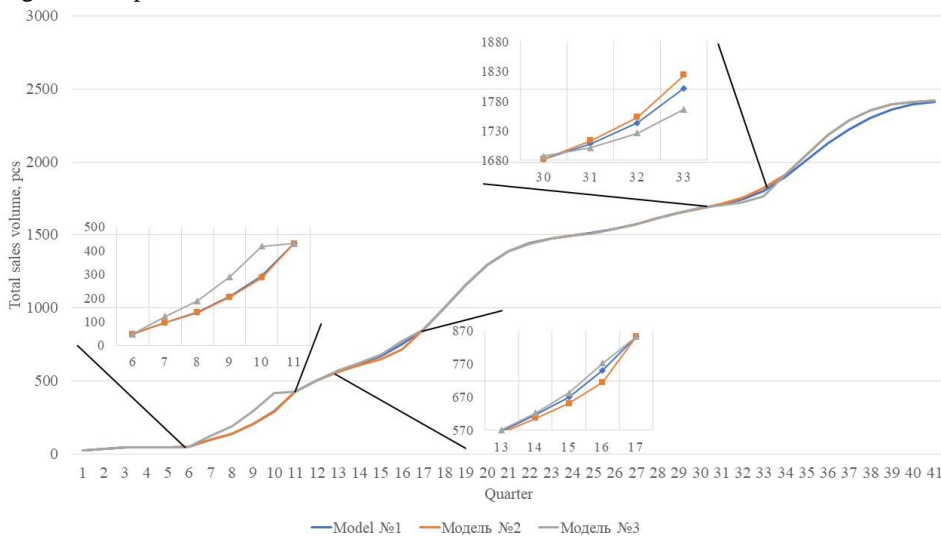


Figure 4. Changes in cumulative sales volume in extreme cases of changing consumer requirements

### 3. Conclusion

Based on the proposed model of cascade diffusion, which takes into account the mutual influence of innovative products based on their technical and economic differences and the time between release, the authors analyzed the impact of changing consumer requirements on the diffusion process using the example of 3D printers of the IMPRINTA company. The error of the resulting model was 5.12%.

The results obtained indicate the need for enterprises to form a strategy for development and commercialization, taking into account

various demand scenarios for products, depending on the susceptibility of consumer preferences to change. Depending on the degree of changes in the company, the risks of developing in-demand products and achieving sales targets for new products increase.

Further research in this area requires expanding the boundaries of the model and including in the considered contour the influence of consumer requirements on the available market volume, depending on the degree to which they correspond to the direction of changes in the product.

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## UNDERSTANDING QUALITY FACTORS IN R&D ACTIVITIES: A NEW MODEL FOR QUALITY MANAGEMENT

**Abstract:** *Project quality management is one out of ten areas of project management defined by the Project Management Institute (PMI 2019). According to definition, it includes the processes for incorporating the organization's quality policy as regards planning, managing, and controlling project and product quality requirements in order to meet stakeholders' objectives. The current paper focuses on R&D (research and development) projects, whose specificity and high-uncertainty of the results requires a specific approach to quality management. In view of the lack of research efforts in this area, the objective was to propose a new, multicriteria based model for R&D project quality management. The construction of this model was based on the review of the extant knowledge and interviews with certified R&D project managers. The model includes factors influencing both the quality of project activities and the quality of R&D results. As a next step, the model was tested based on multi-criteria evaluation of the relative importance of these factors. It has potential, inter alia, to support decision-makers in selection of the optimal project quality management strategy. Finally, relevant recommendations have been provided for researchers and practitioners.*

**Keywords:** *project quality management, multicriteria evaluation, research and development, R&D*

### 1. Introduction

Research and development (further: R&D) projects serve as the cornerstone of innovation policy at both the macro level, involving the state, and the micro level, concerning the organization conducting the project. The successful execution of R&D projects is key in determining whether an organization is achieving full competitiveness. However, management of R&D projects takes place in constantly changing and extremely uncertain conditions. Thus, effectively managing R&D projects demands not only a high level of expertise, but also proficiency in advanced PM tools

(Kisielnicki 2014).

The concept of quality in R&D projects is a very complex problem, which requires incorporating different knowledge domains and approaches. They include, *inter alia*, quality management processes in project management, competencies of project managers (PMs) to implement these processes in the specific ecosystem of R&D activities (especially if they are carried out in SMEs), as well as different methods which help to operationalize quality management factors in such a complex environment. The system of quality assurance (QA) in R&D projects can be defined as the planned and systematic actions to verify whether R&D

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processes are conducted in a proper manner and the R&D results satisfy customers' requirements (Kim *et al.* 2013).

Project Management Institute, an international, US-based, non-profit organization associating project managers, defines project quality management as the processes for incorporating the organization's quality policy as regards planning, managing, and controlling project and product quality requirements in order to meet stakeholders' objectives (PMI 2021).

Quality also constitutes the central (middle) element in the so-called Project Triangle (or: Iron Triangle, Triple Constraint Model). This is a key concept in project management, representing the relationship between four criteria (project constraints): budget (costs), scope, time (schedule) and quality (Pollack *et al.* 2018).

The aim of the current research is to bring together all the challenges and problems related to R&D project quality management into one, multicriteria-based model, and demonstrate how it may contribute to decision-making processes in enterprises carrying out R&D activities.

## 2. Key terms in management of R&D projects

Before we go further, it seems right to explain several important terms pertaining to R&D projects, such as the following: *innovation*, *technology readiness level (TRL)*, *industrial research*, *experimental development*, and *commercialization*.

**Innovation.** The most widely used definition of innovation, and categorisation thereof, has been provided by OECD/Eurostat (2018). It defines *innovation* as "a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit

(process)", while *innovation activities* are defined as "all developmental, financial and commercial activities undertaken by a firm that are intended to result in an innovation for the firm" (p. 20). Further, it defines eight types of innovation activities, where R&D takes the first place on the list, followed by i.a. engineering, design and other creative work activities, intellectual property (IP) related activities and innovation management. It also classifies innovations into four categories, including product, process, organizational and marketing ones. The manual also emphasizes the role of *knowledge* in innovation processes.

**Technology Readiness Level (TRL).** This is a concept introduced first by NASA (Sadin *et al.* 1989), which helps to classify the current state of technology maturity at one of the 9 levels: from "1" - beginning of fundamental research, where basic principles of a physical phenomenon were observed, to "9" - actual system tested and proven in operational environment, ready for implementation and use in real conditions.

**Industrial research and experimental development.** These terms have been defined jointly by the Commission Regulation (EU) No 651/2014. *Industrial research* is the "planned research or critical investigation aimed at the acquisition of new knowledge and skills for developing new products, processes and services, and for bringing about significant improvements in existing products, processes and services. It (...) may include the construction of prototypes in a laboratory environment or in an environment with simulated interfaces (...)" (art. 85). *Experimental development* has been defined in the same Regulation as "acquiring, combining, shaping and using existing scientific, technological, business and other relevant knowledge and skills with the aim of developing new or improved products, processes or services" (art. 86) (Prusak 2017). These are jointly called R&D activities, and they correspond to particular TRLs.



Specifically:

- TRL 1: fundamental (basic) research,
- TRL 2-6: industrial research,
- TRL 7-9: experimental development.

*Fundamental research* is “original experimental research or theoretical research undertaken primarily in order to acquire a new knowledge of the fundamentals of phenomena and observable facts, without intention of direct commercial use” (Act of January 15, 2015, amending the act of financing science in Poland).

**Commercialization.** Some authors associate commercialization as the market-facing stage of R&D activities (Godin 2006). However, it has many definitions in the literature and can be generally described as the process of introducing a new product or production method into commerce, that is, making it available on the market and offering to customers (Slok-Madsen *et al.* 2017).

**Financing R&D.** This is perhaps the most difficult aspect of R&D activities due to high costs and uncertainty of the final results, both in terms of technology and the market. These problems have been widely recognised by the EU authorities, who acknowledge the role of innovation in the global marketplace (European Parliament 2023). To stimulate private-sector innovation and motivate to undertake R&D activities, the EU provides a number of financial instruments to support entrepreneurs, such as the European Regional Development Fund or Horizon Europe 2021-2027 (European Commission: ec.europa.eu). These instruments are distributed to the European entrepreneurs through the calls for proposals, in which entrepreneurs may compete in gaining funds to finance their innovative projects. Such calls take place either at national and at the European level.

### 3. Project quality management in R&D projects

The term *project* has been defined by another project management organization, International Project Management Association, IPMA, as “a unique, temporary, multi-disciplinary and organized endeavor to realize agreed deliverables within predefined requirements and constraints” (IPMA 2015). Interestingly, this organization recognised the existence of R&D projects as a distinct category of projects, and provided sub-certification for R&D project managers. As regards R&D projects specifically, they should follow similar principles of project management, but their management is much more demanding and requires specific skills. This is due to the fact that R&D are categorized as not only the hardest, but also most significant projects for both an organization and the whole society (Kisielnicki 2014).

Project quality management addresses both the management and deliverables of the project. It was defined in PMBoK as one out of ten areas of PM, namely: integration, scope, time, costs, stakeholders, communication, resources, risk, procurement and quality. As regards the quality management, it consists of three groups of processes: Plan Quality Management, Manage Quality and Control Quality (PMI 2021). *Plan QM* is “the process of identifying quality requirements and/or standards for the project and its deliverables, and documenting how the project will demonstrate compliance with quality requirements and/or standards”; it can be done through a properly applied expert judgment, data analysis and decision making; *Manage Quality* means “translating the quality management plan into executable quality activities”; and *Control Quality* is “the process of monitoring and recording the results of executing the quality management activities to assess performance and ensure the project outputs are complete, correct and

meet customer expectations” (p. 271).

There are four main criteria that are key in project quality management (Locker and Gordon 2005):

- Maximizing satisfaction of stakeholders and other project output users, which requires proper communication systems at various stages of R&D projects.
- Ensuring proper implementation and completion of all planned activities.
- Achieving the quality of both the final products and project processes, using a proper monitoring system.
- Ensuring that the project management system constitutes a supportive environment to reach the adequate quality of project output.

As R&D activities are seen as a primary catalyst for innovation processes, and with more and more R&D being integrated into business models, they should become the focus for implementing the quality management systems into the projects (Mikulskiene 2014).

## 4. Model and method

### 4.1. Model

Based on the above mentioned processes of quality management and the review of relevant literature, supported by interviews with two R&D project managers employed in a technology start-up in Poland, the following key QM challenges have been identified.

In order to operationalize the above challenges, a model was built combining the above three project quality management processes and quality factors (criteria) in innovative, R&D projects.

**Plan QM.** Defining requirements for output technology, taking into account the unknown factors inherent in highly innovative ideas; the higher level of innovation, the higher risk

of failure. The possibility of output parameters’ simulation using professional engineering software is very important, but not enough to ensure final quality of the project. Such parameters may include technology features such as eg. resistance to temperature and humidity, which often require testing in real conditions. Defining what may possibly go wrong and affect the quality is also very important.

**Manage Quality.** Reacting to the rapidly changing marketplace and scarcity of resources required to maintain the planned level of quality of products and processes. It refers to both material and human resources (eg. specialized and poorly available components, highly trained and qualified R&D personnel). In addition, R&D staff often used to work in a remote way and/or with irregular work hours, a fact which generates significant communication problems affecting the quality of work and final product.

**Control Quality.** As R&D processes often require an iterative approach, it takes time to go through all TRLs up to commercialization. Thus, R&D projects are often long-lasting (taking more than 4 years), which makes the quality control processes difficult and often ends up in control of only the final output.

In order to operationalize the above challenges, a model was built combining the above project quality management processes and the respective criteria, specific for R&D projects (**Table 1**).

**Table 1.** Criteria for quality management in R&D projects

Process	Criteria affecting quality
Plan (P)	Output parameters to satisfy market needs and expectations (P1) Output parameters to be simulated (P2) Output parameters to go wrong (P3) Availability of resources to be predicted (P4)
Manage (M)	R&D work quality to be measured (M1) Quality of materials to be measured

	(M2) Quality of final product to be measured (M3)
Control (C)	R&D work quality to be executed (C1) Quality of materials to be executed (C2) Quality of final product to be executed (C3)

## 4.2. Method

In the next step, we discuss how the above general schema can be applied to support quality management in R&D projects. The aforementioned challenges can be translated into a hierarchical structure consisting of the main goal (“Highly demanding project in terms of quality”), processes (“Plan”, “Manage”, “Control”), their relevant criteria (factors), and possibly the R&D projects as decision variants at the bottom of the hierarchy. Thus, the analytic hierarchy process (AHP) can be applied to get the following answers: 1) which criterion is the most important in R&D project quality management, and 2) which alternative is most demanding in terms of quality management and needs particular attention.

The AHP is one of the most frequently used MCDM (*multiple criteria decision method*), described and explained by numerous researchers. Besides the manual of its creator, T. L. Saaty (Saaty 2000), publications such as Prusak and Stefanów (2014) or Kułakowski (2020) explain step-by-step how to use this procedure. It involves the following steps: 1) building hierarchy; 2) evaluating hierarchy using fundamental, 9-point pairwise comparison (PC) scale; 3) constructing PC matrices (PCM); 4) calculating local priorities (weights) using one of a dozen prioritization methods; 5) calculating consistency of judgments based on Consistency Ratio (CR); 6) calculating global priorities; 7) in group decisions, aggregating priorities into common ranking vectors.

## 5. Results and discussion

The application of AHP to evaluate quality management factors in R&D projects is demonstrated based on the expert comparisons provided by two R&D project managers. **Table 2** shows their aggregated judgments - priorities (weights) for processes (P, M, C), and their respective criteria (P1 - C3). “Local priorities” are those which reflect the importance of a given element with respect to its parent element (one level above in the hierarchical model), while “global priorities” reflect the importance of a given element in the whole system. Thus, global priorities are calculated by multiplication of the process priority by local weight of the particular criterion.

$$w_g = w \times w_l$$

For example:

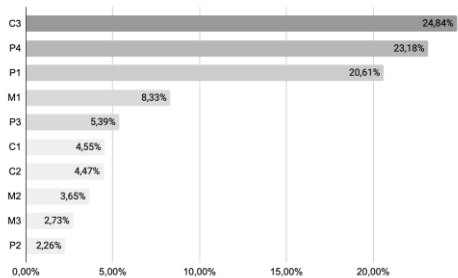
$$w_g(P1) = w(P) \times w_l(P1)$$

$$w_g(P1) = 0,3971 \times 0,2097 = 0,0833$$

**Table 2.** Priorities for processes and criteria

Processes	w	Criteria	w local	w global
P	0,3971	P1	0,2097	0,0833
		P2	0,1145	0,0455
		P3	0,5837	0,2318
		P4	0,0920	0,0365
M	0,2734	M1	0,0827	0,0226
		M2	0,1635	0,0447
		M3	0,7538	0,2061
C	0,3295	C1	0,0827	0,0273
		C2	0,1635	0,0539
		C3	0,7538	0,2484

The ranking vector of global priorities is shown in the barchart (**Figure 1**). It indicates that the priorities of three criteria (C3, P4 and P1) exceed 20%, and they all together account for nearly 70% of importance in the quality management of R&D projects.



**Figure 1.** Global priorities of the criteria of quality management in R&D projects

As it was expected, the most important factor in R&D project quality management is execution of the quality of the final product ( $w(C3)=0,2484$ ). The next quality criterion in terms of the importance is planning the availability of resources ( $w(P4)=0,2318$ ). It demonstrates the contribution of resources (both human and material ones) to R&D quality management. It was especially evident during Covid-19 pandemic, and it continues due to the war in Ukraine. For example, shortages in worldwide supply of electronic components, resulting from stopping production in Chinese factories, forced many R&D project managers to lower the quality parameters of their innovative results. The interviewed experts stated that they had to redesign the product to be able to meet the deadlines and functionality, but it happened at the expense of quality. Moreover, low availability of R&D personnel was also a major problem affecting the quality of products and processes. It resulted from both the Covid-19 restrictions and rapid growth of inflation rate. The latter fact caused many entrepreneurs not being able to afford the wage requirements of their highly qualified and experienced research staff.

The third significant criterion is to plan result parameters which satisfy market needs and expectations ( $w(P1)=0,2061$ ). High score assigned to this criterion indicates the

importance of the commercialization phase following R&D activities. It also demonstrates the significance of the planning processes in R&D quality management, which received nearly 40% priority ( $w(P)=0,3971$ ).

In addition to setting the ranking of the quality criteria, the AHP can be applied to indicate which R&D project has the highest quality requirements. This would require taking into account project variants in the hierarchical model, and analyze them based on pairwise comparison against each criterion. It is also possible to establish the ranking of the specific parameters which can be modeled as sub-criteria of the relevant criterion. However, we do not present it here due to character limits, but it is a problem worth further scientific considerations.

## 6. Conclusions

The problem discussed in this paper, a multicriteria-based modeling of challenges related to R&D project quality management, is currently very important in Poland. This country is the largest beneficiary of the EU funds devoted to innovative, R&D projects, carried out in the private sector (especially by the SMEs). It is reflected in the enormous number of R&D projects co-financed from the EU funds. For example, the National Centre for Research and Development, the Polish largest agency responsible for distributing the EU funds, provided a list of nearly 14000 beneficiaries of the Operational Program Smart Growth 2014-2020, aimed at fostering R&D activities in enterprises. It raises questions about the quality of both the R&D processes carried out, as well as the quality of their innovative results. Thus, more exploration is needed in this area, and the research effort reported in this paper is one of them.

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## PRINCIPLES OF CYBERNETICS IN THE INNOVATION AND INVESTMENT DEVELOPMENT OF UKRAINE

**Abstract:** *The relevance of the study consists in highlighting the principles of cybernetics in separating relatively self-sufficient whole economic systems from reality, considering their functioning and the relationship between them and the environment, and discovering analogies and general patterns of development and action in an innovative atmosphere. The purpose of this study is to identify and then apply in practice the general laws and principles governing economic processes in Ukraine, and the transformation of cybernetic information elements in innovative development. Cybernetics, which is an interdisciplinary science, studies the operation and functioning of particularly complex economic systems without regard to the material from which they are created. The cybernetic aspect represents the ability to perceive and capture the surrounding economic reality, to observe the changes occurring in it, their causes, and consequences comprehensively and dynamically. For this purpose, the article used the following methods: functional analysis, logical method, and scientific abstractions. The management principles and general laws of cybernetics look for analogies between all components of economic organisms and social systems, discovering common laws borrowed from various sciences. Cybernetics allows these laws to be transposed into a completely different field, providing a variety of practical applications. The findings indicated the potential for the development of an innovative national economy as a set of interrelated resources and opportunities for their realisation in the context of cybernetic individual, collective and societal systems. The categories of innovative development in the investment potential of Ukraine were considered. Its components are analysed predominantly from the perspective of an innovation management principle, which was implemented gradually according to the achievement of objectives at defined assessment points. The practical relevance lies in the analysis of the principles of cybernetics in the innovation segment, and the examination of the current state of the investment sphere and its policies from the perspective of the cybernetic component of the economic system.*

**Keywords:** *Laws Of Cybernetics; Principles Of Governance; Innovation; Investment Sphere; Politics; Ukrainian Economy; Emergence*

### 1. Introduction

Cybernetics as a "techno-science" about managing systems by controlling data and

information flows represents a change of perspective on concepts, a real epistemological revolution, and a profound paradigm shift in relation to classical

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science. Cybernetics and its principles seek to mimic complex laws even more effectively by accurately emphasising the logic of cause-effect relationships, communication, and interactions between the various elements of a self-regulating system. The medium then becomes a "network of messages and signs" or an autonomisation of the entire universe of practices and forms as an operational and accounting sector (Ramazani, 2010). Unlike traditional science, which studies the structure of matter and energy transformation, cybernetics also studies the process of information transformation and control of a system that consists of three elements: material, energy, and information, where it considers material and energy only as necessary prerequisites for the operation of the system and does not investigate what material the system consists of or how it is transformed energy and focuses specifically on the information. Cybernetics relies on a real electronic, mechanical, neural, or economic machine as a prototype, studying the function of all dynamic systems of matter, and revealing their behaviour in terms of functionality (Zannetos & Wilcox, 1969).

Automatic control is an interdisciplinary discipline that has its origins in engineering, mathematics and has since been applied in various social sciences, including economics, sociology, psychology, criminology, and financial systems. Automatic control is also called control theory because of its emphasis on theory. The control system consists mainly of measurements, comparisons, calculations, and corrections (Seppanen et al., 2007). The basic principle of control theory is feedback. Initially, feedback was a biological concept related to a system that can influence the continuous operation of the system, and later became the basic concept of modern science and technology. Feedback in control theory refers to the process of returning the output of the system to the input and some change

in the input, thereby affecting the output. The device performing the feedback function is called a controller, which can be a circuit, a machine, or a human brain receiving signals. The most basic characteristic and requirement of control theory is stability, where classical control theory is suitable only for linear systems with one input and one output. The control process in the control system is essentially the same as in engineering and biological structures: it uses information feedback to identify the difference between the indicators and the benchmark, taking corrective measures to stabilise the system in a given target state. Therefore, theoretically, methods suitable for engineering and biological cybernetics are also suitable for analysing and explaining management and control tasks in the aspect of the state of Ukraine (Harryson et al., 20088; Gilsing & Duysters, 2008).

In a modern management system, the combination of human, financial, material, and other elements is different, time and space change, the environment has a great influence, and the internal work and structure sometimes change greatly. In such a complex system, the process is inconceivable without controlling the attainment of the goal and development in the competition. It is based both on the development of technology and on an analysis of the various activities in which man can be assisted, controlled, or even replaced by a machine, to establish the laws of substitution that guide the programme of "technological evolution" (Thorgren et al., 2009). In this area, cybernetics can be thought of as building on the intersection of applied mathematics and automatic computation. Financial efforts and socio-economic integration are aged here, both in terms of equipment and services. Nevertheless, the sector is experiencing a renaissance driven by recent applications, the Internet, and the ubiquity of interoperable electronic components.



Information sciences and technologies combine computing, electronics, automation, telecommunications, and robotics. In this respect, one of the main theses of economics is that a modern unification strategy is neither conceivable nor achievable without the prior and social development of a new worldview directly influenced by aspects derived from cybernetics (Van der Valk et al., 2011; Riemer & Klein, 2006).

The purpose of this study is to identify and then apply in practice the general laws and principles governing economic processes in Ukraine, and the transformation of cybernetic information elements in innovative development.

## 2. Materials and Methods

The methodological basis of the study consisted of the following approaches to the study of this issue: the method of functional analysis, logical, and scientific abstractions. The method of functional analysis made it possible to explain economic phenomena in accordance with the analysis and study of the functions of cybernetic phenomena, where a function is understood as the role that the economic component plays in discourse and in its structural relations with other components. Theoretically, it underlines that cybernetics in this case is a continuum created to meet needs, and emphasises explaining dynamic economic or social phenomena from a functional point of view. In practice, the focus is on collaborative observation, which requires a deep immersion in reality, integrating all the principles of the control system. The structure of functionalism, according to which the function of Ukraine's economic system depends, allows the system to be maintained, continued, and operated. Its elements allowed focusing on the integrated development process, investment trends and the influence of the international political system.

The logical approach reflects the full application of the methodology of system sciences in economics, highlighting the transformation of political science research from traditional static analysis to dynamic and interdisciplinary. Its essence lies in the decomposition of things into various parts, aspects, attributes, and their separate study. The synthesis of the methodology consists in organically combining all the parts, aspects, and properties of things into a coherent whole according to their intrinsic relations to perceive the essence and laws of things. The components of logic are interpenetrated, transformed, and analysed under comprehensive guidance. The causal inference approach helps to understand the scientific causes and ways in which cybernetic matters change. It can be seen as an open-source mindset designed to find a causal link between the laws of cybernetics and the principles of innovation management in Ukraine's economic system. Persuasive logical reasoning allows, in this case, to shed light on the subject under study, thereby enabling it to become sufficiently complete and affirmative, characterising the relevant evidence and explanations.

The method of scientific abstractions made it possible to reveal the process of studying political economy and analysing the capitalist mode of production, where objective matters appeared in diverse and complex phenomena, which were not limited to a simple description of phenomena but revealed their essence and laws through the form of cybernetic principles. By revealing the nature of the matter under consideration, the approach made it possible to understand and transform the objective mechanisms of the system more effectively. The existing connections were investigated to establish a scientific theoretical system. The methodology of scientific abstraction presented a process of investigation from the concrete to the abstract by means of the abstract reasoning ability, revealing the

essential links and internal regularities underlying complex economic phenomena, thus forming a series of concepts and theoretical categories. The use of a number of abstract theories and concepts about the nature of cybernetic aspects for a clearer and deeper explanation of the process of economic and social evolution has led to concrete representations in the thought process, where the concrete is no longer just a perceptual thing, but a rational concreteness with a rich connotation, which is a synthesis of many rules and unity of diversity.

### 3. Results and Discussion

Ukraine's informational model of economic subjectivity seeks to embed a determinism on a par with the machine in any theory dealing with the question of the subject, which boils down to the simple status of a thing whose behaviour can be predicted because it is represented informationally. Here, other key concepts of cybernetics, such as "feedback" and "entropy", are interpreted, after a brief evocation of their genealogy, as the tools by which the "new science" was able to embrace all economic products. Cybernetic concepts induce a communicative representation of society. Having become a huge communication system, the latter exists only through the exchange of information between its participants. However, the validity of these theses about the relationship between the epistemic content of cybernetic science and the status of the subject in it will become possible only from the moment when the economic component of management integrates cybernetic formalism, its language, and its tasks. Accelerating the construction of an autonomous, managed, secure, and reliable digital infrastructure is an inevitable choice to increase the country's core competitiveness. To further expand the possibilities of technical support for digital

infrastructure, it is necessary to accelerate the joint investigation of basic and applied technologies (Olsson, 2010). At the same time, it is important to strengthen the protection of intellectual property rights in digital infrastructure, accelerate the development of key common standards and key technical standards, facilitate the establishment of a standard management system and the promotion of advanced technologies and the interconnection and sharing of facilities.

The practice of innovation management applied by Ukraine has changed radically over the past two decades. The progress recorded in information and communication technologies, along with increased competitive pressure, have prompted the economic system to deploy strategies that are increasingly based on a combination of their internal capabilities with various external resources. The functionality of strategies is characterised by an increased degree of openness in research aspects, in particular, the paradigms of open innovation popularised by H.W. Chesbrough (2006), a theory of user innovation introduced by E. von Hippel (2006), or even the ecosystem and business model approach initiated by J.F. Moore (1993; 1997). All of them consider innovations as a result of interaction and cooperation between economic organisations of the state. They involve the search, selection, combination, and integration of a wide variety of tangible and intangible resources embodied in various organisational and technological contexts distributed within the system. These interactive approaches to innovation are accompanied by a violation of the processes and methods of knowledge management applied by innovative components (Freel & de Jong, 2009). Thus, the dissemination of knowledge associated with the performance of tasks related to the invention and commercialisation of innovations leads to a change in the ways of their creation,

application, and use. They involve the adaptation of codification and integration practices, sharing and transfer, protection, and enhancement of knowledge. In addition, a knowledge that has been created at least in part externally should be exploitable to supplement the system's internal knowledge. Finally, the transformation of innovation models is changing the way the economy manages the knowledge involved in the commercialisation of innovations.

Strategic innovation indicators refer to measures used to quantify the facts related to the development of an innovation strategy and to identify, evaluate and select ideas in the innovation process. Strategic innovation indicators can be structured according to the phases of the innovation process. Innovation management and the innovation process are at the heart of the competitiveness and growth of the state. Therefore, it is the basis of the future viability of the economy and determines its success or failure. Thus, key performance indicators are central variables for monitoring Ukraine's future success. Innovation management encompasses the overall structure, including innovation strategy and business operations. In other words, it is about integrating innovation into everyday activities. Different operations go through concepts such as teams, responsibilities, resources and equipment, risk management, processes, cooperation, exchanges between different functional areas, control, and optimisation. The innovation process is a kind of performer arising from the general framework of innovation management. This innovation process should not be limited to one economic aspect but should be applied wherever it is useful and possible. Above all, the process allows for achieving perfection and provides an innovative environment for development. Therefore, financial interventions alone are not sufficient, they need to be complemented by strategic and operational key performance indicators so

that early indicators allow for timely intervention if it is found that objectives cannot be achieved (Rampersad et al., 2010; Abidian & Martin, 2009).

One of the inherent advantages of Ukraine's planned economy is the value of a long-term investment in infrastructure and strategic technology, as it can exist without fear of falling market demand or loss of confidence, which usually leads to project cancellations. This means that consumer demand can be restrained in favour of further capital investments for the economic development of a specifically desired model. For example, the state of Ukraine can start building heavy industry without waiting for many years to accumulate investment capital or necessarily choosing financial debt. British cyberneticist S. Beer (1995), believed deeply in the basic principle of cybernetic engineering, where the regulation of system variability is through planning and constant adjustment. The principle exported to the economic planning environment of Ukraine, as a process of artificial immunisation with constant feedback, is a kind of bet on regulatory intervention in the form of an attenuated aspect. Today, advanced computing developments would make it possible to create a single, global, and accurate production plan, eliminating the problem of economic calculation and mitigating sudden imbalances resulting from speculative market fluctuations. Within this conceptual framework, it is possible to formulate a political and technological germ for managing an effective and coherent European digital socialism, based on the central role of the common good of the European Union (EU) (Francois, 2004). In fact, although this label sounds difficult to implement, the preliminary plans for the so-called digital model have a planning component. It is not just a question of a way of investing in new technological infrastructure, but also of managing consumption rationally rather than

excessively, and encouraging the allocation of public resources to the sectors concerned.

It is necessary to develop various applications aimed at integrating technological and theoretical systems, creating data streams that will be supplied with information in real time for various users, which may be ministers, the presidential cabinet, companies, and various organisations. It is also important to integrate citizen participation from home into public decision-making. This is one of the first e-government initiatives and an extension of the concept of creating and encouraging action groups and development in a collaborative working environment using truly effective information management tools. Modern science and electronic computing offer the government new opportunities to tackle today's complex issues of the Ukrainian economy. Investments in the construction of digital infrastructure are huge. At the initial stage, it is worth focusing on application scenarios and engineering construction with a better foundation, wider application, and faster effect, and implementing a new application infrastructure, concentrating on sectors such as intelligent manufacturing, social management, online medicine, online education, digital life services, focused on the needs and concerns of the state (Heims, 1993). It is also important to compile and issue a list of needs for building digital infrastructure application scenarios, organise application innovation competitions and other events, and use the market mechanism of "list disclosure and team acceptance" to select excellent solutions.

In 2017, the investment attractiveness index of Ukraine reached its highest level in the last 6 years – 3.15 points on a five-point scale. This assessment was given by the European Business Association (EVA) after conducting a survey among 142 major

international and Ukrainian companies. The fact is that Ukraine has managed to improve its investment attractiveness and this growth is confirmed by the good situation in the commodity market, where the country is an active player, leading in the trade of grain, agricultural products, metals, and ore. The Ukrainian market is undoubtedly attractive to Western entrepreneurs. Its openness attracts investors, which augurs for its further imminent growth in the future. To improve the investment climate in Ukraine, a series of reforms need to be undertaken. Policy, not efficiency, is the dominant factor influencing the trend of the investment market. In the medium and long term, the direction encouraged by the policy is of greater importance, where investment opportunities, which are mainly concentrated in semiconductors, are the creation of a system of high-tech equipment, the promotion of new infrastructure, the emergence of new applications controlled by artificial intelligence and the modernisation of manufacturing industries with accelerated advancement. Facing the current market, anticipating future developments, and looking ahead to the next one or two years, the likelihood of the market making a relatively good profit is quite high. While the economy is gradually stabilising and supporting healthy development, the innovative viability of Ukraine is becoming stronger, new industries continue to appear and mark high growth rates, and traditional industries will continue to be rebuilt and updated. According to the Ministry of Finance of Ukraine (2022) for the 1st quarter of 2019, the total amount of capital foreign investment increased to \$600 million. The economy offers a fertile ground for a large number of investment opportunities, which will continue to bring investment opportunities to the stock market (Table 1).

**Table 1.** Capital Investments in Ukraine by Asset Type, for 2019

	January-March	January-June	January-September	January-December
In actual prices, UAH million				
Total	108298.0	233995.5	379203.1	584448.6
Investments in tangible assets	102653.6	223986.0	364774.5	563573.1
Housing stock	11664.0	24457.2	38404.2	55623.6
Non-residential facilities	13503.1	31181.7	54628.2	89717.7
Engineering structures	20159.8	46295.6	79879.0	131910.5
Machinery, equipment, inventory	37712.5	82715.0	131531.3	198709.5
Vehicles	14994.1	29127.9	44156.4	63319.1
Land	311.7	840.5	1207.3	1866.0
Long-term livestock and crop production assets	929.9	1921.1	2886.3	4101.2
Other tangible assets	3378.5	7447.0	12081.8	18325.5
Investments in intangible assets	5644.4	10009.5	14428.6	20875.5
Software	2076.7	4377.9	6619.7	9886.6
Patents, licenses, concessions	2656.4	4070.8	5622.3	7525.3

*Source: formed based on data from the Ministry of Finance of Ukraine (2022)*

However, investments in equity of cross-border investors in Ukraine have recently decreased by \$868 million, which is the first decrease in inflows since 2015. This was stated by the President of the National Bank of Ukraine (2021), pointing out that the key reasons for the low interest of foreign investors in the Ukrainian economy are the underdevelopment of the domestic market, the ongoing armed conflict with the Russian Federation and the low level of the legal protection of investments. Ukraine is still perceived by investors as an unfriendly place to invest capital in the ranking of the Global Index of Attractiveness of Countries for Foreign Direct Investment. Other challenges are also pointed out by the Ukrainian finance minister, as he acknowledges that the COVID-19 pandemic and the situation in the world economy do not encourage investors to commit capital. He believes that Ukraine still has a solid foundation in the form of domestic private investors, government

investment activity and support from international institutions. This allows for gradual improvement of the investment climate. In the regional context, a significant decrease in capital investments in April – June occurred in Volyn (by 64.1%). Kirovograd (by 17.1%). Mykolaiv (by 13.3%) Oblasts. The main source of funding for capital investment remains the equity of enterprises and organisations, which accounted for 75.2% of total investment. In 2019, the volume of capital investments in Ukraine increased, but only by 8% – up to UAH 624 billion. There has been a decline in contributions from businesses and organisations and from the public for the construction of housing. At the same time, foreign investment increased by 159% to UAH 4.7 billion (Ashby, 2015). Investments in agriculture, trade, transport, information, and communication have decreased (Table 2).

**Table 2.** Capital investment indices by economic activity for 2019 in Ukraine (in %)

	January-March	January-June	January-September	January-December
Total	117.8	112.3	112.4	115.5
Agriculture, forestry and fisheries	102.1	91.4	88.7	90.0
Hunting and related services	102.8	91.8	89.1	90.4
Logging	57.3	63.0	60.9	60.7
Industry	132.0	130.8	128.1	134.7
Construction	103.4	105.0	105.6	109.8
Wholesale and retail	118.9	106.3	112.4	100.3
Transport, postal and courier services	120.8	104.7	99.8	96.6
Temporary accommodation and meals	257.2	199.3	167.5	148.7
Information and telecommunications	57.7	62.7	76.6	83.4
Publishing, cinema, radio, television, programmes	142.5	134.7	137.4	124.8
Computer programming	147.1	126.7	127.8	140.5
Financial and insurance activities	75.4	82.5	92.8	102.8
Scientific and technical activities	188.7	164.5	143.8	131.4
Public administration and defence	186.7	145.8	134.1	129.9
Education	124.6	122.6	122.7	131.6
Healthcare	135.9	127.3	132.4	146.6
Art, sports, recreation	244.3	152.1	118.0	117.1

Source: formed using the data State Statistics Service of Ukraine [23] data.

The prognostic assessment of Ukraine's investment sphere development, given the principle of emergence, refers not to a specific, finite time, but to a permanent process of change. Economic emergence causes a gap, a historical and identifiable sequence of getting out of the backwardness trap. Growth causes structural, nonlinear, and unbalanced changes. The resulting concentration of activity and income causes social tension, which increases as a result of globalisation. In this context, economic emergence should be analysed as an indefinite, nonlinear and heterogeneous process that generates gaps and hides blockages, the scale of which is specific to socio-political and geographical space, but the general mechanisms of which can be

identified. Consequently, this may seem to contrast with other countries where earlier economic changes have taken place in a different context. The increasing external returns of the country, associated with the concentration of certain additional activities, can cause an acceleration of growth, and spread to the rest of the economy when there is an overflow of knowledge or sufficiently dense intersectoral relations. The dynamics of industry growth is likely to cause a movement towards convergence, first sectoral, and then more global if the sector in question maintains close relations with other sectors. Economies of scale and training, sanctioned by the size of the global market, as well as technological, logistics and marketing transfers caused by investment

ties, will allow competitive sectors of activity to quickly approach the levels of productivity of the technological front, which has implications for the entire national

production system. According to the State Statistics Service of Ukraine (2022), capital investments in Ukraine have collapsed by 38.2% by the end of 2020 (Table 3).

**Table 3.** Capital investment by economic activity asset type in 2020, in UAH thousands

	The volume of capital investments	Investments in tangible assets	Investments in intangible assets
Agriculture, forestry and fisheries	50679695	49781904	897791
Industry	180537373	177399868	3137505
Construction	39614886	39534816	80070
Wholesale and retail	41684741	38864968	2819773
Transport, storage facilities, postal and courier services	34884633	34491549	393084
Temporary accommodation and catering	1951234	1713769	237465
Information and telecommunications	22381603	13223155	9158448
Financial and insurance activities	11979335	7664411	4314924
Real estate transactions	19940118	19779661	160457
Public administration and defence	62303585	62043447	260138
Education	3740151	3722658	17493
Healthcare	14835634	14096141	739493
Art, sports, recreation	2772823	1633922	1138901
Administrative services	8623796	8333580	290216
Professional, technical and scientific activities	11823599	10613869	1209730

*Source: formed using the data State Statistics Service of Ukraine (2022) data.*

In terms of emergence, Ukraine is undergoing profound structural changes that accompany high and sustained growth phases, but the cause-effect relationship between the two has not been clearly established. Economic success, first of all, is based on the often random synchronisation of national political strategies and a favourable configuration of the global economy. It is likely that, in the future, the growth of globalisation will not allow the state to be constrained by the narrowness of convergence conditions after successful integration into the world economy at the expense of investment components. This raises a more fundamental question about the emergence of production systems capable of both meeting the requirements of international competitiveness and ensuring sufficient activity for workers of all skill

levels. The study of the conditions for the possibility of a harmonious increase in the standard of living involves going beyond the purely quantitative characteristics of economic changes and diving into the core of new political regimes emerging in a globalised environment. The scientific and technical base is formed spontaneously as knowledge is acquired. Although this model seems attractive from the point of view of the principle of emergence, it assumes the fulfilment of certain conditions and therefore is not suitable for all situations. It essentially requires a minimum of skills, a sufficiently developed scientific apparatus and a skilled labour force. For an economy with a low level of scientific and technical potential, it is often unattainable and can lead to a waste of resources if the technologies transferred at great cost are not mastered within the

country. On the other hand, it may represent a relay model after reaching a certain skill level. Thus, if the investment model is regarded by regions, Kirovograd (by 33.5%), Odesa (by 29.4%) and Volyn Oblast (by 26.5%) suffered the most in 2021, similar to the period of 2020. Capital investments in

2021 increased the most in Luhansk (81.5%), Zaporizhzhia (60.1%) and Ivano-Frankivsk Oblast (47.5%). Capital investment in Ukraine in 2021 fell by 9.5% y-o-y, according to the National Bank of Ukraine (2021) (Table 4).

**Table 4.** Capital investment by asset type by region for 2021 in UAH thousands

	Volume of capital investments	Investments in tangible assets	Investments in intangible assets
Vinnitsia Oblast	14013094	13854948	158146
Volyn Oblast	8263244	8181409	81835
Dnipropetrovsk Oblast	65469771	64848238	621533
Donetsk Oblast	30072847	26159814	3913033
Zhytomyr Oblast	9484439	9397856	86583
Zakarpattia Oblast	5126333	5046060	80273
Zaporizhzhia Oblast	18270778	18058827	211951
Ivano-Frankivsk Oblast	8408234	8215085	193149
Kyiv Oblast	35927395	35073524	853871
Kirovograd Oblast	6540378	6482354	58024
Luhansk Oblast	3291761	3281992	9769
Lviv Oblast	24041905	23256837	785068
Mykolaiv Oblast	8272664	8212564	60100
Odesa Oblast	18853678	18477148	376530
Poltava Oblast	23808239	23585824	222415
Rivne Oblast	6076296	6032460	43836
Sumy Oblast	7465009	7366575	98434
Ternopil Oblast	8536591	8519684	16907
Kharkiv Oblast	19438622	19087320	351302
Kherson Oblast	5157946	5117786	40160
Khmelnyskyi Oblast	10874810	10772730	102080
Cherkasy Oblast	9590276	9452174	138102
Chernivtsi Oblast	3397187	3376722	20465
Chernihiv Oblast	8367139	8268683	98456
Kyiv	170053375	155119685	14933690

Source: formed based on data from the National Bank of Ukraine (2021).

However, Ukraine, as a country with a rather immature system, is a candidate for emergence. Its ability to achieve the status of a developing state depends both on their initial position and on the actions taken to develop and structure the national innovation system. The nature of immature systems makes it impossible to describe a single trajectory that allows creating conditions for

emergence. Nevertheless, it has a certain number of common features that open many avenues for reflection, where one of the contributions of the concept of the national innovation system is the possibility of a synthetic vision of dysfunctions. All of them are characterised by both the weakness of knowledge production activities and a very low level of network density between



aspects of the system. Important areas for the appropriation of innovation and know-how to enter international markets, such as quality and standardisation in its various variations, are usually ignored. They should concentrate most of their scientific and technical activities in the least developed areas related to the policy of monitoring and technology selection. The strengthening of the national innovation system is accompanied by a sharp increase in gaps between regions and between industries. There is every reason to believe that to achieve a sufficient level of attractiveness it is reasonable to concentrate funds on a reduced number of centres of excellence,

which will be able to benefit from very substantial funds in terms of financial resources. This concentration will be used to attract foreign investment, which would find the conditions there favourable and thus cooperate and function. Such a process can be seen in the statistics of capital investments in Ukraine, where since 2015 the level of investment of Ukrainian enterprises has increased markedly. However, in 2020 it decreased by 38.2%, while in 2018-2019 it increased by 16.4% and 15.5%, respectively, as stated in the data of the State Statistics Service of Ukraine (2022) (Table 5).

**Table 5.** Capital investment by asset type for 2015-2020 in Ukraine (UAH million)

	2015	2016	2017	2018	2019	2020
Investments in tangible assets	254730.9	347390.5	432039.5	542335.1	600568.1	483324
Residential premises	45609.8	44864.9	53371.8	57395.9	58014.9	34885.7
Non-residential premises	43330.9	59398.3	65605.2	88846.1	100468	78920.1
Engineering structures	50948.7	67517.1	78563.5	111314.8	149153.5	127995.4
Machinery, equipment	84423.2	123133.3	154721.7	187650.4	198455.3	161636.6
Vehicles	19650	36685.7	60123.9	73926.2	65870.8	50074.6
Land	1441.8	1915.8	1994	1673.1	2230	2298.5
Long-term biological assets	2762.6	3162.7	3727.9	4528.3	5999.8	5247.4
Other tangible assets	6563.9	10712.7	13931.5	17000.3	20375.8	22265.7
Investments in intangible assets	18385.5	11825.6	16422	36391.3	23410.8	24893
Commercial property rights	12653.9	4435.8	6228.1	24381.6	8389.5	8389.1
Software and databases	4908.4	6315.5	8196.4	9476.4	10215.3	12411.1

*Source: formed using the data State Statistics Service of Ukraine (2022) data.*

According to Ukraine's parliamentary ombudsman for business, Algirdas Šemeta, per capita investment in Ukraine is five times lower than in Poland and ten times lower than in Estonia. The main reason for this is corruption and distrust of Ukrainian judiciary, which are the biggest obstacles to foreign investment. However, the investment market of Ukraine is characterised by dynamic development, high demand for investment resources and a fairly high level of interest from foreign investors, along with investment attractiveness, which is confirmed by statistical data on foreign direct investment. The current state of the

investment sphere and its policy in Ukraine characterizes the process of integration of the state into the globalised economy and world capitalism through strong economic growth for several years. Supporting multipolarity, emergentism has a geopolitical dimension in that it legitimises the country's representation in international institutions and is economic rather than social in nature. It is possible to expand the functionality of the principle only if it is integrated into the global capitalist system. Developing states share common characteristics, found in more or less pronounced form and with variations depending on the situation: a large

population, but completed its demographic transition; a stable but often authoritarian political regime; the emergence of a middle class able to consume and hold intermediate positions in services and administration; rapid metropolisation and often a growing wealth gap, leading to the coexistence of a rapidly enriching oligarchy with masses of people living in poverty, often in peripheral, rural or landlocked regions (Holland, 1996). Due to sufficient liquidity and constant inflow of foreign capital, the overall liquidity of the stock market is at a historically low level, which provides a good basis for creating medium- and long-term investment returns. The stock market will continue to improve with the gradual decline in corporate profits, and structural opportunities will arise.

Modern Control Theory, developed in the 1960s, is a new theory based on the concept of state variables, using modern mathematical methods and computers to analyse and synthesise complex control systems and suitable for multi-input, multi-output, time-varying and non-linear cybernetic systems of the Ukrainian economy. The application of modern control theory for analysis and synthesis can bring the effectiveness of the control system to a new level. The current reality of global capitalism increasingly reveals on a global scale the essential contradiction of an economic system which, while promoting continuous scientific and technological development with the robotisation of production, artificial intelligence, and big data, unfolds regressive social dynamics, generating unemployment and job insecurity, social polarisation and ever more serious crises. To address the basic challenges facing humanity, given the inability to manage or reform the blind logic of capital, which subordinates the entire society to the ever-increasing demands of profitability and accumulation, global alternatives to the capitalist order must be created that make

possible the modern ideal of civil self-government with social and rational control over the economic process and the only possibility to direct the development of society towards democratically chosen goals. In this perspective, the principles of cybernetics assess the possibilities of socialism and economic planning in the light of current scientific and technological possibilities in information technology (IT), telecommunications, and artificial intelligence, and propose a model for a democratically planned, viable and efficient socialist economy for discussion. In the planned economy of Ukraine, without market processes and competitive pricing, rational economic calculation is impossible, which inevitably condemns to inefficiency (Richardson, 1999).

The subject matter contained in modern control theory is very broad in the understanding of cybernetics and is characterized by the basic principles: linear systems, nonlinear systems, optimal control, stochastic control and applied control theory. The theory of linear systems is the most basic and relatively mature branch of modern control theory. It focuses on the management and observation of economic conditions in linear systems. The main method of analysis and synthesis is the state space method. According to the mathematical apparatus used, linear systems theory is usually divided into three schools: geometric theory, based on geometric concepts and methods; algebraic theory, based on abstract algebraic methods; and complex frequency theory. The nonlinear system theory is not yet perfect. The areas of investigation are mainly limited to the stability of system motion, the control and observation of a bilinear system, and the problem of non-linear feedback. A more general nonlinear systems theory has not yet been created. Since the mid-1970s, some methods derived from differential geometry theory have provided powerful theoretical

tools for the analysis of certain types of non-linear systems. From the cybernetic interpretation of the Ukrainian economy, the principles of equifinality and multifinality are derived, very far from the deterministic postulate of R. Descartes (1938) on linear direct communication, where the cause precedes the effect (Umpleby & Dent, 1999). In 1948, the American mathematician N. Wiener (1985) published his book "*Cybernetics or control and communication in the animal and the machine*" in English and French, which discusses the general method of control theory, further specifies the concepts of feedback and the mathematical definition of the regulator and gives a new meaning to the subject of control theory. At the same time, four basic principles are distinguished, namely universality, rationality, non-determinism and black box testing methods. With the assimilation of cybernetic theories systems came the understanding of the regulation mechanisms of economic structures as negative feedback processes aimed at preventing deviations (Meystel, 1996). Cybernetic systems strive to maintain a viable stable state of interactions in changing conditions through a process of trial and error. In France, Dr J. de Rosnay (1975) was one of the first to popularise the main concepts of cybernetics and to apply them to a systems approach to management: cell, body, city, economy, and ecosystem. The management of the system, in this case, is to link it to another system, the role of which will be to maintain as little variety of results as possible. The purpose of stochastic control theory is to solve stochastic control systems, analysis, and synthesis. The N. Wiener filter theory (1985) and the Kalman-Bucy filter (Kalman, 1960) are one of the foundations of stochastic control theories. A major component of stochastic control theory is stochastic optimal control, and the solution to such stochastic control problems depends on dynamic programming

concepts and techniques (Varela & Maturana, 1992). Adaptive control theory is a type of control system that can automatically adjust its own characteristics based on the idea of imitating biological adaptability. The study of an adaptive control system can often be attributed to the following three main tasks: identifying the dynamic characteristics of the managed object; choosing a solution based on the recognised object; producing a reaction or action based on a recognised object.

One of the pillars of modern management theory is the principle of optimal management. This principle has been applied in practice since the early 1960s (Klir, 2001). This process changes the design method of classical control theory, which focuses on stability and dynamic quality, and looks at system performance over the whole period of operation, selecting the optimum control law that can significantly improve the performance of the Ukrainian economic system. The theory of optimal control studies the control laws and complex methods of a controlled system at optimal specified performance indicators. In the theory of optimal control, the main methods of synthesis of optimal control systems are the maximum principle and dynamic programming. The scope of studies in optimal control theory, such as optimal control of large systems and optimal control of systems with distributed parameters, is expanding. Another core of modern management theory is the principle of optimal estimation. It provides a powerful mathematical tool for solving stochastic elements and stochastic control problems, overcoming the limitations of the filter of linear, stationary, or non-stationary random processes.

#### 4. Conclusions

Thus, the last decades of the 20th century have been characterised by the explosive

development of the Internet and the processes associated with globalisation. The concepts of cybernetics include a system of interdependencies between markets in which they are internally balanced. The economy resulting from this paradigm is looking for optimal and sustainable solutions in static and dynamic senses. A condition for sustainability in Ukraine's innovative development is that there are alternative approaches to explaining economic shocks and phenomena, where the cybernetic aspect represents an interesting alternative to an equilibrium economy. The structure of economic governance has changed over time: it has been amended in response to new economic challenges. The mechanisms and legal framework of the economic architecture in the cybernetic aspect are designed to show that the model of economic management was burdened with structural flaws from the very beginning. Ukraine's economic management principles are excessively rigid, opaque, and ineffective, often in the form of non-compliance with accepted rules and policy recommendations, a lack of adequate room for manoeuvre, and the absence of emergency management mechanisms in situations of economic shock or crisis.

Innovation is an important factor in the competitiveness of Ukraine, since it contributes to economic growth, improves living standards, and enhances the country's image in the international arena. The study diagnoses both favourable and weaker conditions for the development of innovation and investment principles in Ukraine. Particular emphasis was placed on the country's investment opportunities, given the principle of emergence. They are based on multivariate theoretical approaches with an analysis of the strengths and weaknesses of each. Living in a time of information revolution, the economic factors in a cybernetic perspective are overwhelmed by an incredible amount of content and back information. This science provides extremely effective solutions to issues which interact with the environment through feedback. Innovative controls prioritise spending on existing infrastructure to free up the resources needed for further innovation. The principles of cybernetics are not questioned but are fiercely debated, as they are deemed totally unsuitable for an economy as weak as Ukraine's, and this series of tactical errors could lead to the deindustrialisation of the country, accompanied by massive system failures.

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**THE EFFECT OF HUMAN RESOURCE  
COMPETENCE AND INNOVATION ON  
EMPLOYEE COMPETITIVE  
ADVANTAGES:  
AN EMPIRICAL STUDY IN SMALL  
MEDIUM ENTERPRISE**

**Abstract:** *The purpose of this research is to understand the impact of human resource (HR) and innovation skills on competitive advantage at small medium enterprise (SME) in Yogyakarta, with entrepreneurial marketing as a moderating variable. This study uses a quantitative survey method. In Yogyakarta, 120 SME entrepreneurs were randomly selected. Sampling through non-probabilistic techniques using a criteria-based approach. The collected data was then analyzed using structural equation modelling (SEM) with the help of the Smart Partial Least Square (PLS) application. The research findings show that small doses of HR expertise and entrepreneurial marketing have a significant positive impact on competitive advantage, whereas innovation does not have such an effect. Marketing innovation and HR expertise have a huge impact on start-up businesses. Finally, evidence suggests that innovative marketing and entrepreneurship can bridge the gap between HR expertise and competitive advantage.*

**Keywords:** *Entrepreneurial Marketing, Human Resource Competence, Innovation and Competitive Advantage*

## **1. Introduction**

As a consequence of the growth of the industrial sector, the business world is experiencing an increasingly fierce level of competition (Eggers, et.al, 2018). This situation has the potential to open many doors, but in the long run it will also lead to increased business competition (Muhammad et al., 2019). As a result, it is very clear that businesses need to have a sole competitive advantage in order to survive and thrive in the current market climate. Cultivating competitive advantage is one of the key strategies by which companies can survive in the face of intense competition in the market

(Naidoo, 2020). Competitive advantage is self-confidence that comes from understanding that one's organization has superior resources and a higher level of productivity compared to other businesses operating in the same industry (Ektebang & Eniola, 2018).

There are several factors that influence competitive advantage in a business, including market orientation, product innovation, environmental adaptability, entrepreneurial orientation, training and market orientation, and management capabilities (Wahyudin, 2015); (Satria & Sulisyawati, 2018). (Satria & Sulisyawati, 2018). As SMEs play such an important role

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in the Indonesian economy as a whole, the government is currently focusing a lot of attention on the country's small and medium enterprise sector (SME). The non-migration processing economy sector saw the largest increase in GDP investment, with the food and beverage industry providing up to 36.4% of the investment. The economic sector saw the greatest growth in SME investment (Edi, 2021).

To be successful in today's increasingly competitive marketplace, business owners need to work more diligently than ever before to develop cutting-edge innovations that will assist them in maintaining and improving the quality of their products and services without compromising their ability to turn a profit. In addition to the quality of the product itself, the improvement of the quality of customer service must be examined. Accurate descriptions are necessary due to the convenience of ordering and receiving food and beverages online, as well as the wide variety of goods and services available. To find a solution to this problem, you need an all-encompassing marketing strategy that incorporates entrepreneurial characteristics. Becherer (2017), Hidayatullah et al. (2019), and the work of others should be followed as a guide (Mahrous, et.al, 2020).

According to (Morrish, et.al, 2017) entrepreneurial marketing is helping proactively and taking advantage of opportunities to buy and retain customers who have subscribed and are profitable with innovative approaches in managing risk, using human resources and creating corporate value. According to Green's (2018) examination of target markets, modern consumers are more likely to consider their sentiments, desires and imaginations when making purchasing decisions, whereas in the past they were more inclined to base their decisions on rational factors. [citation needed] As a direct consequence of this, the marketing approach needed to be revised.

Contemporary marketing tactics place greater emphasis on visual intuition while paying attention to words, in contrast to earlier marketing strategies which placed greater emphasis on analysis, words and numbers. As a result, it is not surprising that many Indonesians choose to eat outside the home given the country's alluring cuisine, fashionable dining locations, and Instagrammable food (Jones, 2017). In the complex modern world, companies must be able to apply creative marketing techniques to achieve their goals in a more timely and more effective manner.

A company's ability to successfully market its products is critical to a company's success because it makes those goods more available to people who might be interested in buying them. It is this marketing strategy that will ultimately determine how successful the marketing of a product is because it is this strategy that will consistently build and maintain client demand in the long term. It is very important, when sales of a particular product start to grow above expectations, to identify whether this is due to inefficient marketing methods or whether or not this is due to changing consumer tastes and expectations.

It is very important to have knowledgeable HR professionals to carry out the responsibilities required to gain a competitive advantage. Alajmi (2016), Mitchelmore (2017), and Nemli (2018) all agree that HR is an important component of a company's most valuable asset. In the enterprise system, the success or failure of the company's goals is determined, and the company. need to pay more attention. It is not enough for organizations to simply identify the perfect employee for the position; instead, each candidate must possess the requisite abilities.

The marketing process used by SMEs is related to human resources in a number of ways. According to Alajmi, having skills in HR may be beneficial for entrepreneurial



marketing (2016). The contribution of an organization's human resources is one of the most important factors in determining how effective a program will be. The sustainable success of a company depends on access to human resources who are able to think creatively and analytically. Because of these characteristics, companies can more quickly manufacture goods tailored to customer needs and preferences.

In achieving competitive advantage through HR expertise, innovation plays an important role. Innovating is essential for those with their own businesses, and fresh concepts are essential for the kinds of forward-thinking marketing methods entrepreneurs typically use. Researchers Afriye (2019), Miles (2016), and Morrish (2017) all agree that company-led innovation can have an impact on the marketing strategies used by SMEs. To be successful in today's turbulent economic environment, companies that want to stay in business need to improve their marketing skills, broaden their customer base, and increase their sales and revenues to compete with more established businesses.

It seems that the market is becoming more and more significant in today's increasingly competitive environment. Companies are under increasing pressure from customers with rapidly changing wants and must be agile enough to keep up with the times by implementing various innovations that keep up with the changing nature of business. Customers place this pressure on businesses, which are already under increasing pressure from customers with rapidly changing wants and needs. One reason is that clients have varying demands at different points in time; consequently, they may choose to purchase products from other companies if they are not sure that one business can meet all of their requirements. Therefore, for businesses to continue to achieve their goals, they need cutting-edge innovation. Innovation has the potential to impact every aspect of a company, including the way its merchandise

is marketed.

Production techniques, product presentation and marketing strategies all have the potential to be changed by innovation. Customers examine not only the final value of the product and the benefits they will derive from its use when deciding whether to make a purchase or not, but also whether or not the price of the product is competitive with other comparable items. Research conducted by Chang (2017), Dereli (2015), Le & Lei (2018), Mathenge (2018), Varadarajan (2019), and Udriyah (2019) shows that company innovation has the potential to increase a company's advantage over its competitors. By providing creative innovation, it is hoped that the company will be able to provide goods that are different from those produced by other companies in the past and offer advantages that exceed what is offered by goods on the market today.

Enhancing a company's competitive advantage requires a large amount of HR expertise as well as new capabilities. Sandiku Dushi (2019) claims in a recent essay that entrepreneurial marketing is a realistic strategy for small and medium enterprises (SMEs) due to the fact that the majority of SMEs have limited resources and, as a result, need to be creative in order to be successful. There is great hope placed on marketing SMEs as it is anticipated that they will be able to gain a competitive advantage through leveraging HR knowledge and new solutions.

Findings from a number of studies that focus on market orientation have led researchers to the conclusion that market orientation has a considerable influence on business performance across various measures of growth, sales, and profitability (Long, 2018). A strong market orientation also requires a strong level of motivation to seek new opportunities and markets, which has a major influence on market orientation (Reijonen et al., 2017). Research conducted

by Arafah (2018:8) shows that having a strong focus on the market can greatly improve a company's performance. According to Mamun and dkk (2018: 133), additional research was carried out with the title "Effect of Entrepreneurial and Market Orientation on Consumer Engagement and Performance of Manufacturing SMEs". on the level of consumer involvement and manufacturing performance in small and medium enterprises (SMEs) and resource based view (RBV). According to the research conclusion, customer participation is the most important component, accounting for 31% of the total, followed by an emphasis on enterprise business (12.6%) and market orientation (9.2%). According to Buli (2017), in his research entitled "Entrepreneurial Orientation, Market Orientation and Performance of SME in The Manufacturing Industry: Evidence from Ethiopian Enterprises", empirical studies claim that the success of small and medium manufacturing enterprises (SMEs) is strongly influenced by market orientation. them, as much as 12 percent. Buli's research was conducted on Ethiopian businesses. Nonetheless, there is a contradiction between these findings and research conducted by Kajalo (2015) and Mahmoud (2018), both of whom came to the conclusion that market orientation has no significant correlation to company performance.

These two authors found that the correlation was weak. According to research conducted by Anwar (2018: 998) entitled "Networking and new venture's performance: mediating role of competitive advantage," competitive advantage acts as a powerful mediator between financial intermediation and business performance. Moreover, competitive advantage acts as a powerful mediator between business networks and business performance. In addition, research conducted by Asyhari (2018: 123) entitled "The Role of Competitive Superior Mediation on the Determinants of SME

Business Performance in Batik Weaving Centers in Central Java" shows that the ability of SMEs to generate competitive advantage through differentiation, durability, imitation, and cost competition is an important factor in the realization of business success.

This study intends to explore the effect of HR capabilities and innovative thinking on competitive advantage in SMEs in Yogyakarta by using entrepreneurial marketing as a moderating variable. The results of previous research and the existence of research gaps are the foundation of the research objectives.

## 2. Literature review

### 2.1 Entrepreneurial Marketing

Visionary marketing is a kind of marketing strategy that is not predetermined and used by business owners who have a broad vision, according to Morris et al. (2018). Visionary marketing is described as a type of marketing strategy that is not predetermined. Marketing on an entrepreneurial scale requires adaptability in dealing with change, openness to new concepts, concentration on developing market potential, and capacity to meet customer needs (Jones, 2017). According to Carson (2017), SME sales are truly the sales of the entire corporation. Moore (2017) argues that the foundation of effective entrepreneurial marketing consists of four pillars: concepts, strategies, techniques, and market intelligence.

According to Dushi (2019), entrepreneurial marketing is one of the best strategies for small and medium businesses because most of these businesses have limited resources and need to be creative to be successful. This is why entrepreneurial marketing is one of the best strategies for small and medium businesses. According to Morris (2018), one of the methods that can be used to build a competitive advantage in the twenty-first century is by adopting an entrepreneurial

approach in marketing. This strategy can be used to create new products or services that are rated higher than competitors.

According to the findings of research conducted by HidayatuHah (2019) and Mahrous (2020), commercial marketing influences marketing performance by influencing marketing performance measures such as competitive advantage. Again, research shows that entrepreneurial marketing has an impact on the performance of companies as well as their prominence in the market (Mahrous, 2020). According to Becherer's research, entrepreneurial marketing does have an impact on the results obtained in SMEs (2017).

According to findings published in 2019 by Autio, entrepreneurial marketing and innovation are inextricably linked in ways that help each other. Agyapong (2017) found the same results, showing that there is a correlation between innovation and marketing procedures carried out within the company. A recent study (Afriye, 2019) came to the conclusion that innovation in all four categories (products/services, processes/operations, organizational structure/functions, and marketing) has a major impact on a company's marketing success. According to Morris (2018), there are a total of twelve indicators for business marketing, and they include the following: proactiveness, risk taking while considering potential consequences, attention to opportunities, utilization of available resources, customer focus, and value creation.).

## 2.2 Competence of Human Resources (HR)

Increasing productivity is one of the goals that can be achieved through the use of human resources in a company. The strategic decision-making process (HR) is the engine that drives an organization's efforts to achieve or fulfill its vision and goals. The

process of developing skills in HR is implemented throughout the organization, starting with the recruitment stage and continuing through to awarding. According to Shahhosseini (2021), having HR capabilities will make it easier to complete a project, which will ultimately give the organization an advantage in the market. HR competence affects all aspects of the company's operations, including the marketing strategy it uses. According to Franco (2018), for SME entrepreneurial marketing efforts to be successful, the human resources currently available must be able to think creatively and not be fixated on the marketing methods of large companies. This is because SMEs have limited resources, both in terms of human resources and financial resources. HR in SMEs must be able to respond to market opportunities and needs, maintain consistency in marketing university products, and be able to communicate with a wider audience.

Adoption of HR practices has a positive and statistically significant impact on a company's competitive advantage, according to research conducted by Alajmi (2016) using data collected from employees in a thousand one hundred and thirty manufacturing companies. This data is collected from employees in one thousand one hundred and thirty manufacturing companies. Improving one's skills in HR will help the company to operate at a higher level of efficiency, which in turn will result in achieving better operational results. This shows the need to use human resources in every initiative undertaken by a company to build a competitive advantage for itself. NemII (2018) emphasized that HR competency influences the company's competitive advantage. "knowledge", "skills", "self-concept", and "motivation" are indicators of HR competency, as stated in (Gordon, 2017).

### **2.3 Company Innovation**

In order for a company to continue to maintain its leading position in an increasingly competitive business climate, innovation is absolutely necessary for the company's success. In order for a business to innovate successfully, it must apply the new concept as a whole in all of its activities (Ceylan, 2018). The process of identifying opportunities to produce goods, services, or unique methods of doing business is referred to as "innovation", and it is included under the umbrella word "innovation". The company's capacity to develop new products, services and processes can have a major impact on company performance and can be considered an investment with a long-term horizon (Andries, 2019).

Until 2016, Prajogo had completed research on business creativity by interviewing 194 business managers in Australia. According to recent research findings, technical innovations brought by technology prove to be more useful in helping businesses achieve their goals. (AtaLay, 2019) conducted a study of top-level managers in 113 Turkish vehicle assembly companies in 2011 and found results comparable to those findings. The research results show that technological innovation has a positive and significant impact on business performance, regardless of whether the impact is measured in the form of outputs or processes. According to Vaccaro (2020), a company's ability to innovate in terms of features and functional efficiency of its products can have a considerable impact on a company's profit and, as a result, on its ability to compete in the market. According to Coloson (2020), innovation is an important component of any marketing plan that can be considered effective for entrepreneurial ventures. Entrepreneurial marketing places significant emphasis on change management, opportunity analysis, and product development as its three main areas of

concentration.

According to DereII (2015), effective innovation management can generate a competitive advantage for one's company. As a result of the fact that the main goal of innovation is to meet client demands, it is widely recognized as a strategy that can help companies gain an advantage over their competitors. According to the findings of a study conducted by Udriyah (2019) which involved the participation of 150 SMEs in SeLangor, market orientation and innovation have an effect on competitive advantage. Another researcher, Ie (2018), came to a very similar conclusion. He observed that the level of innovation in an organization can affect its competitive advantage. Product innovation, process innovation, marketing innovation and organizational innovation are the four types of innovation identified by the OECD as indicators of innovation.

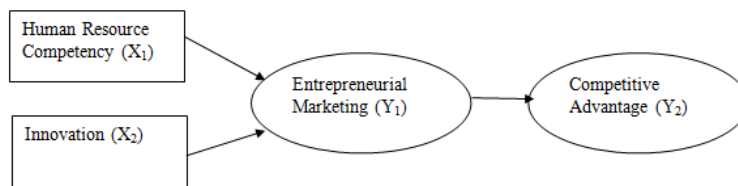
### **2.4 Competitive Advantage**

When a business has a "competitive edge", also known as an "advantage", it shows that the business has a more prominent position in its industry compared to its competitors (Kumar & Pansari, 2018). If the company has access to competent and unique sources of strength, it is likely that the company will have a competitive advantage in the market. An organization's internal resources and its position in the external market are the two fundamental sources of strength that determine a company's competitive advantage. Hinterhuber (2019) confirms that the most successful corporate strategy for growing new competitive resources is the most significant competitive advantage. In the business world, every company is constantly competing with each other to see which one is the most successful in the market. Every company has a strategy for growth, and that strategy usually involves delegating tasks to different departments to maximize efficiency. Formulation of an

effective strategy is very important for long-term business continuity, because to maintain market share, the strategy must be able to provide a lasting competitive advantage.

When a business consistently maintains a market share that is in excess of what its competitors have achieved, this is the best demonstration of an organization's competitive advantage. A large number of different approaches to running a company can be used to secure a long-term advantage over the competition (Poter, 2017). The goal of this tactic is to achieve significantly lower operating costs than competing firms. As a result, the focus of this tactic is on increasing productivity. It is impossible to ignore the fact that cost reduction represents greater profit potential and greater capacity to withstand the effects of price competition

(Zekiri & NedeIea, 2019). Whyudin (2015) identifies market focus, product innovation, and environmental flexibility as the three main reasons for a company's capacity to maintain a competitive advantage. According to research by Satria and SuListyawati (2018), the factors that determine a company's competitive advantage include entrepreneurial orientation, training, market focus, and management skills. According to II (2018), an organization's competitive advantage can be broken down into several criteria, some of which are price/cost, quality, delivery speed, product innovation, and market time. Given the theoretical work just discussed, a further research framework can be conceptualized as follows:



**Figure 1.** Research Concept Framework

### 3. Research methods

The research method used in this research is a quantitative survey. It seems that the actual number of Yogyakarta residents who are members of the SME is unknown, but the population consists of these residents. Variations in sampling are evaluated, and sample size is determined based on the smallest number of samples that will produce valid results. When the standard deviation is smaller than five, the number of samples required is 120, as stated by Cooper (2018). The methodology used to collect samples is called non-probability sampling, and uses a purposive sampling method. In order to meet the minimum standard, a

company must have been in operation for at least two years and generate an annual revenue of at least IDR 2.3 million.

Standard questionnaires were distributed via Google Form to SME students who are members of several student organizations in Yogyakarta to compile this information. After the information is obtained, it is evaluated with the help of the Smart PIS program through the structural equation model (SEM). According to the findings (Gozali & Iatan, 2015), the following is an overview of the data processing steps for this particular study:

1. The Mode for Evaluating Success Called the Staged Mode At this point, instruments are put through their paces in the testing

phase, where the accuracy and reliability of various indications are evaluated. The Staged Evaluation Framework is the first instruction. At this point, the instruments will live their step in the testing phase, where many indicators will be evaluated for accuracy and precision. An instrument is said to be valid and reliable if its calculated value is greater than its mean value at a significance level of 0.05 and its Cronbach's Alpha value is better than 0.6. second literacies of the Test Phase structure model. At this point in the hypothesis testing procedure, the aim is to determine whether the independent and dependent variables, as measured by the Smart PIS mode, really have a relationship that can be considered statistically significant. The statistic known as the r-squared coefficient is used to determine the extent to which the variables in the model are related to each other in some way. After that, the estimation of the radiant efficiency of the paving stones was obtained by applying the bootstrapping approach. If the t-statistic is greater than 1.96 and the p-value is less than 0.05, then the result is considered statistically significant; if the value of r is greater than r table at a significance level of 0.05, then the result is valid; and if Cronbach's Alpha value is greater than 0.6, then the result is considered reliable.

2. The evaluation of the structural model, also known as a hypothesis, is the second stage of testing. The purpose of this stage is to determine, through the application of the partial least squares statistical method, whether the hypothesized relationships between the various construct variables and nodes are significant or not (PIS). The statistic known as the r-squared coefficient is used to determine the extent to which the variables in the model are related to each other in some way. After that, an estimated line efficiency coefficient derived through bootstrapping is displayed. The results were considered statistically significant if the t-

statistic was greater than 1.96 at a significance threshold of 0.05, while the beta coefficient was used to indicate the direction of influence. Staged Mode as a Means of Evaluating Success At this stage, the instrument will be tested for its capabilities, in which various indicators will be evaluated for accuracy and precision. An instrument is said to be valid and reliable if its calculated value is greater than its mean value at a significance level of 0.05 and its Cronbach's Alpha value is better than 0.6. The second iteration of the Test Phase structure mode. At this point in the hypothesis testing procedure, the aim is to determine whether the independent and dependent variables, as measured by the Smart PIS mode, really have a relationship that can be considered statistically significant. The statistic known as the r-squared coefficient is used to determine the extent to which the variables in the model are related to each other in some way. After that, an estimated line efficiency coefficient derived through bootstrapping is displayed. The results were considered statistically significant if the t-statistic was greater than 1.96 at a significance threshold of 0.05, while the beta coefficient was used to indicate the direction of influence.

## 4. Results

### 4.1. Output Test of Validity and Reliability

The test was given to a total of 35 people using the instrument. When the significance criterion is set at 0.05 and the r-squared statistic for table is 0.372, the instrument is considered valid if the r-squared statistic is higher than the r-squared statistic for table. The reliability test can determine how consistent the readings are from a measuring instrument. Analysis whether the ranking is consistent or not using Cronbach's Alpha. Cronbach's alpha value of more than 0.6

indicates that the instrument has a high degree of dependability.

All r product moment values are greater than or equal to 0.372, which indicates that all research items for all research variables are valid. This conclusion is reached by determining the extent to which the research instrument can be relied upon. Since all variables have a Cronbach's Alpha value greater than 0.6, the entire set of variables can be trusted.

## 4.2. Structural Analysis of the PLS Equation Model

### a. Outer Model Results

The convergence validity criterion requires that each dimension in model I meets a certain threshold, which is defined as an absolute loading factor greater than 0. If this is not successful, the relevant dimension will be removed from the model. The results of the convergence test conducted to determine the accuracy of the data are presented below.

**Table 1.** Output Convergent Validity

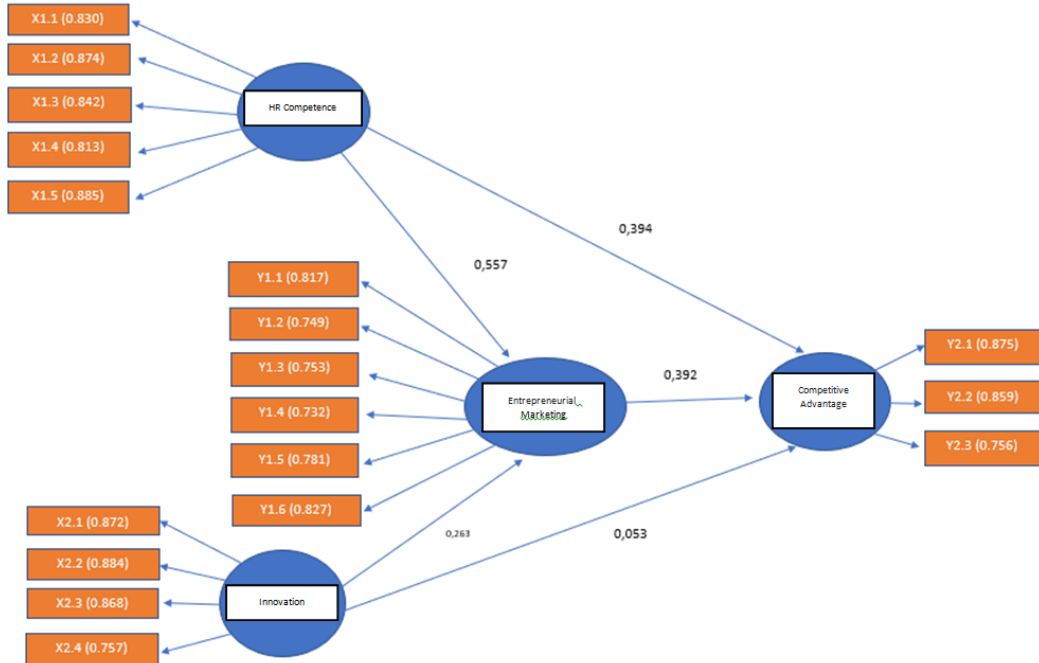
Indicator	Entrepreneurial Marketing	HR Competence	Innovation	Competitive Advantage
X <sub>1,1</sub>		0.830		
X <sub>1,2</sub>		0.874		
X <sub>1,3</sub>		0.842		
X <sub>1,4</sub>		0.813		
X <sub>1,5</sub>		0.885		
X <sub>2,1</sub>			0.872	
X <sub>2,2</sub>			0.884	
X <sub>2,3</sub>			0.868	
X <sub>2,4</sub>			0.757	
Y <sub>1,1</sub>	0.817			
Y <sub>1,2</sub>	0.749			
Y <sub>1,3</sub>	0.753			
Y <sub>1,4</sub>	0.732			
Y <sub>1,5</sub>	0.781			
Y <sub>1,6</sub>	0.827			
Y <sub>2,1</sub>				0.875
Y <sub>2,2</sub>				0.859
Y <sub>2,3</sub>				0.756

SMARTPLS 3.0 Output Data Source by Researcher, 2023.

Table 1 shows that all dimensions have outer loading > 0.700, so there are no dimensions that need to be removed from mode I. The results of convergent validity can also be seen visually as shown in the figure 2.

Model measurements can also use AVE (Average Variance Extracted) and CR (Composite Reliability), and the following are the results (table 2).

The recommended AVE value is > 0.5, while the composite reliability value is > 0.7. The AVE value obtained is above 0.5, this means that the variance that can be explained by the dimensions is above 50%. Meanwhile, the composite reliability value > 0.7 means that all of the stable variables have good reliability



**Figure 2.** Convergent Validity Model Results of SEM-PLS Entrepreneurial Marketing and Competitive Advantage

**Table 2.** Results of Average Variance Extracted (AVE)

Variable	Composite Reliability	Average Variance Extracted (AVE)
Entrepreneurial Marketing	0.895	0.593
HR Competence	0.912	0.714
Innovation	0.863	0.683
Competitive Advantage	0.934	0.728

SMARTPLS 3.0 Output Data Source by Researcher, 2023.

**b. Inner Model Results**

The following is the result of the analysis of the coefficient of determination (R<sup>2</sup>) of the inner mode.

**Table 3.** Value of the Coefficient of Determination (R<sup>2</sup>) in the Inner Model

Variable	R Square	R Square Adjusted
Entrepreneurial Marketing	0.557	0.543
Competitive Advantage	0.594	0.589

SMARTPLS 3.0 Output Data Source by Researcher, 2023.

The meanings that can be explained in table 3 are:

1. It has been determined that a value of 0.543 should be assigned to the determinant coefficient for the final stage entrepreneurship marketing variable. This shows that human resources and inventive talent can explain 54.3% of the variation in entrepreneurial marketing, while other factors outside the mode account for 45.7% of the variation in entrepreneurial marketing.



2. Second, the value of the competitive advantage of the latent variable will always be 0.589% regardless of other factors. This suggests that HR competency orientation, innovative marketing, and entrepreneurial marketing may be responsible for 58.9% of the variance in competitive advantage, while

out-of-mode factors are responsible for 41.1% of the variance.

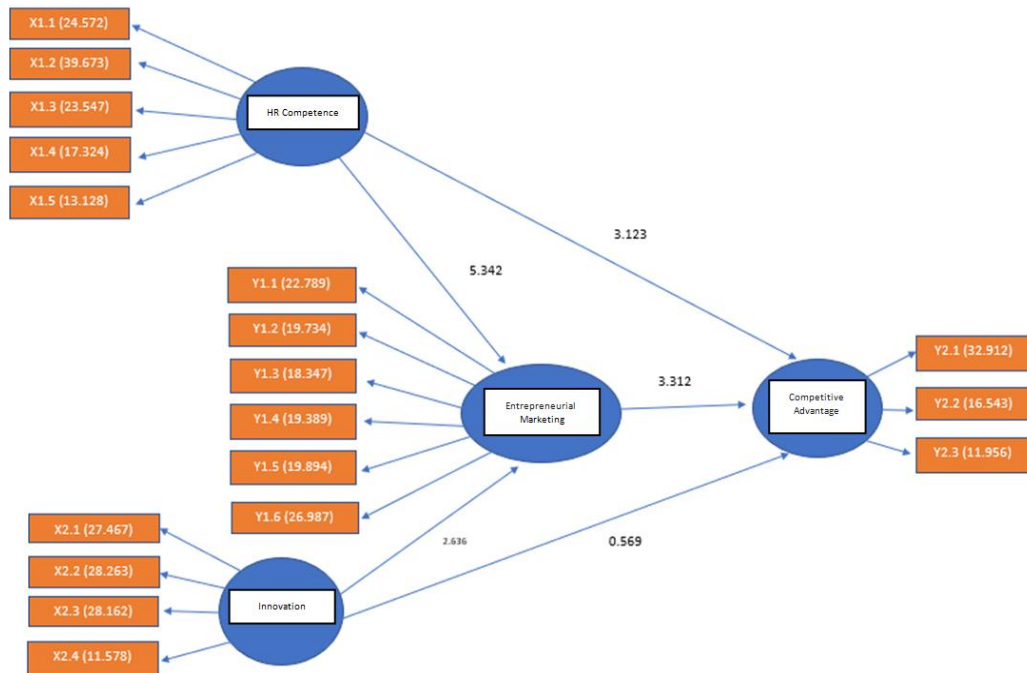
Estimation of the path coefficient of the least square model of entrepreneurial marketing and competitive advantage is shown in table 4.

The results of a causal relationship between latent variables are stated in the figure 3.

**Table 4.** Estimating Results of Partial Least Square Entrepreneurial Marketing Models and Competitive Advantage

Information	Original Sample (O)	Standard Deviation	T Statistics	P Values
Entrepreneurial Marketing to Competitive Advantage	0.392	0.115	3.312	0.001
Innovation towards Entrepreneurial Marketing	0.263	0.096	2.636	0.008
Innovation towards Competitive Advantage	0.053	0.102	0.569	0.567
HR Competence on Entrepreneurial Marketing	0.557	0.107	5.342	0.000
HR Competence on Competitive Advantage	0.394	0.125	3.123	0.003

SMARTPLS 3.0 Output Data Source by Researcher, 2023.



**Figure 3.** RESULTS OF SEM-PIS Entrepreneurial Marketing Modelling and Competitive

Advantage. The estimation results of the research model are as follows:

$$EM = 0.557 KS + 0.263 IS$$

$$KK = 0.394 KS + 0.053 IS + 0.392 EM$$

The structural equation can be explained as follows:

- a) The HR competency variable has a significant positive effect on Entrepreneurial Marketing (EM) with an estimated path coefficient of 0.557 and a p-value of 0.000. This means that the better the competence of the HR (KS), the better the Entrepreneur Marketing (EM).
- b) The latent variable of innovation has a significant positive effect on Entrepreneurial Marketing (EM) with an estimated path coefficient of 0.263 and a p-value of 0.008. This means that the better the innovation (IS), the better the Entrepreneurial Marketing (EM).
- c) The HR competency variable has a significant positive effect on competitive advantage with an estimated path coefficient

of 0.394 and a p-value of 0.003. This means that the better the competence of human resources, the higher the competitive advantage (KK).

d) Innovative innovation variable (positive but not significant effect on competitive advantage with an estimated path coefficient of 0.053 and a p-value of 0.567. This means that the more innovative, the competitive advantage will increase, but the increase that occurs is not statistically significant.

e) Entrepreneurial Marketing Identification Variable has a significant positive effect on competitive advantage with an estimated path coefficient of 0.392 and a p-value of 0.001. This means that the better the entrepreneurial marketing (EM) is, the higher the competitive advantage will be.

Table 5 below is used to see the indirect effect of HR competence and innovation on competitive advantage through Entrepreneurial Marketing (EM).

**Table 5.** Indirect Effect

Information	Original Sample (O)	Standard Deviation	T Statistics	P Values
Entrepreneurial Marketing to Competitive Advantage				
Innovation towards Entrepreneurial Marketing				
Innovation towards Competitive Advantage	0.104	0.045	2.347	0.021
HR Competence on Entrepreneurial Marketing				
HR Competence on Competitive Advantage	0.216	0.090	2.413	0.012

Data Source SMART-PIS 3.0 Output by Researcher, 2023.

According to Table 5, it can be explained that the indirect influence of HR competence and innovation on competitive advantage through entrepreneurial marketing.

a) The path coefficient of the indirect influence of HR competence on competitive advantage through entrepreneurial marketing is 0.216 with a p-value of 0.012 (significant at a level of 5%). The positive indirect path

coefficient indicates that the higher the competence of HR, the competitive advantage will also increase mediated by Entrepreneurial Marketing.

b) The path coefficient of the indirect effect of innovation (IS) on competitive advantage (KK) through entrepreneurial marketing is 0.104 with a p-value of 0.021 (significant at a level of 5%). The positive indirect path coefficient indicates that the better the innovation, the competitive advantage will also increase mediated by Entrepreneurial Marketing.

## 5. Discussion

### 5.1. The Effect of Human Resource Competence on Entrepreneurial Marketing

Examination of the available data reveals that HR capabilities have a constructive and material influence on business expansion through marketing. That is, the level of HR expertise possessed by an entrepreneur will be directly correlated with the quality of the marketing efforts carried out by the entrepreneur, and the increase will be directly proportional. Based on the findings of this study, there are four components that make up HR competence: knowledge, skills, beliefs, and motivation. Their strong level of confidence and drive has a beneficial effect on their respective business marketing activities, even though the Yogyakarta SME participants may have minimal knowledge and abilities. SME business owners looking to start their own companies have a significant demand for entrepreneurial marketing because it offers tactics that large organizations do not have. Therefore, to improve entrepreneurial marketing, SME students in Yogyakarta need to improve their HR skills as a whole. Our findings provide support for the claims made by Ahmad and Zainal (2020) and Gerardo and Alberto (2019), who argue that HR is an important

component for achieving the day-to-day operations of an organization. Therefore, acquiring related skills in business management is an important step in the process of building a strong and competitive SME. The results lend credence to the claims made by Shahhosseini (2021) and Franco (2018), who argue that the application of HR skills has a significant effect on the level of success achieved by entrepreneurial marketers.

### 5.2. The Influence of Innovation on Entrepreneurial Marketing

According to statistical research findings, innovation has a beneficial and materially significant impact on entrepreneurship in the field of marketing. The concept of innovation is dissected into four different aspects during this investigation, namely product innovation, process innovation, marketing innovation, and organizational innovation. Seeing how innovators in the food and beverage sector are increasing their market share, this conclusion has important meaning for the entrepreneurial marketing of the food and beverage business. In order to develop and expand their company in the face of increasing competition and a society whose behavior is constantly changing to meet changing social customs and advances in technology, company owners must be innovative in their approach to problem solving. One example is the COVID-19 pandemic that occurred this year.

As a result of the government rationing rules that have been in effect in Yogyakarta since the start of the latest outbreak, SME players have had to adapt to shifting customer preferences. To supply cutting-edge goods and services to consumers, business owners must be able to generate innovative innovations, creative ideas and fresh points of view. As a result, innovation is becoming increasingly important not only as a tool for ensuring business continuity but also as an

important instrument for competing successfully in the marketplace. The level of success of a company in generating positive consumer views will be directly proportional to its capacity to produce new products, services and processes. The end result of this procedure is the generation of a distinctive quality that differentiates them from their competitors. The results of this study support the findings of previous studies (Afriye, 2019; Sakhosseini, 2021; Miles, 2016; Morrish, 2017) which shows that innovation has a large influence on the marketing strategies used by entrepreneurs.

### **5.3. The Effect of Human Resource Competence on Competitive Advantage**

According to statistical investigation findings, having HR competence has a materially beneficial impact on a company's competitive advantage. Based on these facts, the competitive advantage of Yogyakarta SMEs is expected to increase in direct proportion to the level of HR knowledge possessed by the actors. HR competence can be broken down into five different components: one's knowledge, abilities, motivation, level of self-confidence, and personal philosophy. Having high HR knowledge and skills has a positive effect on the efficiency and effectiveness of task completion; having a high level of motivation increases productivity; having a high level of self-confidence makes it easy to make adjustments and take risks; and having low levels of these traits has the opposite effect. Therefore, human resources are an important asset that requires careful planning and management at every stage, from initial recruitment to permanent placement to developing skills and abilities to maintaining positive working relationships. This is necessary so that the talent of the company's employees can help the company gain a competitive advantage. For a business to have a significant advantage over its

competitors, it is necessary to have a certain level of human resource competency to fill the available roles. The results of this study provide evidence that supports the findings of Nemi (2018) and Alajmi (2016) who found that HR knowledge is related to competitive advantage.

### **5.4. Effect of Innovation on Competitive Advantage**

According to statistical research findings, innovation does have a good impact, but it does not lead to long-lasting competitive advantages. Due to a lack of substantial resources, researchers at SMEs in Yogyakarta are faced with significant hurdles. Increased capital is necessary for innovation, but small companies often have limited access to financial and human resources (Sdiku-Dushi, 2019). Due to their limited resources, small businesses have a hard time innovating as they are forced to rely more on limited internal resources when they manufacture their products. According to the data collected in this sector, the most typical type of small enterprise that develops conventionally over generations is the one that was started and developed by members of the same family. Newly established companies have difficulty realizing their full potential in SMEs because of the constraints that exist there, which include low levels of education and skills and low levels of talent. In addition, it is known that the Free Trade Agreement (FTA) between the United States and Canada which took effect in 2003, as well as the Asia-Pacific Economic Cooperation (APEC) in 2020 will have a significant impact on the ability of small and medium enterprises (SMEs) to compete in the global market. free trade market. This is what drives the government to support small businesses in the islands so that they can be productive and efficient in meeting consumer needs. This finding is in line with discussions (Afriye, 2019; Autio, 2019;

Miles, 2016; Morrish, 2017) which highlight the huge impact of direct innovation on a firm's competitive advantage.

### 5.5. The Effect of Entrepreneurial Marketing on Competitive Advantage

Findings from statistical studies show that entrepreneurial marketing has a very large influence and a positive impact on a company's advantage over its competitors. The relevance of this finding lies in the fact that the comparative advantage possessed by SMEs in Yogyakarta will increase in direct proportion to the level of entrepreneurial marketing carried out by the institution. Yogyakarta SME practitioners demonstrated their mastery in marketing by consistently being proactive, adaptive, daring to take risks, focused on customers, and intense on customers. Small businesses, as a whole, have limited resources, which means that they need to be creative with how they offer their products to be successful. The use of entrepreneurial marketing strategies is very helpful in situations like this (Sadiku-Dushi, 2019). According to Morris (2018), one way to gain an advantage over one's competitors in the twenty-first century is to implement a marketing plan that takes an entrepreneurial approach.

In this regard, it is very important for business owners to have a solid understanding of entrepreneurial marketing in order to enhance their advertising efforts and, ultimately, to realize the possibility of gaining a competitive advantage. These findings provide support for the argument that entrepreneurial marketing has a major impact on a company's competitive

advantage, which is supported by research conducted by (Becherer, 2017); (HidayatuIlah, 2019); and (Mahrous, 2020).

## 6. Conclusion

According to the findings of this study, strategic demand management (HR) skills and entrepreneurial marketing skills have a positive and significant effect on the competitive advantage of SME in Yogyakarta, while HR skills and innovation have a significant effect on SME marketing skills. This shows that HR skills and innovation have a significant impact on SME marketing skills. However, HR knowledge and innovation have a major impact on competitive advantage when entrepreneurial marketing is used as a mediator. Competence in human resources is the main component that determines the level of competitive advantage of the company, perhaps more than innovation. This highlights the importance of HR in the process of gaining an advantage over other businesses. For companies to innovate, they need to have knowledgeable human resources and adequate financial resources. This is because innovating requires an investment of money. Since most of the people working in the food and beverage industry still lack strong human resources and innovation skills, to gain a competitive advantage it is necessary to harness the entrepreneurial spirit that tends to penetrate SME workers and incorporate them into marketing. This is because most of the people working in the food and beverage industry still lack strong human resources and innovation skills.

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## A SYSTEMATIC REVIEW OF GEOPOLYMER MATERIALS INNOVATIONS, PREVAILING CONSTRAINTS AND RESOLUTIONS

***Abstract:** Geopolymer is a novel eco-friendly or biodegradable cementitious material that its creation might lessen the carbon-dioxide emission created through Portland cement manufacturing companies. Geopolymer material not only possess exceptional mechanical properties, but as well possess other admirable properties like fire and corrosion or oxidization resistance. The majority of industrial solid waste (ISW) and waste smoldering bottom ash (WSBA) are stacked up, which in turn fills land mass, besides has a harmful influence on the surrounding. Reprocessing them could be utilized as materials for making geopolymers. These can efficiently adsorb heavy metals, dyes or pigments, and other radioactive contaminant, that is very helpful to humanity's future development. On the other hand, as a result of the exceptional features of geopolymer material, its functions go further than that. Specific helpful information regarding geopolymer materials was make known in this study. Likewise, this paper encompassed the source of geopolymer materials, the geopolymerization, the categories of activators, their formation techniques, and the diverse usage areas of geopolymer materials. Also, the factors influencing the mechanical features of geopolymer materials were discoursed. Conclusively, the inadequacies and usage precincts of these materials were abridged, and their evolution was abridged to prepare a theoretical or hypothetical base for the lasting improvement of geopolymer materials*

***Keywords:** Geopolymer, GGBS, Curing, Activator, Strength, Poly ethylene glycol*

### 1. Introduction

Geopolymers also well-known as alkali activated materials (AAM), is an inorganic polymer materials, that can use both waste products and natural materials as the key raw materials blended by acid activation or alkali reaction. Popular raw (natural) materials with their acronyms are displayed in Table 1. GP are very good in resisting chemical

corrosion or oxidization and fire, besides possess excellent durability, and high mechanical strength (Aike et al., 2018a; AliquesGranero et al.,2019; Lahti et al. 2019; Li et al., 2020d; Bi et al., 2017; Vafai et al., 2018a). Ever since the beginning of 1980s, GP materials have been counted as stand-ins for Portland cement, mostly on account of their functioning advantages and low carbon dioxide emissions. Investigators

successfully formulate the geopolymer glaze with exceptional features like high strength, synthetic ageing and high temperature resistance (HTR), as well as safe processing performance (SPP), which might be utilized as glazings for light-weight polystyrene sheets (LWPS) for partitions or detachments, walls, and roofs (AbdeGhani et al. 2019a; Ly et al., 2019a). Wang et al. (2016) research work on the tektite geopolymer fulfills all performance prerequisites for solar or lunar construction materials: high together with low temperature cycling, about nil water ingestion, vacuum stability, and exceptional mechanical features. Owing to its outstanding features, geo-polymer stuffs have drawn full awareness as an advance material for structure refurbishment from the time of its discovery. For instance, geopolymers have been utilized at the airfield, as well as in core railway sleepers in advance nation like Australia, likewise be utilized for vitiated concrete patch-up of rigid concrete (pavement) in army stations (Shil et al. 2020a). Recently, geopolymers have also been utilized to restrain detrimental metals. Reports have revealed that the ooze actions of numerous hazardous metals though alkali-activated urban solid waste smoldering fly ash (AUSWSFA) was efficaciously obstructed, and the leaking level was within the Chinese paradigm (Liue et al., 2020a and b). Hence geopolymers not only transform waste into paragon or wealth but as well as are eco- friendly. In recent times, viable development has been encouraged all over the globe, which necessitates us to utilize natural and ecological resources as little as doable. With this innovation, the industrial hazardous solid wastes (IHSW) discharge for instance red mud (RM), fly ash(FA), effluence of dyes, heavy metals, slags, and tablets, have stirred publics' concern.

**Table 1.** Popular materials for construction works and their acronyms

Material	Acronyms
Clay	-
Fly ash	FA
Metakaolin	MK
Laterite	-
Red Mud	RM
Mullite	-
Silica fume	SF
Diatomite	-
Cassava peel ash	CPA
Coal gangue	CG
Volcanic ash	VA
Sewage sludge ash	SSA
Ceramic grog	CEG
Rice husk ash	RHA
Glass wool residue	GWR
Kaolin clay powder	KCP
Glass powder	GP
Kaolin	-
Iron ore tailing	IOT
Bentonite	-
Bauxite	-
Zeolite	-
Ground granulated blast furnace slag	GGBS or GGBFS
Halloysite	-
High calcium fly ash	HCFA
Drinking water treatment residual	DWTR
Palm oil fuel ash	POFA
Olive bio-mass fly ash	OBFMA
High magnesium nickel slag	HMNS
Olive bio-mass bottom ash	OBMBA
Pyroclastic flow deposit	PFD
Electrolytic manganese dioxide residue	EMDR
Red clay brick waste	RCBW
Calcium carbide residue	CCR
Urban solid waste incineration fly ash	USWIFA
Pyroclastic flow deposit	PCFD
Bauxite ore tailing	BOT

The universal yearly production of FA is projected to range from seventy-one million tons to one billion tons. Lots of FA discarded of in land fillers, ash or slag ponds, as well as air entrainment of particles and leaching of contaminated materials into the water or soil propounds a major hazard to the environs (Dindi et al., 2019). Right now, there are various studies on mixed-base geopolymers. Equally, all categories of raw materials supplement each other; contrariwise, they can efficiently lessen the ingesting of natural and ecological resources. Some properties and usage of geo-polymers have been deliberated by researchers at home and overseas, however the dialogue is not broad enough presently. This scrutiny goal is to appraise the formulation and blending of geo-polymer materials, the features influencing the physiognomies of geo-polymer materials, as well as the multi-functional usage of geo-polymers. From the prevailing limitations of geopolymers discovered, the resolution progress is abridged to present a theoretical and hypothetical base for the long-term improvement.

## 2. Geopolymerization

Geopolymers are blended via the geopolymerization of alumino-silicate materials that melted in the alkali-activator mixture at very high temperature, creating and materializing an amorphous stage, as well as three-dimensional (three-D) silico-aluminate net work composition (Cong and Cheng 2020; Bondar 2019; Duxson et al., 2007). Even though investigators have different notions concerning the integration technique that happens throughout geopolymerization, like majority beliefs that the geopolymerization can be split into three main phases (Cristelo et al., 2019; Darmayanti et al. 2019; Duxson et al., 2007; De faveri et al. 2019; Chindaprasirt and Chalee 2014).

(1) The dissolution and suspension of alumino-silicate materials in the strong or distilled alkali solution develops the free-silica as well as the alumina tetra-hedron component.

(2) The displacement, solidification/ or materials gelation, the concentration of alumina reaction versus silica-hydroxyl for creating the inorganic and inert geopolymer crystallize stage. At this phase, water is released from the system as a result of the hydrolysis system.

(3) As the crystallize stage sets, it shrinks to generate a three dimensional (3-D) set-up of silico-aluminate that creates a geopolymer. It means that activators perform very crucial task in geopolymerization as displayed in Fig. 1. The concentration of 10M NaOH yielded greatest suspension rate of  $Si_4p$  plus  $Al_3p$  ions in alumino-silicate materials equated with the lesser NaOH concentration, which causes a greater rate of geopolymerization (Darmayanti et al. 2019; Duxson et al., 2007; De faveri et al. 2019; Chindaprasirt and Chalee 2014). To boot, the curing temperature is paramount to the geopolymerization, because the suspension of raw materials is augmented with the temperature and, more rapid happening of amorphous stage crest in XRD display specifies that the greater temperature is good for geo-polymerization (Cristelo et al., 2019; Zhag et al. 2017e).

## 3. The material origin

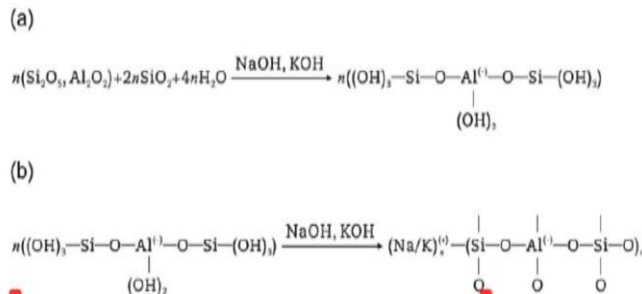
### 3.1 Raw materials

#### 3.1.1 Clay concept and its resources

Clay is an alumino-silicate salt with very tiny particles less than two millimeters (<2 mm). It is a broadly spread natural mineral resource, with cohesive as well as acquiescent down-to-earth rock structure. Also is a class of encrusted silicate from alumina octahedral layered and as well as

silicon oxygen tetrahedron composition (Cong and Cheng 2021; Chen et al., 2019). Due to its physiognomies, it has been utilized as a precursor for creating geopolymers and widely utilized are zeolite, kaolin and so forth. Kaolin is also titled dolomite, is fine, white as well as soft clay, with fire resistance and enriched plasticity. Similarly, metakaolin (MK) is an anhydrous aluminu-silicate created throughkaolin clay dehydration at standard temperature between 6000C to 9000C. Fig. 2 (a) and (b), reveals the common MK that have been comprehensively utilized in the geopolymers making. TheMK-created geopolymers show thermal insulating features (Prudhome et al. 2011; De faveri et al. 2019; Chindaprasirt and Chalee 2014; Sellam et al. 2019), very high bonding strength as well as compressive strength (Duan et al.,2016),

etcetera. Because of the exceptional mechanical features of MK-produced geopolymers, several investigators have blended other ingredients with the system to minimize costs and sustain its exceptional deed, whereas achieving resource recycle (Caiet al., 2021; Guseien et al., 2019; Tstuque et al., 2020). Likewise, the research amalgamates kaolinite-produced porous geopolymer materials (KPGM), which possess dual purposes of decreasing heat transmission and noise (Zao et al., 2021). In recent times, some researchers have publicized that ninety-five percent of raw kaolin is riveted, besides the formulate through alkali excitation have a compressive strength equal to 67.1 MPa (Kelisser et al., 2022). The usage of natural or raw kaolin rather than calcined-metakaolin lessens costs and adversative ecological effects.



**Figure 1.** Graphic illustration of the creation of (a) geopolymer materials precursor, (b) backbone of geopolymer (Cai et al., 2020).

### 3.1.2. Lateritic soil

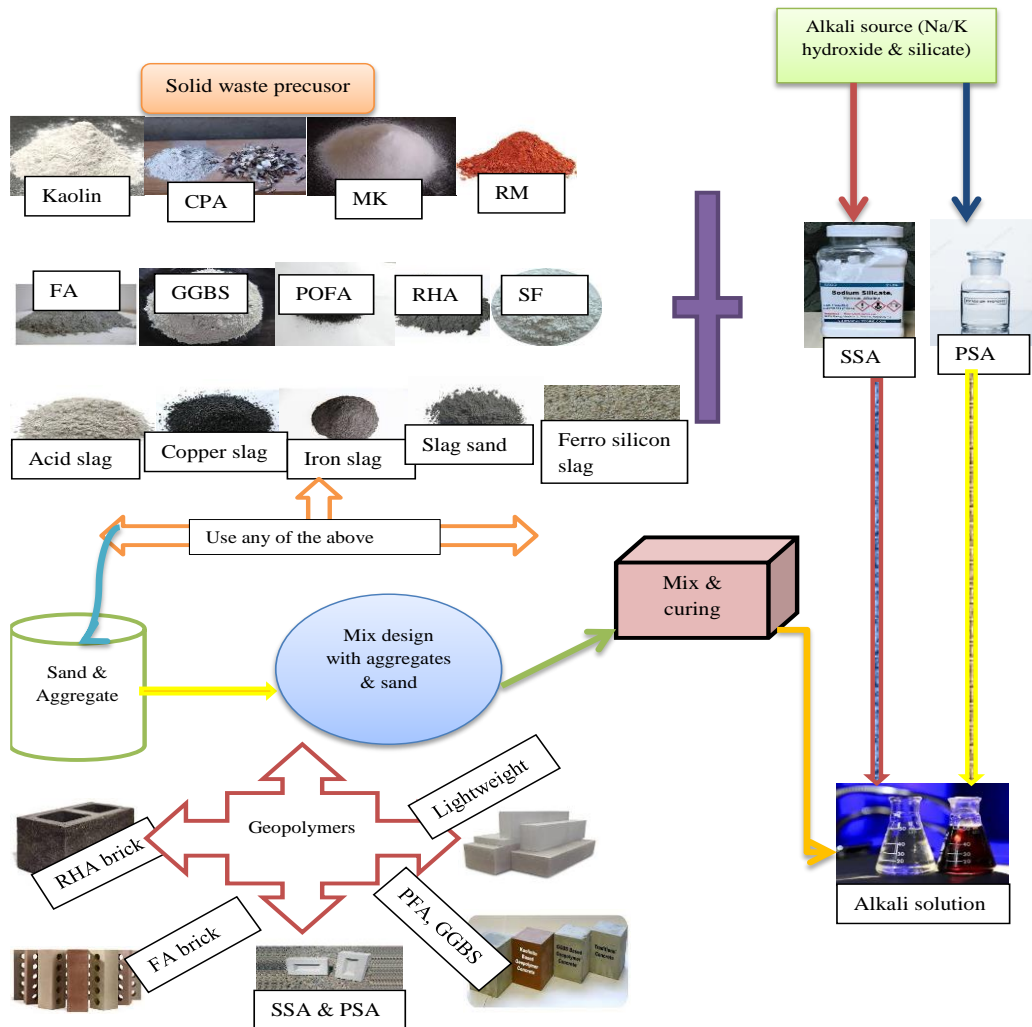
Lateritic is a mineral (soil) that is rich in aluminum, alumino-silicates and iron. Majority of lateritic soils are reddish-brown in colour and have been utilized for a very long period as a conventional building, brick, and road, due to its strong resistance to oxidization. In recent years, there is a novel trend in geo-polymer invention based on laterite, which possess high mechanical strength (Tathew and Isac, 2021; Zubaer et al., 2020). What is more, the chemical physiognomies of lateritic soil has excellent

molar corrosion ratio (SiO<sub>2</sub>/ or (Al<sub>2</sub>O<sub>3</sub>+Fe<sub>2</sub>O<sub>3</sub>)), which is utilized as raw/ or natural material for the geo-polymer class Na-poly (sialate-siloxo). Since, the molar oxide proportion of silica to alumina substantially alters the microstructure as well as mechanical physiognomies of the lateritic-soil geo-polymer (Subaer et al., 2016). Additionally, to obtain high strength, preferable mix laterite with other solidwastes. Both lateritic plus mixed lateritic-slag geopolymer is good for non-load bearing building materials. (Lemougna et al., 2017).

### 3.1.3. Others minerals

Raw or untreated minerals are precursors of GP, and the widely used are halloysite, bentonite, bauxite, mullite, diatomite, and etcetera. Some of their features are displays in Table 1, and they are observably alumino-

silicate materials. Because of the small amorphous quantities of some raw minerals, which create an unsatisfactory action, some of them must go through high temperature pre-curing as well as mechanical instigation treatment, etcetera as presented in Figure 2.



**Figure 2.** Geopolymer concept (materials, mix and curing).

### 3.2. Waste products

#### 3.2.1. BFS (Blast furnace slag)

BFS often called slag, is an iron making bi-product that can be achieved at roughly 1500°C (Amran et al., 2020). It common slag is displayed in Figure 3(a) and (b). Based on the cooling scenario, GGBFS (ground granulated blast-furnace slag), is the type of the BFS cooled in water, which is largely utilized as a part replacement for OPC after crushing as a result of its amorphous quality, high pozzolanic as well as hardness action (Defaveri et al., 2019; Cong and Cheng 2021). GGBFS is one among conventional raw materials for geo-polymers, with the

Si:Al ratio of 1.71-3.67. GGBFS is extremely reactive to the amalgamation of geopolymers and, it is promising at obtaining a good reaction rate at a temperature as small as 0°C (Derossi et al., 2019; Assi et al., 2018). Because when slag is utilized as a cement supernumerary, a lesser amount of heat is generated during hydration, and also decrease cracking threat (Duan et al. 2016; Cheng et al., 2013). GGBS might be utilized to enhance the long-term strength, the porosity or absorbency, sulfate resistances, alkali silicate reactivity (ASR) of concrete, and lessen the water needed, permeability as well as hydration heat of the concrete (Amran et al. 2020a; Bayiha et al., 2019).

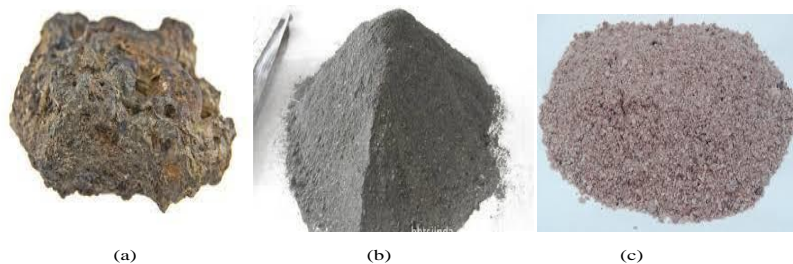


Figure 3a. widely utilized slag raw (natural) materials; a) slag deposit; b) Powder form; c) Granulated blast furnace slag.

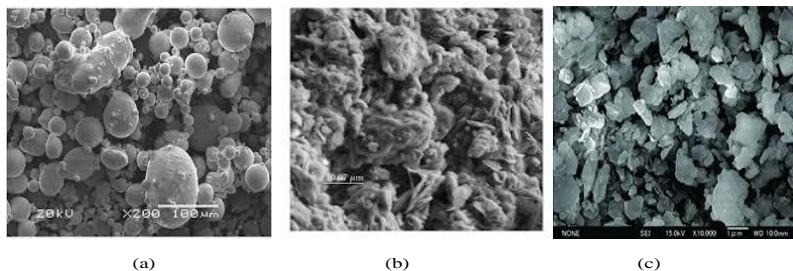


Figure 3b. SEM Images of: a) Slag; b) Steel slag and c) Granulated blast furnace slag.

#### 3.2.2. Bio-mass ash (BMA) and waste blazing bottom ash (WBBA)

Rice fibre/ or husk ash (RHA) is derives from leftover from burning rice husks. Agricultural or agro wastes are rich in silica,

especially RHA, which is regarded as a clean substitute for enriching geopolymers' properties (Baenla et al., 2019; Bondar 2019). The usage of RHA additive in geo-polymer concrete can decrease the utilization of nano SiO<sub>2</sub>, also helps lessen



the litter nuisances created by the dumping of RHA in landfills, specifically in rice producing nations (Bi et al., 2017; Cheng et al. 2003; Cong and Cheng 2021). RHA has been extensively utilized in self-compacting geopolymer concrete (SCGC) owing to its great reactivity enticed via high silicon content as well as ultrahigh specialized surface zone (Chen et al., 2012). Similarly sugar-cane bagasse ash (SCBA) is another byproduct from industries that has been utilized by several investigators for volcanic ash materials (VAM) feed-stocking that are rich in silicates as well as alumina (Dingi et al., 2019; Chen et al., 2012).

Bottom ash (BA) is the principal byproduct of metropolitan solid waste smoldering. In heavy metals BA with a tiny particle size is very high (Amran et al., 2020), besides BA has lately been progressively reprocessed as building concrete and binders (Cong and Cheng, 2020; Bi et al., 2017). More to the point, BA from the burning of metropolitan sewage slurry is utilized in concrete with ten to fifteen percent dose, which might attain greater strength compared with concrete without addition of BA (Cai et al., 2020; and Cheng, 2020).

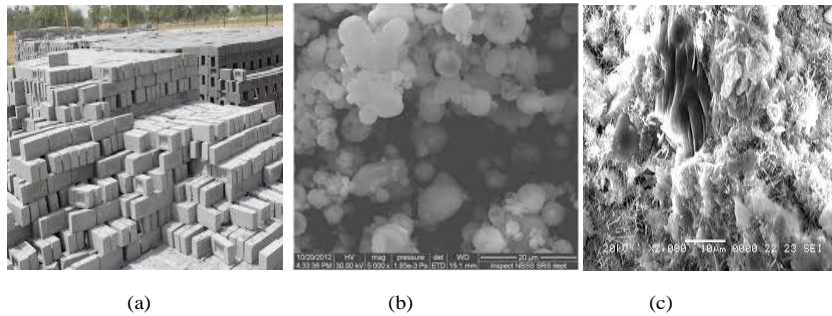
### 3.2.3. Fly ash (FA)

FA is a byproduct from industries created through smoldering of coal, which in general classified into class C, as well as class F. The incineration of bituminous coal forms a well-known class of fly ash with a very little CaO

contents, identified as type F fly ash (FFA) (Cheng, 2020; Duxson et al., 2007). Both lignite as well as sub-bituminous coal are as well utilized as novel power fuels to create type C fly ash (CFA) with very high calcium content, and is displayed in Figure 4(a) and (b). FFA features is related to that of ecological volcanic ash (Dingi et al. 2019a). FA is readily available by-product universally since early 20th century, commonly introduced as a main ingredient of cement or concrete and is widely used raw material for preparing geopolymers, with microscopic shape of fine spherical particles (Askarian et al., 2018; Dua et al. 2016). But utmost free CaO contents restrains the usage of HCFA in OPC system, whereas in geopolymer, the usage of HCFA is far above resourcefulness (Alzebaree et al., 2020; Azsi et al., 2020; Binder et al., 2018; Chen et al., 2012). CFA and FFA is 1.82-2.52 and 1.86-3.09 respectively. Substituting cement with FA makes environment fine because it diminishes greenhouse gas emissions (GHGE), as well as lessens construction prices. FFA is advantageous at low cost, easily available, good spherical feature, high activity amorphous silicate and aluminate contents, etcetera. Similarly, high engineering strength geopolymers can be effortlessly manufactured in an alkali activator solution (AAS) (Cai et al., 2020; Cong and Cheng, 2021; Duxson et al., 2007).



**Figure 4a.** widely utilized FA raw (natural) materials; a) FA deposit; b) Powder form; c) types of FA



**Figure 4b.** Images of FA: a) Bricks; b) SEM and c) Blended composite

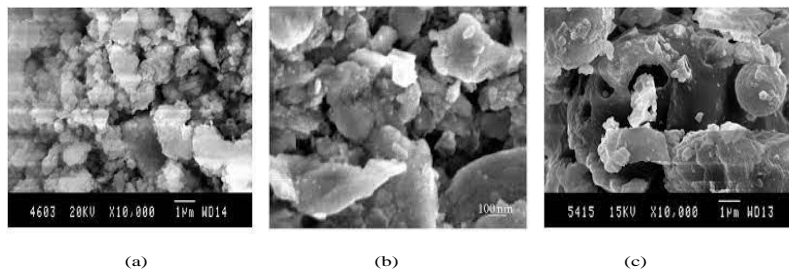
### 3.2.4. Red mud (RM)

RM is gotten from Bayer process by-product utilized in industrial aluminium refinement. Fig. 5 (a) and (b) displays the widely used RM. Below high temperature with pressure scenario, the Bayer activities melts the soluble portion of bauxite and sodium hydroxide. Inexorably, an in significant quantity of sodium hydroxide utilized in this

activities stays in the RM, and yielded high pH value (Ban et al., 2017; Duan et al. 2016). Utilizing RM in this type of mud conserves the energy and time needed for mud drying; it lessens the total quantities of alkali activator through using RM at extreme alkalinity level, hence help decreasing the price of the GP construction (Bhutta et al.,2019; Duan et al. 2016).



**Figure 5a.** widely utilized RM raw (natural) materials; a) raw; b) Powder form; c) made with RH geopolymer.



**Figure 5b.** SEM Images of: a) Untreated RM; b) treated RM and c) sintered RM.

For FA-created geo-polymers, the optimum substitution quantities of RM are varies, comparative to NaOH concentration as well as curing scenarios (Chindaprasirt and Rattanasak, 2020). Also from research it reveals that the GP blended with RM possess greater strength plus durability (Li et al., 2020).

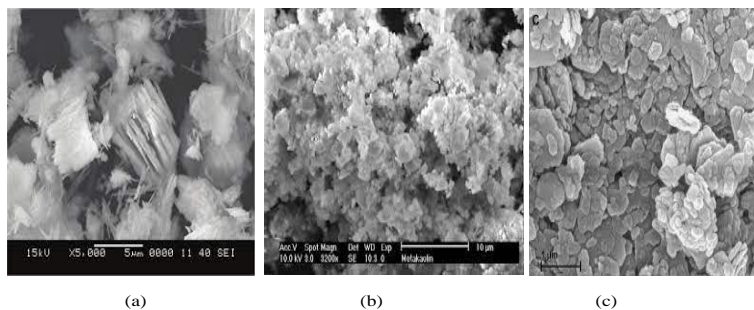
### 3.2.5. Other raw materials

The most frequently utilized materials for geopolymer are metakaolin (MK) Figure 6 (a) and (b); steel slag (SS), coal gangue (CG), silica fume (SF), high magnesium

nickel slag (HMNS), volcanic ash (VA), and wasteglass (WG), etcetera. RM, FA, BFS and the materials like RHA as the main bio-mass ash, all indicated high silica as well as alumina content that are appropriate as the add-on or gelling materials. The waste catalytic agent residue released from several industrial products have abundant silicon and aluminium features as well as amorphous composition, which can be utilized for synthetic geopolymers; meanwhile it has value of compressive strength ranges from 40MPa to 85 MPa (Bhutta et al., 2019; Lee and Kang, 2016)



**Figure 6a.** widely utilized MK raw (natural) materials; a) raw; b) Powder form; c) Bonds



**Figure 6b.** Images of MK: a) SEM; b) micro-morphology and c) Reactivity in alkaline environ

## 4. Categories of activators

### 4.1. Acidic activators

Some geopolymer are activated via acidic activator, while majority are through alkali activators Figure 7. The MK-created geopolymer was manufactured via an

activator called phosphoric acid solution that has excessive compressive strength of roughly 93.8 MPa (Bimdi et al. 2021; Ascensia et al., 2018). Additional report as well revealed that acid-created GP possess greater temperature resistance equivalent to 14500C, and excellent mechanical features than alkali-created geo-polymers (Celerir et

al. 2018). The scrutiny of phosphate manufactured geo-polymer samplings with various Si/ or Al as well as Al/or P illustrates that the impacts of P-poor, Al-enrich, and Si-enrich, features are safer (Chindapasirt and Rattanasak, 2020; Celerier et al., 2018).

#### 4.2. Alkali activators

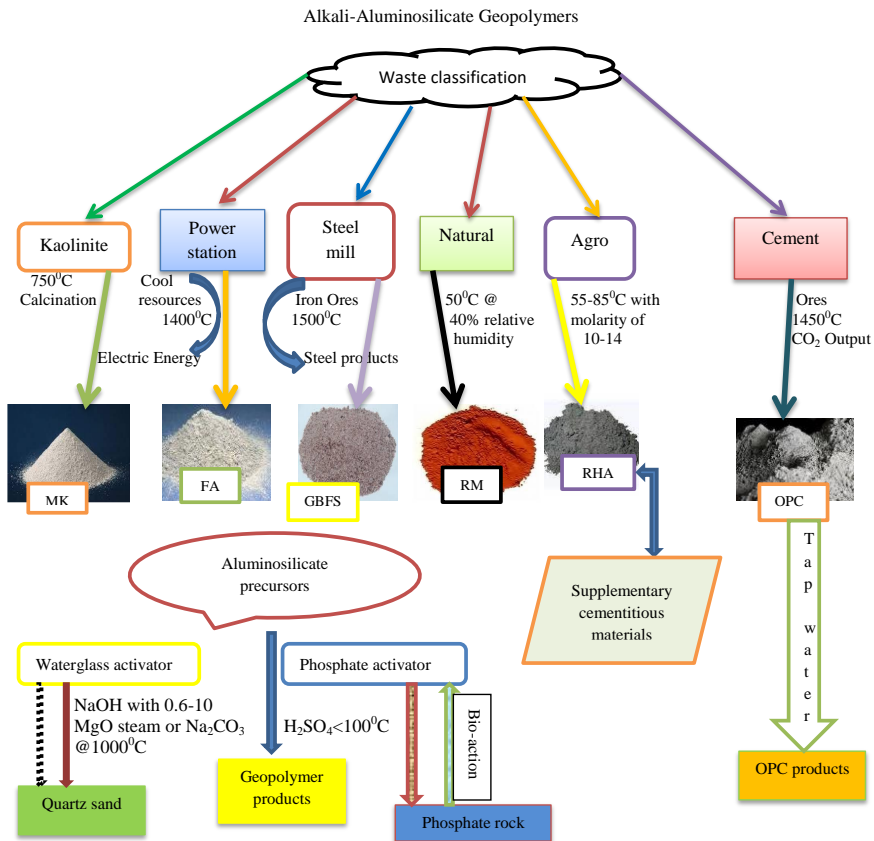
Several researches have publicized that geopolymer materials are usually activated via alkali activators, which is combination of liquid plus solid. Conversely, NaOH and Na<sub>2</sub>SiO<sub>3</sub> have been expansively utilized as activators in prior researches, but now most of substantially corrosive alkalis are hardly utilized as activators, and are steadily substituted by diverse solid activators. For example sodium water-glass was utilized as an activator to create MK-created geopolymer that has compressive strength equaled to 63.82 MPa (Ban et al., 2017; Cong and Cheng, 2021). By using hydrated lime and solid Na<sub>2</sub>CO<sub>3</sub> as activators of BFSS created geopolymer, the strength is between 50MPa and 85MPa at 28 d, with curing temperatures of 250C and 850C, correspondingly (Bi et al., 2017). Likewise, Na<sub>2</sub>CO<sub>3</sub> and Na<sub>2</sub>SiO<sub>3</sub> are activators that are substantially enhanced the overall setting time, but compressive strength lessened with Na<sub>2</sub>CO<sub>3</sub> quantities. Meanwhile the synthetic activator activated geopolymer cleans above the single Na<sub>2</sub>SiO<sub>3</sub> or Na<sub>2</sub>CO<sub>3</sub> activated geopolymer (Derossi et al., 2020). Additionally, sodium sulfate as an activator have little influence on FA with excessive Fe<sub>2</sub>O<sub>3</sub> quantities, but considerably affects the early strength of FA-created geopolymer (Duan et al., 2016). Most common utilized activator like potassium and sodium based activator. From prior investigations activation efficacy of sodium-created alkali activators is above that of potassium-created activators for F.F.A (Bi et al., 2017; Helmy, 2016). On the other hand, Askarian et al., (2018) and Antoni et al. (2016) discovered

that the usage of potassium composites in GP structures exhibited greater alkalinity than NaOH. Investigators validated the efficiency of lithium hydroxide solution as an alkali motivator that can be glazed with GP particles to lessen the suspension of active silica, as well as the probability of liquefied active silica forming ASR gel (Gong et al., 2021; Cheng et al., 2003).

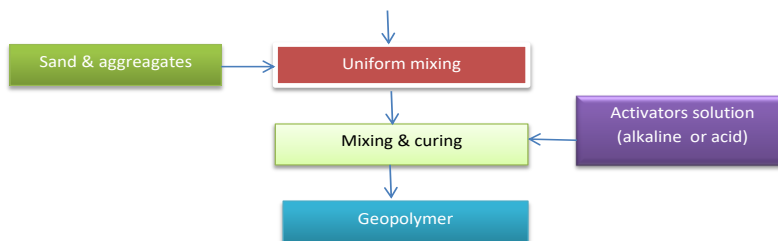
#### 5. Formulation technique of geopolymers

Based on the prior formulation techniques of geo-polymers, majority of them are classified into two categories. Depend on the category of activators, first among them is used for formulation of one-portion, while the second is the formulation of two-portion geo-polymers. For the one-portion formulation, handling of activators is stress-free via averting the usage of risky alkali solution. To start with, all dry materials, comprising of the precursor material as well as the solid activator are dried up at steady or dawdling speed before blended consistently.

Then the water is introduced bit by bit to the mixture while blending at a gradual rate (Lemougna et al., 2020; Alrefei et al. 2019; Zhen et al., 2022; Cheng et al., 2003). For two-portion formulation geopolymers, the activator is made twenty-four hours (24h) before mixing. Figure 8. Then, the already made alkali solution is blended with more water. Next, the liquefied ingredients were introduced to the dehydrate blend and continued stirring till its homogenous (Zhen et al., 2022; Defaver et al., 2019; Bi et al., 2017; Duan et al., 2016; Duxson et al., 2007). Lastly, the freshly made blend is slowly transferred into the mould via vibration molding, covered with polyethene coat, then discharged after twenty-four hours for curing in accordance to specification (Dong et al., 2019; Alrefaei et al., 2019; Binder et al., 2018; Cong and Cheng, 2021; Chen et al., 2003).



**Figure 7.** Creation and reinvigoration of alkali aluminosilicate geopolymers and various features (Cong and Cheng 2021; Lahoti et al., 2018)



**Figure 8.** The formulation of bipartite geopolymers

## 6. Features of geo-polymer materials

The cement company infects the air, whereas geo-polymers are favourable to investigators

due to their exceptional cleanness. Geopolymer concrete (GC) is a novel and sustainable innovation of construction materials, equating with OPC and has numerous merits. It is understandable that

the features rest on numerous physiognomies such as geo-polymer mortar (GPM) and geo-polymer concrete (GPC) novel blending deed, microstructure investigation, as well as hardening operation.

**6.1. The fresh behaviour of geopolymer materials**

**6.1.1. Slump and workability**

Workability of geopolymer is being essentially influence by the particle shape of raw materials as showed in Table 2 and Figure 9. For instance, reduction in FA particle size enhances the fineness of FA as well as the geopolymers workability (Dohra et al., 2020; Duan et al., 2020).

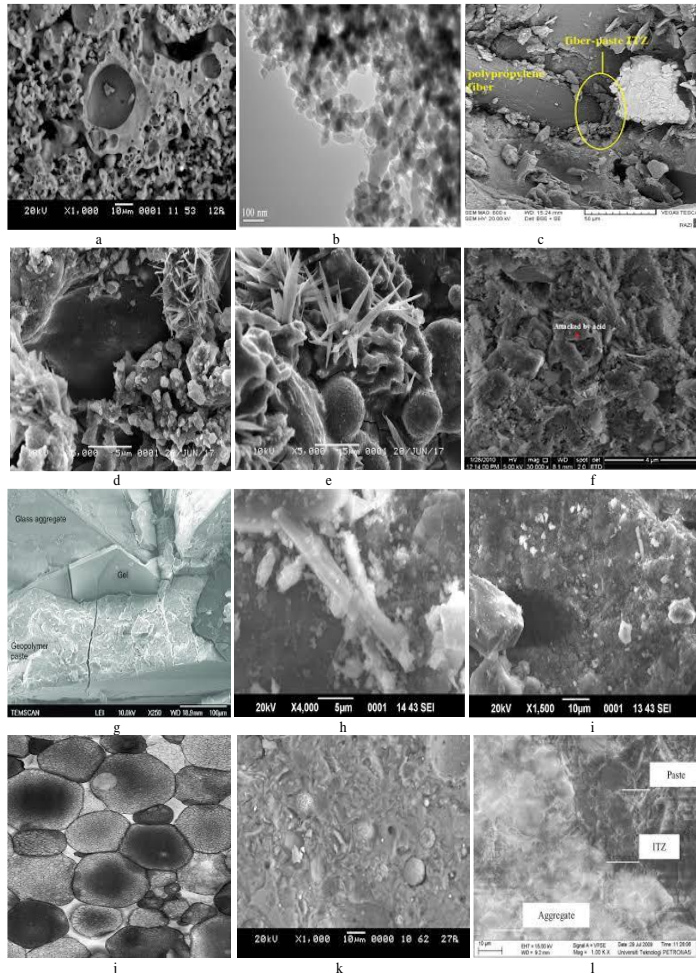
**Table 2.** Compressive strength (CS) of GPC

Alumino-silicate precursor& Reference	Activator	Length /Breadth ratio	Slump (mm)	Density (kg/m <sup>3</sup> )	Curing period &T <sup>o</sup> C	Compressive strength @28days (MPA)
* FA + SF + MK (Gong and Zheng, 2022)	PH + PS	-	-	-	25 <sup>o</sup> C	80.72
*FA + GGBFS (Gong and Zheng, 2021).	SH + SS	-	131	2433	76 <sup>o</sup> C for 1 d	52.32
*GGBS (Cong and Cheng 2021).	SH	0.36	-	2248	26 <sup>o</sup> C	36.02
*GGBS (Bondat et al. 2018)	SH + SS	0.55 (w/b)	240.02	2421	22 <sup>o</sup> C	64.42
*GGBFS +RHA (Melita and Siddique 2018).	SH + SS	0.55	-	-	81 <sup>o</sup> C for 1d	59.72 for 3d
HCFA + RHA (Bi et al. 2017).	SS + SH	-	720	-	26 <sup>o</sup> C	38.21

On the contrary, slag created geopolymer ingredients is irregular because of its particle shape, thus produce poor machine ability. Another investigation stated that the activator solution oxidizes with GGBFS much quicker than FA, Figure 10, and the plasticity of geo-polymer mortar (GPM) will be lessened when the proportion of GGBFS is moderately high (Gholampouret al., 2019). Though, the GP workability was enhanced when investigators substituted GGBS with MK (Cong and Cheng 2021; Bi et al., 2017). Similarly, some findings have revealed that the introduction of calcium carbonate or silicon powder auxiliary materials might enhance the GP workability (Cong and Cheng, 2021; Zie and Tang, 2020). Moreso, the workability of GGBFS-FA created geopolymers can be stabilized by introducing a certain quantities of super-

plasticizer; when the level of alkali-activator at extreme, there is no noticeable impact on enhancing the freshness as well as hardening activities of GP mortar (Cong and Cheng 2021; Laskar and Talukdar, 2018). Numerous researches on the fiber reinforced geo-polymers (FRG), reveals impact of fiber additive on GP workability. The flow rate of GP mortar manufactured from untreated plus synthetic fibers is better than control GP mortar, which specifies that the usage of all fibers substantially lessens the flow capability of the geo-polymers (Duan et al., 2016; Bimd et al, 2019). Besides, the polyester fiber had higher impact on the workability of geopolymers (GP) than those manufactured from high performance steel fiber (Cong and Cheng, 2021; Bi et al., 2017). Regarding activators ASMS (anhydrous sodium meta-silicate) has

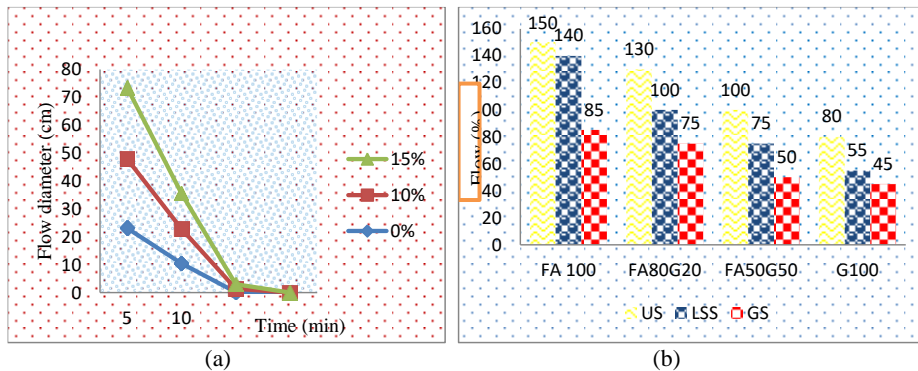
enhanced fluidity or plasticity than other activators (Laskar and Talukdar, 2018).



**Figure 9.** Illustration of various geopolymer SEM: (a) FA, (b)MK, (c)fiber, (d) Na<sub>2</sub> (e) SiO<sub>3</sub>, (f) NaO<sub>2</sub>, (g) clay, (h) Alkali-Silicate gel, (i) BA, (j) GP Concrete, (k) Temperature @ 600°C and (l) curing (Binder et al. 2018a)

Diverse activators have diverse viscosity that has impact on the viscosity or glueyness of geopolymers. Similarly, reducing in workability of mortar is triggered by increasing the viscosity of the activator solution (Cong and Cheng 2021). For instance, Mehta and Siddique affirm that Na<sub>2</sub>SiO<sub>3</sub> act as an alkali activator, without the introduction of NaOH, causes reduction

in the geopolymer concrete slump noticeably, which might be due to the extreme level of Na<sub>2</sub>SiO<sub>3</sub> viscosity (Cong and Cheng, 2021). Meanwhile, another research reveals that the slump of geopolymer concrete rises with the quantities of SiO<sub>2</sub>/Na<sub>2</sub>O in Na<sub>2</sub>SiO solution (Duan et al., 2016).



**Figure 10.** FA substitute with GGBS outcome showing: a) Diameter of flow in percentage (Bayiha et al., 2019). b) Untreated sand (US) flow, lead smelter slag (LSS) flow, together with glass sand (GS) flow (Baenla et al., 2020).

### 6.1.2. Setting time

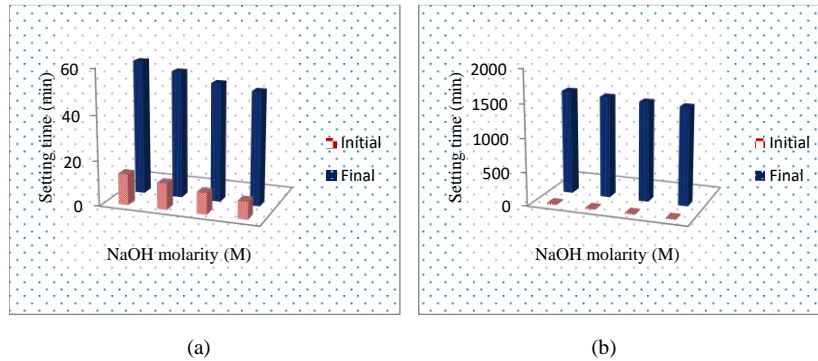
Figure 11 exhibits the setting time of FA vs NaOH molarity. The workability of slag-produced is bad, because of the asymmetrical shape of slag constituent part, and the high slag quantity that aid the acceleration of initial as well as final setting (Cong and Cheng 2021; Bindi, 2019; Darmayanti et al., 2019). Usage of both SF and GGBS can minimize the setting time of geopolymers, though other substitute materials, like RHA, RM, HCFA, and MK, have similar effects (Askarian et al., 2018; Bai and Colombo, 2018). The optimum SF quantity of the FA-slag produced geopolymer (FSPG) is four percent of the whole binder weight (Bi et al., 2017). Consequently, volcanic ash (VA) could be utilized to lengthen the setting time or period of slag-produced geopolymer to a satisfactory level (Cong and Cheng 2021; Lemougea et al., 2020; Bindi, 2019). With the exception of the morphological

physiognomies, the chemical component of natural materials also trigger the setting time of GP. Upsurge in the quantities of calcium oxide proportion in the blend decreases the setting time of the GP mortar (Celerier et al., 2019, 2017).

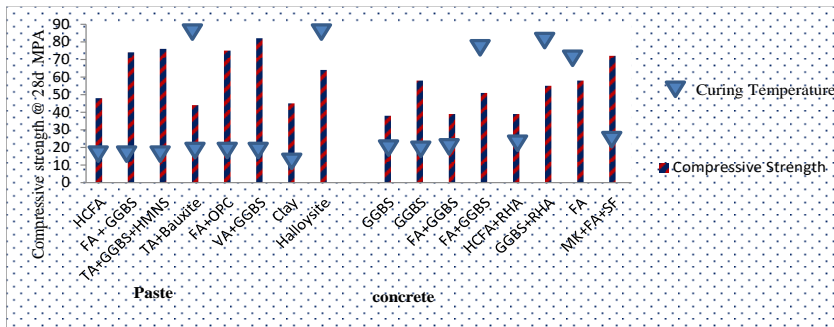
### 6.1.3 Curing

Curing at high temperature might quicken the creation of concrete or mortar strength Figure 12 -14. Though, when potassium hydroxide as well as potassium silicate is utilized as activators, the strength of GPC manufactured at room temperature can up to 80.71 MPa (Cong and Cheng, 2021; Bimdi et al., 2020). It was discovered from the retrospective scrutiny of the several categories of adhesive or epoxy resin and the microstructure of the study, that time of the making of the geopolymers with diverse property, diverse molar concentration of liquid-to-binder, acid or alkali solution, and curing temperature are differs.

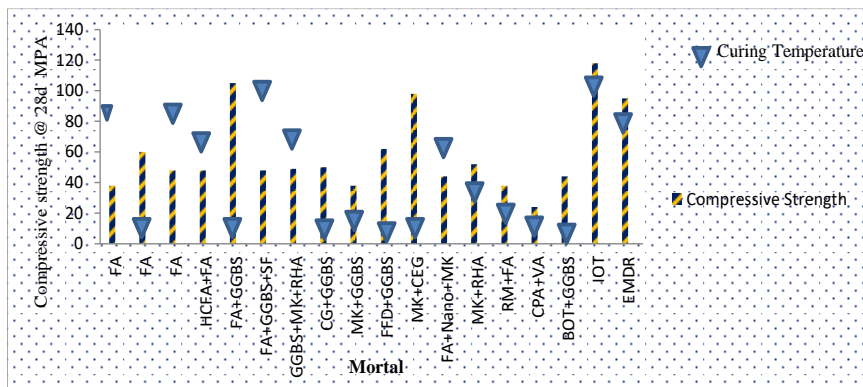




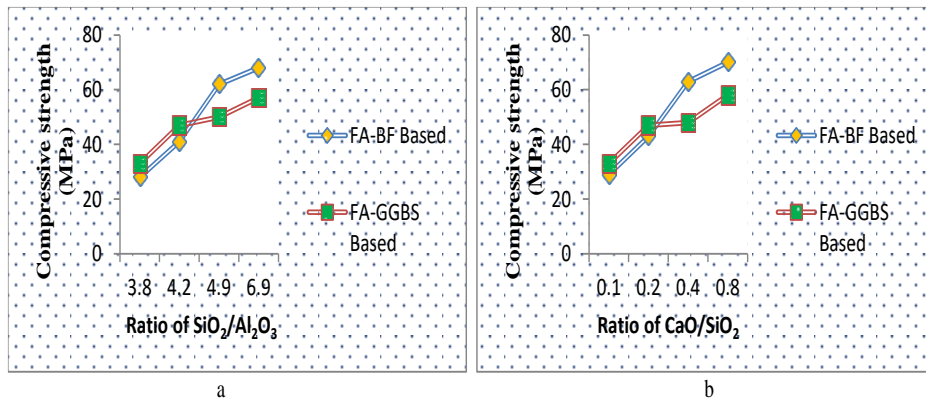
**Figure 11.** NaOH molarity versus setting time of FA-created GP, a) Source: Chen et al., (2020), b) Cong and Cheng, (2021).



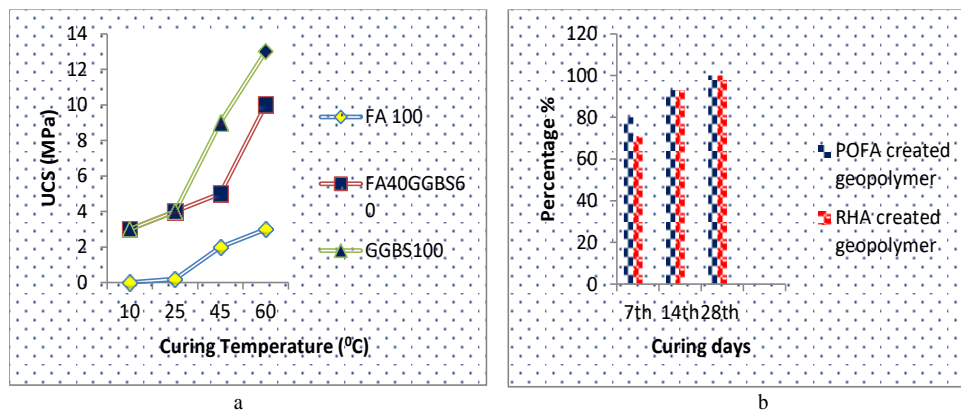
**Figure 12a.** Some geopolymers curing temperature plus early compressive strength for paste and concrete (Abridged from Cong and Cheng, (2021)).



**Figure 12b.** Some geopolymers curing temperature plus early compressive strength for mortal (Abridged from Cong and Cheng, (2021)).



**Figure 13.** Variation of basalt fibre compressive strength at different temperature. (a) SiO<sub>2</sub>/Al<sub>2</sub>O<sub>3</sub>. (b) CaO/SiO<sub>2</sub>(Chen et al., 2019; Celerier et al. 2017).



**Figure 14.** Impact of curing on the strength of blend GP. (a) one day temperature (Aini et al. 2020). (b) several days (Elyamany et al., 2018).

### 6.3. Durability features of GP materials

Strength influences the durability of GP, besides their resistance to abrasive environments, for instance chemical erosion resistance, porosity, carbonization resistance, abrasion operation, dry shrinkage, and other variables. Studies have defined this comprehensively that GP concrete are superb in durability than ordinary Portland cement concrete (OPCC) in most scenario (Alonso et al., 2019; Alrefaei et al., 2019). Dry shrinkage reduction is helpful in enhancing the durability of geopolymers. Investigation on the durability of

geopolymers exposes that gel matrix of the GP is dense and impenetrable; also integrating of nano-TiO<sub>2</sub> can hinder the interconnection of micropores as well as successfully obstruct the nanopores in the geopolymer matrix (Jindal and Sharma, 2020). Thus, the introduction of nano-materials is advantageous to the GP durability improvement.

### 7. Purposes and advance route of GPMs

Based on geopolymers purposes they can be grouped into two classes, which are those

with orthodox physical as well as engineering features, and those with unorthodox physical, chemical as well as mechanical features. Efficient applications, for example fire-prevention, quarantine, heat conservancy, adsorption of detrimental ions, could be utilized for building construction in exceptional areas, for instance insulation or sequestration walls as well as nuclear power plants.

## **7.1. Broad usage of geopolymer materials (GPM)**

### ***7.1.1. Marine constructions***

Exposure of reinforced concrete for a very long-term to saline soil, rainwater, or seawater, will harmfully influence the strength, stability and safety of the structural elements. On the other hand, the chemical resistance capability (CRC) of geopolymer concrete, specifically sulfate resistance, makes it more appropriate for marine construction works. According to the sequel research by Chindaprasit and Chale (2014a), the FA-produced geopolymer after air-dried in the geotechnical laboratory for twenty-eight days (28 d) was revealed to the tidal region of the seawater (brine) environs for three years, the infusion and oxidization of chloride ions reduced with the molarity of sodium hydroxide. Conversely, Cong and Cheng (2021) reveal that FA-based geopolymer concrete in the salt lake environs for six years is easy to carbonize than ordinary Portland cement concrete (OPCC), and also possess high diffusion of chlorides as well as sulfates.

### ***7.1.2. High-temperature and fireproof materials***

Destruction done to building by fire cannot be over looked. For examples the 9/11 terrorist attacks and the Windsor Tate Fire in Shanghai, lead to significant loss of human

properties or assets and life. Thus it is very important to select materials that are refractory in nature for construction works. Continuous enhancement of ecosystem and sustainability must be highly focused in the formulation of high temperature as well as fire-resistant materials today. Geopolymerization is means or techniques of transforming company solid waste (CSW) into chemical durability cement binder (CDCB) that are non-combustibility plus exceptional thermal strength. Gheng and Zhiu (2021) created the recalcitrant GP with GGBFS and discovered that the properties and fire-retardant ability of geopolymerization, were correlated to the features of the reaction products. Similarly, Cong and Cheng (2021) discovered that the GP cement produced from waste glass sodium water has a durable GP composition, which is very nice recalcitrant material. Additionally, RHA-RM created GPs were produced through water glass solution as an activator, then the curing of the GP samplings were at 10000C for two hours (2 h), and still displaying better fire-retardant and higher heat resistance (Armayani et al., 2016a; Duxson et al., 2007).

### ***7.1.3. Renovation materials***

Findings by Phoongernkham et al. (2015) and Alzeebaree et al. (2020) shows that addition of 10% calcium carbonate plus 14 M sodium hydroxide solution, enhanced the flexural strength as well as shear bond of geopolymer mortars. Also Yodsudja et al., (2010a), says that twenty-eight days bond, tensile strength of geopolymer mortar (GPM) and commercial concrete patch up materials are similar, and also possess the capacity to be utilized as concrete mending materials. Likewise, GP mortars possess high strength that can be utilized as a stand-in material for concrete patch-up than other repair binders. Similarly it can be utilized as high-strength geopolymer repair material

(HSGRM), novel waterproof, rapid curing, and hydrophobic (Duan et al., 2017; Alrefaie et al., 2020).

**7.1.4. Insulation materials**

Both thermal and acoustic insulators are indispensable when deliberating on building materials. Good thermal insulator can efficiently lessen energy usage and hence aid reduction of greenhouse impact as presented in Table 3. Acoustic insulators are very crucial since sound-absorbing materials improve indoor. Aural comfort for inhabitants and lessening of health threats are related to acoustic contagion exposure. Geopolymer materials are good in meeting

mentioned needs (Amran et al., 2020; Bi et al., 2017). A brand of absorbent geopolymer from industrial waste (raw or natural) material at low TOC has the capability of stumpy thermal conductivity, price, low water assimilation, biodegradable, and decomposable, which absolutely meet the prerequisites of the departments of building for thermal insulation materials (Assi et al., 2018). Prior researches have publicized that GPs can lessen electricity usage to improve interior TOC, whereas amalgamating micro-encapsulated stage can considerably enhance wall thermal performance as well as conserve energy material made with geopolymer concrete (Cong and Cheng 2021; Lahoti et al., 2018).

**Table 3.** Thermal plus acoustic features of partial geopolymer materials

Materials	Categorization	References
* Geopolymer mortal	Energy-proficient (15.02%)	Cong and Cheng (2021).
* Geopolymer and stage modification materials	Energy-proficient (28.01% -30.02%)	Cao et al. (2019).
* Vegetal geopolymer concrete.	Energy-proficient (46.02-58.01%), Thermal conductivity (0.113-0.191 Wm <sup>-1</sup> K <sup>-1</sup> ).	Cong and Cheng (2021) & Ahmad et al. (2020).
* Kaolin-based absorbed geopolymer	Sound porous coefficient (0.538 @ 5000 Hz, 0.808 @ 500Hz)	Gao et al. (2019).
* FA-based geopolymer fizzes	Sound porous coefficient (0.22@ 500Hz, 0.26@2000Hz).	Luna Galiano et al. 2021.
*SF-based geopolymer concrete	Thermal conductivity (0.13-0.32 Wm <sup>-1</sup> K <sup>-1</sup> ).	Papa et al., 2016a.

**7.2.3. Porous materials**

Geopolymer serves as cleanser production materials, and frequently utilized as adsorbents and porous materials to eradicate metal ions from wastewater, immobilization and control of heavy metal contagions. Utilization of these massive waste produced geopolymer adsorbent that is eco-friendly, cheap and more convenient serves as substitute to powder adsorbent earlier used in the wastewater treatment scheme (Ahmad et al. 2020; Cai et al. 2019). For example, methylene blue (MB) was produced using

FA-created geopolymers from synthetic wastewater. The permeable stuff can be utilized as the primary dye adsorbent in waste-water management. Similarly, the eco-friendly GP paste and adhesive blended from industrial plus agro waste as the porous materials might efficiently eradicate the primary dye MB from aqueous solution (Cong and Cheng, 2021). The quantitative classification of the porous effect of numerous GPs on dyes as well as heavy metals was briefly presented in Table 4.

**Table 4.** Adsorption impact of various geopolymers on dyes, heavy metals and etcetera

Porous material	Adsorption efficacy	Function	Citation
* Ca Si-Al slags-created low alkali (AAM).	97.6% Cs <sup>+</sup> , 99.91% Sr <sup>2+</sup>	Nontoxic, sustainable	Cong and Cheng (2021).
*FA-based self-reinforced (ZFG).	>90.01% Pb <sup>2+</sup>	Extreme adsorption efficacy stability	Han et al. (2020).
*Enormity waste particulate AAM.	99.41% Pb <sup>2+</sup> , 100.01% Zn <sup>2+</sup>	Sustainable, economical, extremely effective.	Cong and Cheng 2021 & Bumanis et al. (2019).
* Multipart geopolymer based on solid wastes.	99.96% - 100.01% Pb <sup>2+</sup>	Stable	Ji and Pei (2020).
*FA-based geopolymer orb.	94.31% MB	Reutilized for eight times (8x) keeping 85.01%.	Cong and Cheng 2021.
*Red mud (RM-CN) composite.	96.91% MB,	Reprocessed performance.	& Novais et al. (2019)
*Permeable geopolymer composite glaze	97.16%MG	Uncomplicated regeneration	Zun et al. (2019).
*Geopolymer permeable duct or tube membrane.	95.01% CV		Zhang et al. (2020c)
	96.52%-98.72% PM 2.5,	Cheap and efficient	Wag et al. (2019a).
	98.02% -99.52% PM 10		

## 8. Prevailing constraints and resolutions

### 8.1. Scarcity of sodium silicate

From review of literatures, diverse techniques for assessing the features of geopolymer materials were discovered. Though the natural material elements were varies, thus an empirical scrutiny technique still needed to be abridged, so that every researcher might learn and enhance one another. On the other hand, shortage of sodium silicate is one of the crucial factors obstructing the improvement of geopolymers. The economic benefit and ecological proficiency of the geopolymer syntheses rest on the quantity of alkali activator. Never the less annual global production of sodium silicate is below ten metric tons, and the processes utilized emit high carbondioxide and energy (Cong and

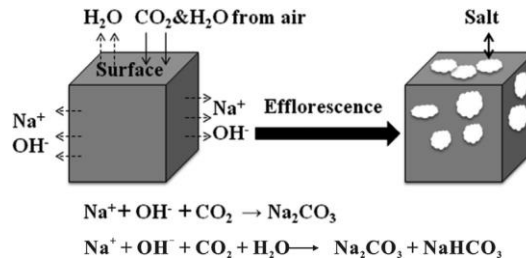
Cheng 2021; Al-Mashhadani et al., 2018a). Conversely, silicon source to create industrial sodium silicate solution like RHA can may substitute sodium carbonate as well as quartz sand, which create greenhouse gas during the production technique (Abdel et al., 2019;; Aiken et al. 2018). For preparation of MK created geopolymer, sodium silicate from RHA and waste glass is the best catalyst (Cong and Cheng 2021;Granero et al. 2019a; Adollahnejad et al., 2020).

### 8.2. Efflorescence

Efflorescence which numerous industrial applications and laboratory researches identified as salt formation in surface alkali stimulated cement is another factor influencing the improvement of geopolymers, and its mechanism and main features (NaHCO<sub>3</sub>, Na<sub>2</sub>CO<sub>3</sub>, and several

sodium silicate components) are displayed in Fig. 11&12 respectively. High quantity of alkali activators of silicon rich systems, can initiate significant efflorescence. Besides, rising in the alumina content, lead to decreasing in the level of efflorescence with

alkali dosage (Cong and Cheng 2021). Also with the decrease of silica particle size, the increase of silica quantity, and the occurrence of the efflorescence in the GP lessen (Aini et al., 2019; Wang2018b).



**Figure 15.** Geopolymer efflorescence system illustration (Cheng et al., 2019; Cao et al. 2020; Chindaprasirt and Rattanasak, 2020a).

## 9. Conclusions and projections

This study presents some valuable information regarding geopolymer materials. It comprises of the reaction principle, main features of geopolymer materials, source of raw materials, kinds of exciter, formulation technique and practical applications in various areas

- (1) Geopolymerization largely comprises of three stages: the suspension of precursor, the creation of silicate network composition and initial gel.
- (2) Aluminium and silicon are the source of geopolymers raw materials which generally include RM, RHA, MK, biomass ash, FA, BFS, etcetera, also steel slag, coal gangue, SF, bauxite, waste glass, volcanic ash, diatomite, and high magnesium nickel slag.
- (3) Most popular activators for geopolymer

production are sodium silicate, sodium hydroxide, lithium hydroxide, sodium carbonate, calcium carbonate, phosphoric acid, and sodium sulfate.

- (4) There are several formation techniques of geopolymers. It is crucial to point out most widely used which is mix to solid material, and after blended with liquid methodically.

- (5) Generally, compared geopolymer with ordinary Portland cement mortars as well as concretes, geopolymer have better fire resistance, more resistant to salt erosion and acid and greater mechanical strength.

Thus, with the technology and science advancement in prospect, GPs are anticipated to be broadly utilized as cementing materials via intensification and the application will be advantageous to economy and the international environment

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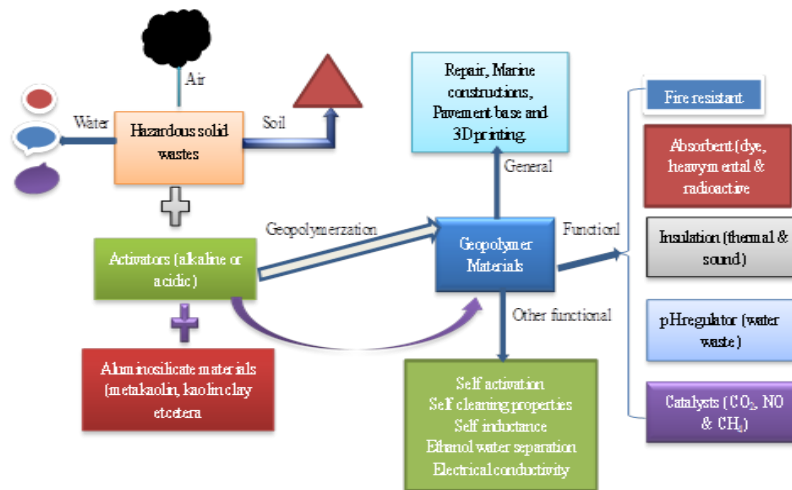
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**Appendix**



Graphical Abstract

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## **META ANALYSIS OF THE INNOVATION AND CREATIVITY IN ENTREPRENEURSHIP**

**Abstract:** *The dynamic acceleration of global change forces business actors to move quickly to build extraordinary innovative ideas. In understanding the statistical relationship related to business globalization, it is crucial to advance theory and practice in this field. This study aims to explore the innovation and creativity of business actors in defending their businesses from the waves of environmental changes. In this study, we used bibliometric analysis and the visualization tool of the VOS viewer software to display conceptions in graphical form from bibliographic data. This includes merging bibliographies, co-citing, and co-occurring keywords. This study collects relevant literature using a retrieval formula from the Scopus.com database. This study's first site conducted a literature analysis based on several aspects, including authors, journals, use of citations, journal publishers, keyword writing, and publication features. In the next step, we conducted a bibliographic analysis of the manuscript, co-citation, and co-occurrence. The results of the study show that there is a significant evolution of literature related to innovation and creativity in entrepreneurship. This study generally believes that innovation increases with the growth of high creativity from business actors. It was also found that there is a stronger relationship between creativity and innovation, especially in large companies. On the other hand, small companies with low technology are generally less balanced and less creative in increasing their productivity.*

**Keywords:** *Scopus, Entrepreneurial, Creativity, Innovation, BibliometricsVOSviewer*

### **1. Introduction**

At the beginning of 2020 all countries in the world were shocked by the spread of the Covid-19 infection, which was eventually designated as a widespread outbreak due to the increasingly widespread spread of the Covid-19 infection. This incident has an impact on all countries in the world, where many countries only focus on how to overcome the widespread Covid-19. In the

end, this has an impact on economic problems, including Indonesia. It is noted that the Indonesian economy is currently experiencing a short 5.3% contraction in the second quarter of 2020, but this is the same for other countries. One of the most severely affected is the Micro, Small and Medium Enterprises segment due to the implementation of Large-Scale Social Restrictions in all regions in Indonesia. Entrepreneurs really feel a very drastic

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decline in turnover, this requires them to do various new ways in selling their products. Entrepreneurs are required to be more creative.

Creative is another word for creating something different from what already exists. While the meaning of innovative is to create something that has never existed into existence or create something completely different from the others. Of the two activities, namely creative and innovative are the most needed or that must be owned by entrepreneurs, especially in times like today. Where the times are growing rapidly, global competition has occurred in various segments, not least in the field of business and business. Entrepreneurs are pioneers in the business world. Entrepreneurs or often referred to as entrepreneurs must have a vision for the future and have superior values in the field of business they develop. Not all entrepreneurs can be called entrepreneurs, because many entrepreneurs do not come from entrepreneurs, but get a business or business inheritance from their families.

Creativity in the innovation process serves as a generator in issuing ideas that can improve the results to be achieved. There are two important aspects of creativity, namely the process and the individual. The process in achieving goals is designed to create a solution to a problem. While the individual is a resource that can determine the creation of a solution. In the process of creativity, the same process will occur but the approach to completion is different and varied. In building a business and business, of course between entrepreneurs with one another will be different both in ways and strategies. Strategy or method is a calculation that determines the final result of creativity and innovation. Individuals who have high creativity will be able to capture and make the best use of opportunities, so that it will have an impact on the results they run. In addition to creativity, in entrepreneurship it is also necessary to be innovative. By innovating, entrepreneurs are

expected to be able to create something new so that they are able to adapt to global changes that occur. Innovation can be developed by means, among others, entrepreneurs must be able to recognize or recognize new discoveries, objects, materials, technology and people. The process of innovative creativity is related to logical thinking and analysis of up-to-date knowledge.

This study conducted an analysis based on authors, documents, most cited research, citation patterns of leading journals, institutions and countries and also analyzed graphically through the VOS viewer (Van Eck, Waltman, Dekker, & van den Berg, 2010) and (Van Eck, 2010). In addition, many bibliometric indicators were investigated including co-citation (Little, 1973), (Kessler, 1963) and co-occurrence of authors' catchphrases. Next in section 2 in this article focuses on discussing the literature review, section 3 reviews the methodology, Section 4 presents the results of analyzing publications, most cited papers, citation structure, leading authors, countries, institutions and the most used author keywords. Section 5 contains conclusions and implications.

## **2. Literature Review**

### **2.1. Innovation**

Briefly (Altshuler&Zegans, 1997) defines innovation as "interest in genuine life". From this understanding the author argues that in fact innovation is the development and implementation of something new, the meaning of the novelty, that innovation is creating and implementing something into a combination and the extent to which something provides a solution to an important problem. Innovation according to Goman (Rusdiana, 2014) is the practical application of creative ideas. Innovation can be realized with a high enough creativity. Creativity is the ability to apply something new to life. Many companies have advanced and

developed to this day because of their creativity and innovation. There are also many companies that die and do not develop because they do not innovate and be creative. Ways in terms of improving innovation capabilities in the field of products and services are: (a) learn innovation from existing experience, (b) reward employees who have innovative ideas, (c) behavior-oriented to innovate, (d) set goals innovating, (e) making innovative products in simple ways, (f) starting to make products with the most minor innovations, (g) conducting experiments and improvements, (h) following the predetermined schedule for innovation, (i) ) always work with passion and have a strong belief in innovation and risk.

The importance of innovation and creativity helps in the development of new ways to improve products or services to maximize company profits. Innovation and creativity encourage entrepreneurs to think outside the holder and look for non-standard answers. In addition, innovation and creativity help in sustainability and long-term performance of all types of companies (Baykal, 2018). Innovation can also be extended to things like coming up with business ideas, such as what to produce to satisfy customers, finding investment opportunities, deciding how to take advantage of those opportunities, formulating company goals and objectives, and conducting market research both in urban areas, and rural areas. Creating companies, starting real business operations, selling and promoting organizational products and services, planning and managing secluded people and fabrics for the achievement of company goals, risk and uncertainty management, creativity, and diversification (Gontur, Davireng, &Gadi, 2016).

## 2.2. Creativity

Entrepreneurship, according to (Clow, James, Kranenburg, & Berry, 2008), is a piece of mobilizing and sacrificing resources (land,

measured, and human resources) to take advantage of business opportunities or implement ideas in a way that meets people's needs for products and services, create jobs, and benefit business owners. Both new and established businesses are involved in these pieces, but the focus is usually on new products or services and new businesses. Therefore, in order for a country to prosper and enjoy sustainable economic growth, creativity and innovation must be injected into the entrepreneurial development arrangements that must be pursued. The economic and social consequences of todays around the world challenges affect society and the rest of the world. Many government and philanthropic efforts fail to achieve the social changes demanded by societies around the world and major social sector institutions are often seen as inefficient in solving social problems (Van der Have &Rubalcaba, 2016). Many entrepreneurs consider creativity as an important element, there is still a lack of understanding of the factors that influence these elements, as well as the relevant management processes (Finkle, 2013). Recently, an economic transition has taken place. The economy is shifting from knowledge-based activities and towards activities that require creativity, innovation, entrepreneurship, and imagination (Okay, Munshi, & Walumbwa, 2009); (Fillis&Rentschler, 2010).

Creativity can be described by generating ideas that will be used in the innovation mechanism such as being selected, assembled, rearranged, and synthesized towards the emergence of an abdicate or novel. Innovation can be defined as radical or gradual, as products or articles. The degree of radicalization or accusation is very dependent on the methods used previously, both in terms of creativity factors and structuring mechanisms, in terms of creativity variables and structuring processes (Roopsang, 2018). To support the above, innovation has been defined by (Okpara, 2007) as adding

something new to an existing product or price that has been built from the ground up and has proven to work quite well. This study establishes a positive relationship between creativity, innovation, competitive advantage, and entrepreneurial growth in Nigeria. Because creativity can be considered as the creation of raw materials, pieces of invention can be considered as the transformation and development of these materials into something concrete, such as a process or product. The relationship between creativity and innovation is neither simple nor indirect. The problem lies in the fact that this confusion can lead to imperfect process management of the two. This uncertainty causes ambivalence among researchers and practitioners, as well as confusion about the conditions that promote creativity and innovation, and the effects of established practices on individuals and the environment in general. Efficiency in this article is a major competitive advantage in industries that demand continuous creativity and innovation from their employees. The continuous innovation of certain companies that are considered creative is very attractive, given some fundamental paradoxes such as the routine/creativity pairing (Fillis&Rentschler, 2010).

### 2.3. Entrepreneurship

According to (Hadiyati, 2011) entrepreneurship or business visionary is derived from the words wira and effort. Wira means chivalry, brave, noble, while business is a productive activity. Generally, entrepreneurs do not work in the government sector, but work in their own companies. So entrepreneurs create their own new innovative businesses with existing risks and take advantage of opportunities, and face competition, so that their business grows big. Entrepreneurship is a process that involves capturing an idea, turning it into a product or service, then building a business to bring that

product to market (Johnson, 2001). The real trend in the study of entrepreneurship in recent years has been away from the subject of small business itself towards the concept of entrepreneurship (Cornwall and Perlman, 1990, Chell, 2001). Entrepreneurship represents organizational behavior. Key elements of entrepreneurship include risk taking, proactiveness, and innovation (Miller, 2014). (Slevin&Covin, 1990) argue that successful companies not only engage in entrepreneurial managerial behavior, but also have an appropriate culture and organizational structure to support such behavior.

Firms pursuing strategic entrepreneurship should engage in both the opportunity-seeking activities required by entrepreneurship and the profit-seeking activities required by the strategy (Hitt, Ireland, Sirmon, &Trahms, 2011). Creativity and innovation in entrepreneurship are needed by those of you who have just started starting a business from the ground up. Creativity and innovation are intertwined, especially in a business. Creativity means new ideas that arise when they see an opportunity in the business world and innovation means how a businessman looks for solutions to develop his creative ideas. With creativity and innovation in entrepreneurial activities, there are several benefits that you can feel as a novice businessman. In an effort to increase creativity, management must be able to create an atmosphere within the company so that creativity can develop among employees. Actions that must be taken by entrepreneurs are: a. Give permission to all employees to generate creativity, b. Tolerance to failure, c. Express curiosity d. Seeing the problem as a challenge, e. Hold creativity training f. Provide facilities in the form of equipment, g. Tolerance to time h. Reward i. Show existing examples.

## 2.4. A brief history of bibliometric analysis and its indicators

Bibliometrics emerged in the early twentieth century as a symptom of the need to study and evaluate scientific production and communication activities. Definitions that will help to understand the concept are given by (Guedes&Borschiver, 2005); according to them, bibliometrics is a set of empirical laws and principles that contribute to building the theoretical foundation of information science (Araújo, 2006). Bibliometrics is part of the mechanism for measuring production, disclosure and use of information obtained through books or other types of production (Machado Junior, Celestino, Serra, Caron, &Ponde, 2016). As the science of analysis, bibliometrics developed, empirical laws were also designed on literary behavior, which was later referred to as bibliometric theory; Araújo says bibliometrics is the law of researcher productivity or Lotka's law (Araújo, 2006); the law of dispersion of scientific knowledge or Bradford's law; and distribution of customized organization and frequency laws in text or Zipf's laws, elaborated in 1926, 1934 and 1949, respectively.

Urbizagástegui defined Lotka's law as the basis of the inverse square law, arguing that the number of authors who made "n" contributions in a given scientific field was approximately  $1/n^2$  of those who made single contributions, and that the proportion of those who made single contributions was approx. 60 percent or more (Urbizagástegui Alvarado & Suárez, 2008). In contrast, Bradford's law is used to measure the productivity of journals, the formation of nuclei and regions of dispersion on certain subjects in the same journal set (Vanti, 2002), that is, by dividing the production of certain fields into zones with the same number of documents published, the first zone will have the same number of documents. Fewer journals; when the following zones are analyzed there will be

more journals in each zone and show the dispersion mentioned. Meanwhile, Zipf's law is divided into two laws (da Costa Santos, 2009): Zipf's first law relates to high frequency individualized organization customized structures in a text, and the second law relates to low frequency individualized customized structures. The high and low frequency is based on empirical observations and analysis of the frequency of occurrence of individualized organizations in long texts that are satisfactory. The premise is that the individualized organization customized structure with a higher frequency is a sign of the central theme of the textual document. These laws provide a solution in performing complex data analysis through sociometric analysis. Among the main analyzes of bibliometric analysis are co-composing, co-reference and bibliographic coupling networks (Bizotto, Camargo, da Motta, de Oliveira, & Coelho, 2015). Co-composing analysis allows identifying linked authors, institutions, or countries based on the number of publications they produce (Van Eck & Waltman, 2014). In a co-reference network, two publications are said to be co-referred to when there is a third publication that references them simultaneously (Small, 1973). With other customized structures, the greater the number of papers in which two publications are referenced together, the stronger the co-citation relationship between them, and therefore the more

## 3. Methodology

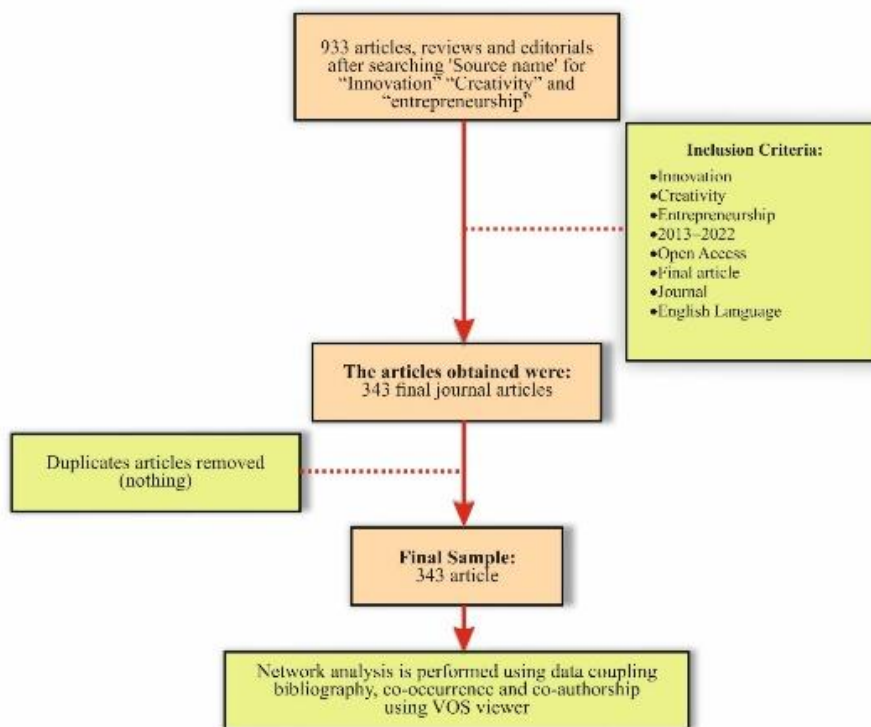
Bibliometric indicators are applied to evaluate bibliographic information, consisting of the number of authors, articles, citations, institutions, and countries. In addition, the documents used for the analysis were obtained from the largest data set of the Scopus multidisciplinary peer-surveyed literature (Mongeon& Paul-Hus, 2016). This premise information is popular and often used to obtain quantitative analysis, due to the

availability of quality articles in the fields of business and management (Verma&Gustafsson, 2020). The author prefers not to use Google Scholar due to some indexing issues as observed in notes from different sources, lack of formal integration in most cases and the need for a lot of cleanup effort which is considered cumbersome and inefficient.

The structure of the analysis used in this study is the same as that of some common bibliometric studies. In this study retrieved 343 articles, for a period of 10 years between 2013-2022 from the database using the keywords:

TITLE-ABS-KEY ("innovation" "creativity" "entrepreneurship") AND (LIMIT- TO

(PUBSTAGE, "final")) AND (LIMIT-TO (PUBYEAR, 2022) OR LIMIT- TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT - TO (PUBYEAR, 2008) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT - TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT - TO (PUBYEAR, 2013)) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SRCTYPE, "j")).The document is then further inspected and then forwarded to VOSviewer. The design of this study is presented in Figure 1.



**Figure 1.** Research design

Bibliographic information was mapped graphically using the VOS watcher technique to further explain the results (Van Eck et al.,

2010). This software produces co-author network analysis, co-citations (Small, 1973), co-occurrence of customized key



organization and bibliographic coupling (Kessler, 1963). However, (Martínez-López&Gualdrón-Pinto, 2018) defines co-initiation as an indicator for evaluating the most productive collections of papers, especially those with the highest co-publication rates. Co-reference is described as the process of citing two papers in a different third paper while co-occurrence of key individualized structures measuring customized organization individualized organization is observed to occur more frequently in papers other than those presented in the abstract.

#### 4. Results

In this study, it was recorded that there were 343 publications in the form of final journal articles discussing innovation and creativity in entrepreneurship published between 2013 and 2022, and from the number of articles, there were 4,808 citations. The development of research that discusses innovation and

creativity related to entrepreneurship is reflected in the analysis of the composition of the authors of the journal article. Figure 2 shows the development of journal articles on innovation and creativity related to entrepreneurship based on the composition of the number of authors according to the top 25 most cited articles (Table 2). Based on Figure 2 articles produced by more than five authors were not found in the sample. There was a decline in article writing with only one author in 2020, as well as a decrease in the number of collaborative authors between two and three authors from 2016 onwards. Based on the total published journal articles, of which there are 343 journal articles, more than 50 percent are written collaboratively by co-authorship (more than one author), with the dominance of articles written collaboratively by more than three authors. This is related to the increasing interest of the academic community on the issue of innovation and creativity in entrepreneurship in published journal articles.



Figure 2. Co-authoring feature

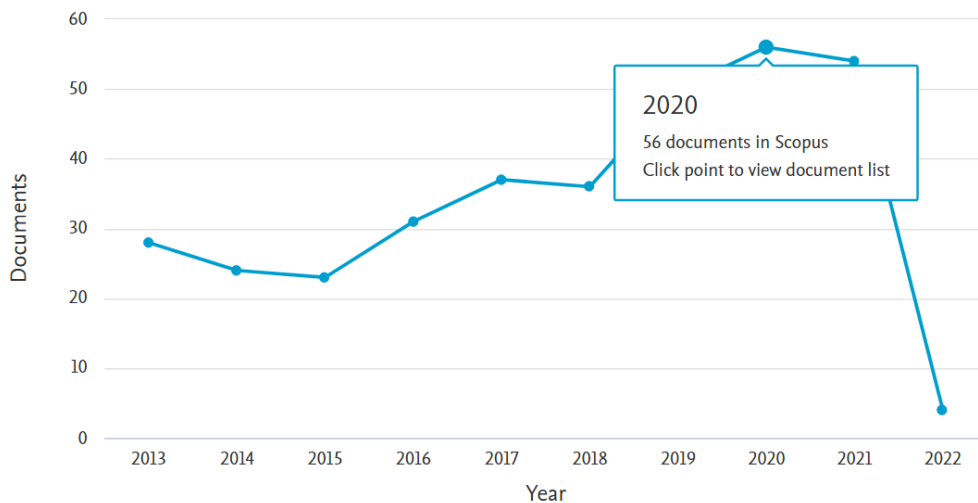
As shown in Table 2, several articles with the issue or key words of innovation and creativity in entrepreneurship during the last 10 years. From the beginning of 2013 to 2022 there were 343 journal articles. Given that the research data used is only up to 2022, it is important to note that the figures presented in

this study are only provisional. The trend of publication of journal articles every year shown in Figure 3 are all documents in the form of journal articles that discuss issues of innovation and creativity in entrepreneurship in published research journals.

**Table 1.** Trends in the number of articles discussing innovation and

Years	Documents
2022	4
2021	54
2020	56
2019	50
2018	36
2017	37
2016	31
2015	23
2014	24
2013	28
Total	343

Documents by year



**Figure 3.** Trends in the number of journal articles discussing innovation and creativity issues

A total of 343 journal articles are those that directly address the issue of innovation and creativity in entrepreneurship. Innovation and creativity are things that must be done in the business world. Innovation and creativity are demands for individuals who are involved in every type of business, whether small, medium or large scale businesses. Business innovation and creativity is very important given the ever-moving economic development. In today's era, innovation and creativity are something that must be done if companies want to survive in the business

world. Not a few businesses have gone out of business due to ignoring the importance of innovation and creativity in business development. Therefore, it is very natural that the issue of innovation and creativity is often discussed in published journal articles.

Table 3 shows the top 25 most cited articles sourced from the Scopus.com database by CiteScore scores. The first order of the most cited articles in journals published in 2014 with the title “The real-time city? Big data and smart urbanism” was written by Kitchin R., in the journal *GeoJournal* and has 1,237

citations listed. The journal article that ranks second most cited is entitled “Social innovation research: An emerging area of innovation studies?” published in 2016, written by Van der Have R.P., Rubalcaba L., in the journal Research Policy, has 270 citations. The third order is an article written

by Sarooghi H., Libaers D., Burkemper A with the title "Examining the relationship between creativity and innovation: A meta-analysis of organizational, cultural, and environmental factors", published in 2015, in the journal Journal of Business Venturing which has 179 citations.

**Table 2.** The top 10 most cited articles

Rank	Authors	Title	Years	Source	Total citation
1	Kitchin R.	The real-time city? Big data and smart urbanism	2014	GeoJournal	1237
2	Van der Have R.P., Rubalcaba L.	Social innovation research: An emerging area of innovation studies?	2016	Research Policy	270
3	Sarooghi H., Libaers D., Burkemper A.	Examining the relationship between creativity and innovation: A meta-analysis of organizational, cultural, and environmental factors	2015	Journal of Business Venturing	179
4	Bevan B., Gutwill J.P., Petrich M., Wilkinson K.	Learning Through STEM-Rich Tinkering: Findings From a Jointly Negotiated Research Project Taken Up in Practice	2015	Science Education	141
5	Florida R., Adler P., Mellander C.	The city as innovation machine	2017	Regional Studies	140
6	Edwards-Schachter M., García-Granero A., Sánchez-Barrioluengo M., Quesada-Pineda H., Amara N.	Disentangling competences: Interrelationships on creativity, innovation and entrepreneurship	2015	Thinking Skills and Creativity	94
7	Watson T.J.	Entrepreneurship in action: Bringing together the individual, organizational and institutional dimensions of	2013	Entrepreneurship and Regional Development	90

		entrepreneurial action			
8	Stephens H.M., Partridge M.D., Faggian A.	Innovation, entrepreneurship and economic growth in lagging regions	2013	Journal of Regional Science	87
9	Ahlin B., Drnovšek M., Hisrich R.D.	Entrepreneurs' creativity and firm innovation: The moderating role of entrepreneurial self- efficacy	2014	Small Business Economics	86
10	Forest C.R., Moore R.A., Jariwala A.S., Fasse B.B., Linsey J., Newstetter W., Ngo P., Quintero C.	The invention studio: A university maker space and culture	2014	Advances in Engineering Education	82

Based on the existing phenomena, it shows that the issue of innovation and creativity is increasingly known and has an increasing trend of discussion in management journals and other fields of science. Innovation and creativity are described as the heart and soul of the company. Innovation and creativity require effort to carry out tasks in a certain way or perform various activities. The benefits of innovation and creativity for entrepreneurs are looking for opportunities to do new things or do old things in innovative ways. Creativity and innovation inspire and drive entrepreneurship that excels in guiding the organization's operations, satisfying customers in the interests of all stakeholders. Entrepreneurship becomes value creation

where the implementation of creative inspiration is described as innovation (Anderson, Potočnik, & Zhou, 2014).

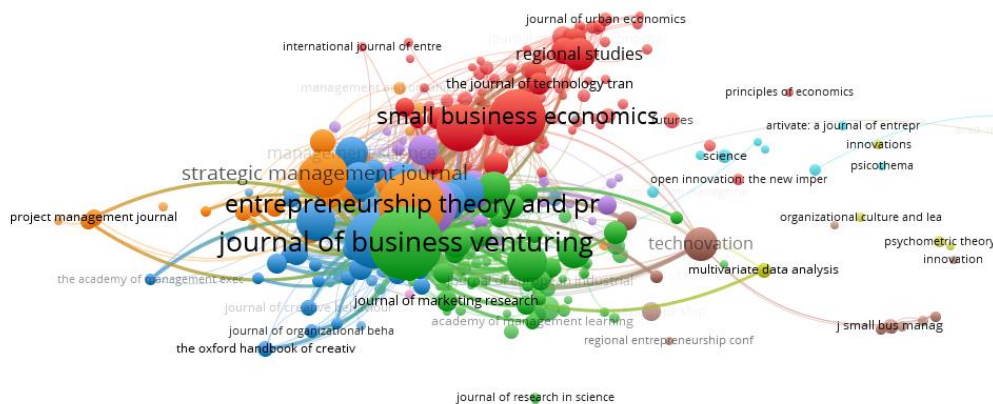
The results of the analysis based on the number of journal article citations from the VOS viewer in Figure 4 also show the same results as Table 3, where (Kitchin, 2014) as the author who has the most citations, and also as the author who collaborates the most with other authors collaborates in writing articles. A research journal about innovation and creativity, the findings in Figure 4 are illustrated in the VOSviewer application's network visualization output depicted with a larger circle than the others.



Figure 4. Citation of document

Documents with a citation threshold of 3, as well as the most representative 423 co-citation connections in the journal between 2013 and 2022 are presented in Figure 5. The results show that the Journal of Business Venturing has the highest number of citations, i.e. 315 citations in Co-citation, as well as a total of links / relationship (link

strength) as much as 13,493. Journal co-citation involves the investigation of two journals cited in the same third source (Small, 1973). This was done to determine two articles from different journals that were cited together in the same third journal (Gaviria-Marin et al., 2018).

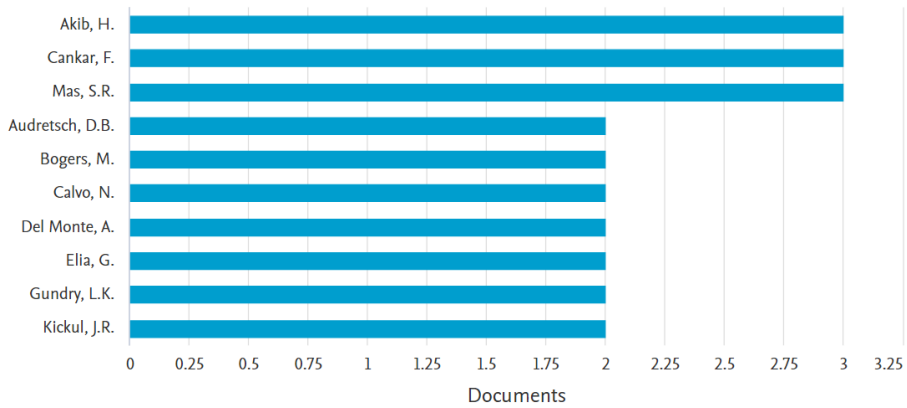


**Figure 5.** Co-citation of journal cited

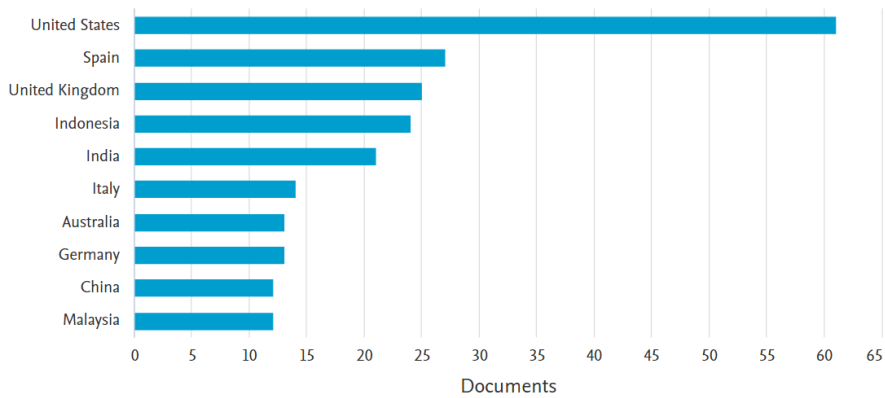
The next research is to conduct a review of authors, affiliations and countries based on keywords or issues about innovation and creativity in published journal articles, between 2013 and 2022. The analysis looks at the best achievement in publications from the Scopus database, looking at the 10 most prolific authors shown in Figure 6 based on the total articles they wrote. The top three prolific writers are Akib, H., with 3 articles, Cankar, F, with 3 articles, and Mas, S.R., with 3 articles. The articles were produced over a period of 10 years (2013-2022) and to date they are the top prolific authors in the journal. Figure 7 is a map of the combined bibliographies of the authors' names. This analysis involved determining 1 article cited by different authors in the third article. The results in Figure 6 show a minimum threshold of 1 article cited at least one hundred 889 between 2013 and 2022. Based on the results of the analysis it was found that Elia G, and

Margherita A, were the most cited authors, of which there were 1,349 citations.

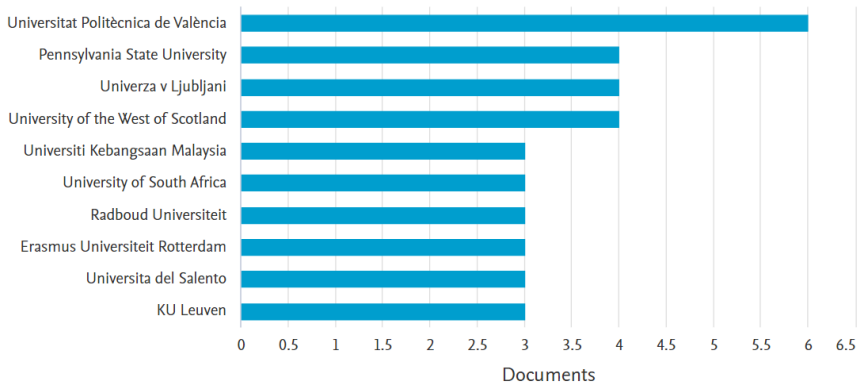
While Figure 7 shows the top three most productive countries, where the United States is the most productive country with 163 articles, followed by Spain with 27 articles, while the United Kingdom is in third place with 25 articles. All journal articles published are related to or discuss the issue of innovation and creativity. Another important part is mapping out the bibliographies of these countries. This analysis involves determining 1 article cited from a different country in the third article. The results in Figure 8 show a minimum threshold of 1 article being cited at least 76 times between 2013 and 2022, the results show where the United States and United Kingdom are the most productive countries in publishing journal articles with issues of innovation and creativity in entrepreneurship.



**Figure 6.** Top earning writers of document



**Figure 7.** Top productive country



**Figure 9.** Top productive affiliation

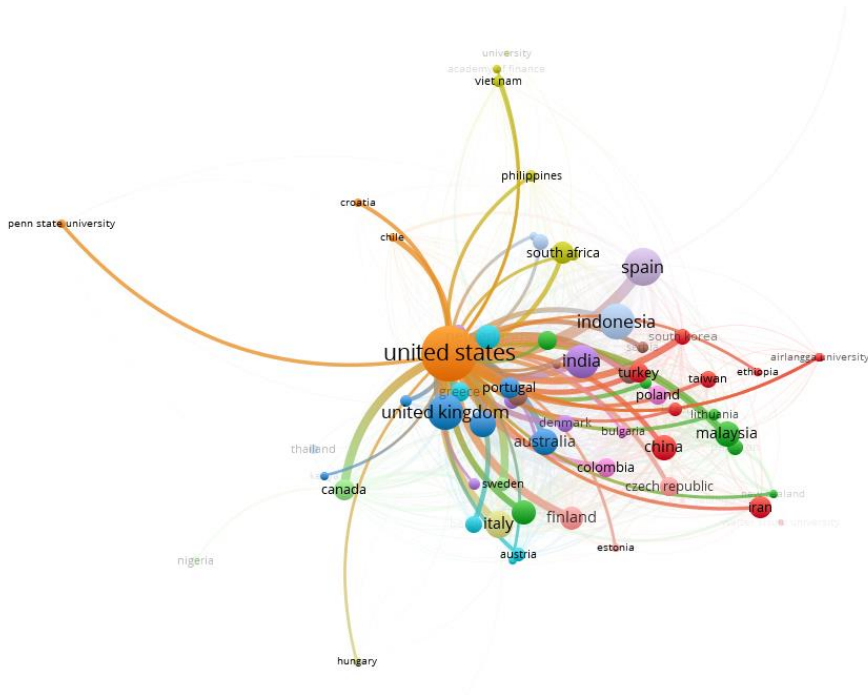


Figure 8. Bibliographic coupling country

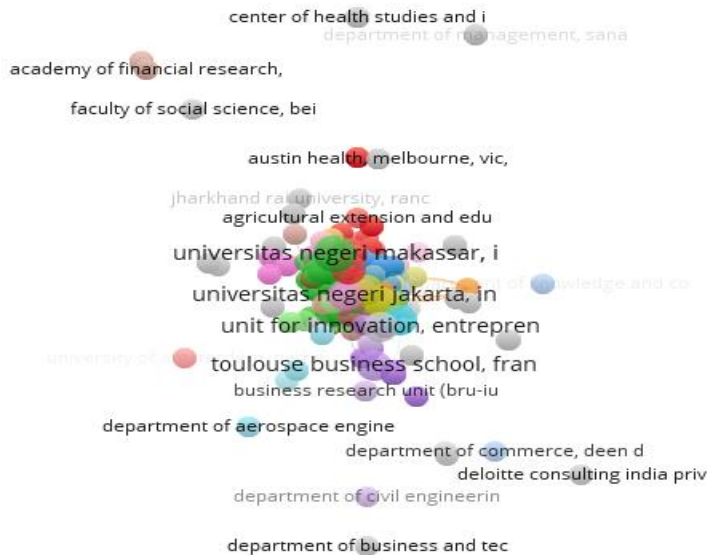


Figure 10. Bibliographic coupling institution







"innovation" are interconnected or have a network with the following sentences: "creativity", "education", "technology", "social innovation", "social entrepreneurship", "corporate entrepreneurship", "intrapreneurship", "leadership", "network", the results of this analysis show that keywords or issues about innovation and creativity have been widely discussed not only in management and business science journals, but have penetrated into journals with other sciences. VOS viewer presents a trend visualization network from the keywords innovation and creativity. In terms of the emergence of co-occurrence of author keywords in network visualization (Figure 13), the keyword Innovation became the first top topic among several other words.

## 5. Conclusion

Organizational, cultural, and environmental factors that greatly affect the level of creativity and individual innovation. The conclusion is in line with Kitchin R. (2014) with his article entitled "The real-time city? Big data and smart urbanism". Where he gives the term 'smart city' which is a city built on innovation and creativity of its residents. Sarooghi H., Libaers D., Burkemper A. (2015) believe that innovation increases innovative activities. However, empirical research on the impact of innovation on innovation, although positive, has yielded various results. In this study, a meta-analysis of 52 empirical samples consisting of 10,538 observations was conducted to examine how organizational, environmental, and cultural factors influence the creativity-innovation relationship. Until finally this research found a strong positive relationship between creativity and innovation, especially at the individual level. In addition, Sarooghi's research also finds an interesting moderating effect in which the relationship between creativity and innovation is stronger for large firms, process innovation, and low-tech

industries compared to small firms, product innovation, and high-tech industries. The next finding is that the degree of uncertainty avoidance maximizes the correlation between creativity and innovation. A study conducted by Edwards-Schachter M., García-Granero A., Sánchez-Barrioluengo M., Quesada-Pineda H., Amara N. (2015) recognizes Creativity, innovation and entrepreneurship as important things to foster an entrepreneurial culture. Empirical findings show that most of the respondents see themselves as creative people and think that creativity is strongly related to innovation and entrepreneurship. Previous studies by Ahlin B., Drnovšek M., Hisrich R.D. (2014) the results of his research show that entrepreneurs and perceived self-efficacy beliefs directly and in interactions affect product and process innovation of companies. These findings provide the basis for future work that enhances individual-level capacities that are important in the entrepreneurial process.

In the end, based on Table 3, the top 10 most cited articles in this study are generally believed that creativity can increase innovation. Innovation is based on four processes, including: 1) community psychology; 2) creativity research; 3) social and societal challenges; and 4) regional development. It was also found that there is a stronger relationship between creativity and innovation, especially in large companies. On the other hand, small companies with low technology are generally less balanced and less creative in increasing their productivity.

The conclusion of this research is to become a successful entrepreneur in difficult times, such as the Covid-19 pandemic to further increase creativity and innovation so that the products offered are competitive, and as an evaluation material it is hoped that entrepreneurs will focus more on making competitive analysis going forward. Furthermore, this research with a bibliometric approach is expected to provide insight in conducting and developing discussions on

innovation and creativity issues, especially in entrepreneurship. This study aims to determine the extent of the trend of discussing innovation and creativity issues in entrepreneurship in published journal articles. In this study, a comprehensive overview of journal articles that have been published from Scopus.com sources is presented, then collected and analyzed using the VOSviewer application. The bibliometric indicators used in this study include: best productive authors, institutions and countries, most frequently used keywords and most cited articles. The

journals used as analytical materials in this study are very credible with a database from Scopus.com. Based on the analysis, it is known that there are several journal articles that are related or directly discuss issues related to innovation and creativity, within a period of 10 years (2013-2022) around 32.2% of articles. The author based on the results of the analysis of this research can be a good opportunity for novice writers who want to write articles about innovation and see creativity in entrepreneurship.

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## QUALITY ASSESSMENT OF E-COMMERCE SERVICES IN TERMS OF PROCESS DIGITIZATION

**Abstract:** Industry 4.0 is driving a massive transformation across all types of businesses, including those in the service sector. An important component of this transformation is the digitization of individual processes within organizations. The recent Covid-19 pandemic has accelerated the digitization of processes, with many businesses forced to pivot to online distribution channels in order to weather the crisis. The digitization of services, particularly in e-commerce, has been a key factor in the adaptation and survival of businesses during these challenging times. The aim of the article was to evaluate the performance of a selected e-commerce website in terms of changes related to its website functionality and the introduction of new options available to potential customers. The evaluation was conducted through surveys administered both before and after the website changes were made. Through these surveys, it was possible to identify which changes were particularly well-received by customers, as well as to gain insights into the additional changes they expect to see in the future.

**Keywords:** Service, service quality, e-commerce, digitalization, Industry 4.0

### 1. Introduction

The Fourth Industrial Revolution, commonly known as Industry 4.0, has been gaining global momentum in recent years. Its goal is the comprehensive integration of all production areas through digitization and the creation of new communication channels (Wachnik, 2022). The revolution also aims to implement modern solutions that enhance business operations, particularly in terms of automating and digitizing production processes (Kleszcz, 2018).

As a result, interest in the impact of Industry 4.0 on companies has increased. Firms are eagerly attempting to introduce new technologies into their production processes (Efimova and Briš, 2022). However, they

encounter numerous challenges along the way (Ingaldi and Ulewicz, 2020).

It is worth emphasizing that Industry 4.0 relies heavily on various technologies such as: traceability, autonomous robots, human-robot interaction, drones, cyber-physical systems, cybersecurity, renewable energy, cloud technologies and simulations, big data analysis, blockchain, internet of things analytics, virtual and augmented reality, artificial intelligence, mobile and cloud computing (Richnák and Fidlerová, 2022). All of these technologies are crucial for the development of Industry 4.0.

Currently, the digitization of processes is one of the key elements of the strategy for most businesses. This is due to the rapid development of technology, particularly the

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Industry 4.0 revolution and the Covid-19 pandemic (Gue et al., 2020; Kmecová et al., 2021). In the initial phase of the pandemic, many businesses were forced to expand their operations and move online to continue operating. It can be observed that the Covid-19 pandemic has accelerated the digitization process of many companies, including those that were previously not interested in digitization. Automation and digitization have become not only goals, but also means enabling business development towards an intelligent company (Grznar et al., 2020; Pekarcikova et al., 2021; Wiśniewska-Sašek, 2020). Currently, there is a trend that if a company does not have its own website or is not digital, it does not exist.

Industry 4.0 is driving the integration of digitization across all production areas, with the goal of enhancing business operations and automating production processes. This has significant implications for service industries, which can also benefit from the integration of advanced technologies and data analytics to optimize and customize their offerings.

The development of e-commerce is one of the most visible effects of the trend of opening new distribution channels. Nowadays, companies use a strategy of combining sales in brick-and-mortar stores with e-commerce to increase the usability of their websites and gain a competitive advantage (Garbarova et al., 2017; Corejova et al., 2022). This strategy can help companies increase accessibility for customers and streamline sales processes, leading to revenue growth. The significant growth of e-commerce is related to the use of modern technologies such as artificial intelligence, big data, or IoT analytics, which allow companies to better understand their customers' behaviors and tailor their offerings to their needs (Bawden et al., 2020; Senthil et al., 2021).

Success in the global economy is often perceived in terms of competitiveness, risk, and innovation. Business success is based on the speed of decision-making and solid

information support in this process (Krynke and Klimecka-Tatar, 2022). Dynamic changes in the market area and intense competition are also associated with the evolution of customer expectations. Therefore, the area of product quality improvement must aim to achieve customer satisfaction (Siwec et al., 2022). The need for continuous improvement of the organization is a consequence of continuous and dynamic changes occurring in the organization's environment and within it. Introducing continuous improvement into management practice means starting the process of building an intelligent and self-improving organization continuously (Knop, 2022).

In addition to the importance of website design and functionality, e-commerce shops need to adapt to changing market conditions and customer preferences to remain competitive. One way to achieve this is by expanding access channels to include electronic ones, such as e-commerce platforms. This is particularly important in the context of Industry 4.0, where digitization of purchasing processes is becoming increasingly necessary.

To evaluate the performance of e-commerce websites and identify areas for improvement, various tools and methods can be used. One such method is the Servperf method, which measures service quality from the customer's perspective. The results of surveys conducted using this method can provide insights into how well a company meets its customers' needs and expectations and which service attributes require improvement.

Regular assessments of website performance and customer satisfaction are crucial for e-commerce stores to stay competitive and adapt to changing market conditions. By utilizing research findings, companies can make strategic decisions to improve service quality and ensure customer satisfaction, ultimately leading to increased customer loyalty and higher revenue.



As part of the evaluation of e-commerce and e-services quality, specific attributes are taken into account. According to many authors (Cristobal et al., 2007; Kim et al., 2006; Lee and Lin, 2005; Yoo and Donthu, 2012; Ghosh, 2018), attributes directly related to the e-commerce website are particularly important, as the entire transaction process takes place there. The most frequently mentioned attributes include: website design, ease of use, reliability, security, personalization, and customer service quality.

The purpose of the study was to assess the performance of a selected e-commerce website in relation to changes made to its website functionality and the introduction of new features available to potential customers. The research was conducted through a survey administered before and after the implementation of changes to the website of the e-commerce store under study. The survey allowed the identification of the areas where customers were least satisfied, which were taken into account by the company developing the new website. It also enabled the evaluation of whether the new website meets customers' requirements and preferences. Additionally, the results of the survey conducted in the second period allowed for the identification of areas where further improvements are still required for the website. Findings from this research could be utilized by other organizations to enhance their online platforms.

## 2. Literature review

Assessment of e-commerce operations is extremely important because it allows for the identification of areas that contribute to customer satisfaction as well as areas that lead to customer dissatisfaction. Therefore, conducting research in this area, especially regarding the functioning of the websites on which customers make purchases, is essential as the entire service delivery process takes

place on these platforms.

"During the evaluation of the quality of e-services and e-commerce, specific attributes are taken into account. Many authors (Cristobal et al., 2007; Kim et al., 2006; Lee and Lin, 2005; Yoo and Donthu, 2012; Ghosh, 2018) point primarily to attributes directly related to the e-commerce website platform, as it is on this platform that the entire transaction takes place. The most frequently mentioned attributes include: website appearance, ease of use, reliability, security, and personalization. One of the characteristic features of e-services and e-service quality is the departure from traditional quality dimensions. The first difference is the lack of direct contact with the service provider. A very important aspect of e-services is the internet platform on which services are offered and orders are placed. In the rest of the text, when referring to a website or web application, the term "internet platform" will be used.

During the process of providing traditional services, the customer has contact with the service provider, who advises on the choice of service, its features, and handles most of the formalities. In the case of e-services, such contact does not exist, and the customer performs individual actions on their own. They contact the service provider through various available channels, and in case of doubts or problems, there is no typical direct interaction between the customer and the company. Therefore, areas such as empathy or professionalism cannot be evaluated. The second important difference is that the customer chooses and orders e-services from any place where they have access to the Internet, without the need to visit the service provider's headquarters. Therefore, attributes such as tangibility, which are important in the case of traditional services, cannot be taken into account.

Due to the increasing popularity of e-services, a hierarchical model has also been developed for their case. This model was developed by

Blut and his colleagues (Blut et al., 2015) and subsequently verified by Blut himself (Blut,

2016). This model is presented in Figure 1.

E-service quality			
Website design: Information quality; Website organization; Purchase process; Website convenience; Product selection; Merchandise availability; Price offerings; Website personalization; System availability	Fulfilment: Timeliness of delivery; Order accuracy; Delivery conditions	Customer service: Service level; Return policies	Security: Security; Privacy

**Figure 1.** Hierarchical model of e-service quality (Blut i in., 2015, Blut, 2016)

Based on conducted research, attributes that, according to the authors, should be taken into account during the evaluation of the quality of e-services were identified and verified. Four groups of attributes were distinguished: website design (9 attributes), content (3), customer service (2), security/privacy (2). It is worth noting that the developed model includes attributes not included in existing scales. One very important detail should be noted. A lot of emphasis in this model, and therefore in the quality of services, is given to the website itself. This is an element that often influences whether a customer decides to purchase a service in a particular store. It takes into account not only the appearance of the website, but also the information that can be found on it and how to use it.

This model should be treated separately because it does not apply to traditional services that are ordered, performed, and delivered in a traditional way. It can be said that it is a kind of complement to the other

service quality models, but due to its application, it must be treated separately.

One of the authors, during her research on various service quality models and the evaluation of e-service quality, also created her own model (Fig. 2) and presented it in her work (Ingaldi, 2022b). The model was partially verified in the work (Ingaldi, 2022a). The quality of e-services consists of three elements: the physical aspect, service quality, and outcome quality. In terms of the physical aspect, it is important to consider the convenience of purchasing the e-service, as well as the appearance of the website through which the client will place the e-service order. When placing an order, the client takes into account the available offer, the possibility of personalizing the e-service, as well as the completeness of information about the offered products.

Since the customer makes the choice and order independently, they take into account

the website's functionality (e.g. availability, navigation) and capabilities (e.g. search engine, cart, registration). For online orders, customers would like to have a variety of payment options available. Some people prefer, for example, to pay cash on delivery in the case of home delivery. The last element, which is probably the most important, is potential contact with the service provider. This means that the customer knows who they are ordering the service from, can easily find the service provider's contact details and, if necessary, contact them.

The final component of the model is outcome quality. This group includes waiting time,

both for electronically and traditionally delivered e-services. In the case of the latter, the materiality, i.e. what the customer receives, will also affect the outcome quality. One cannot forget about safety either. In the case of e-services, the importance of this factor clearly increases. This is related not only to hackers or malicious software but also to the website itself, which may turn out to be fake. Customers also want to be sure about the delivery of the service and whether it will be delivered successfully (e.g. in the case of e-software purchase). The last factor that affects the outcome quality is, as in the case of traditional products, the conformity of the realized e-service with the order.

E-service quality		
Physical aspect: Convenience; website; Accessible offerings; Possibilities for personalization; Information compliancy	Quality of service: website performance; website capabilities; possible payments; possible contact with the service provider	Quality score: waiting time; tangibles; safety; delivery reliability; compliance with order

**Figure 2.** Author's hierarchical model of e-service quality (Ingaldi, 2022b)

This model is very general and can apply to various types of services offered online, including e-commerce services. It can be expanded, and the use of its elements to assess service quality can serve as the basis for selecting attributes for such an assessment.

Electronic service quality is very diverse because it involves interactions between a person and technology, and its dimensions do not correspond perfectly to the dimensions of "offline" service quality (Cotîrlea, 2011). Many scientists have tried to indicate the most important dimensions related to e-service evaluation, in most cases, they indicated the dimensions that directly relate to the functioning of the website through which

customers make purchases (Table 1).

Previous research by one of the authors on the attributes of e-services, presented in a work (Ingaldi, 2022b), based on available literature (analysis of WoS, Scopus and researchgate), allowed for the compilation of 84 attributes into 13 groups. Currently, research is underway to verify this list and create a list of approximately 30 universal attributes that could be used in studies related to the evaluation of e-services. This article used this list and selected those that directly relate to the website and its actions (Table 2), which were used to evaluate the website of the surveyed e-shop twice.

**Table 1.** Selected dimensions of e-service quality (Ingaldi, 2022b)

<b>Author</b>	<b>Proposed dimensions of e-service quality</b>
Dabholkar et al. (1996)	website design, reliability, presentation, ease of use, user enjoyment, and control
Ziethaml et al. (2002)	performance, reliability, efficiency, personalization, quick response to inquiries, communication, security, interactive honesty
Madu i Madu (2002)	Performance, appearance, structure, aesthetics, reliability, fulfillment, security, credibility, responsiveness, personalization, accessibility, reputation, pleasure
Loiacono et al. (2002)	information, interactivity, reliability, personalization, responsiveness to inquiries, appearance, interactive honesty, communication, procedural honesty
Yang i Jun (2002)	website design, security, reliability, personalization, prompt response to inquiries, accessibility
Santos (2003)	ease of use, design, links, structure, components, performance, reliability, communication, security, incentives, customer banking
Lee i Lin (2005)	aesthetic design, reliability, quick response to inquiries, credibility, personalization
Kim et al. (2006)	performance, fulfillment, accessibility, privacy, personalization, speed of response to questions, exchange, communication, accuracy of information, honesty of results
Cristobal et al. (2007)	appearance, implementation, reliability, accuracy of orders
Zavareh et al. (2012)	accessibility, interactivity, proper functioning, user-friendliness, security, attractive appearance

**Table 2.** List of evaluated attributes (Ingaldi, 2022b)

<b>No</b>	<b>Group of attributes</b>	<b>Attributes</b>
1.	Appearance and operation of the website	The website is visually attractive.
2.		The website looks professional.
3.		The website is convenient and easy to use.
4.		The website is organized in an intuitive way.
5.		The website does not experience any malfunctions.
6.		The website is designed in a way that can be used by people with different disabilities.
7.	Website content	The information on the website is current and comprehensive.
8.		The website contains a description of the ordering process.
9.		The regulations of the e-shop are accessible and understandable.
10.		The website contains the full range of e-service provider's offers.
11.		The website contains appropriately selected product categories.
12.	Products	The website contains a wide variety of products.
13.		The website contains an exact description of the products.
14.		The website contains photos of the products.
15.		The website includes price information.
16.		The website contains information about the delivery date.

17.	Search engine	The website features a product search engine.
18.		Product search is simple.
19.		The search includes option for filtering results.
20.		The website has personalized selection features.
21.		The website includes order history options.
22.	Making orders	Registration on the website is not mandatory to place an order.
23.		The process of placing an order is simple and fast.
24.	Contact with e-shop	The website contains accurate contact information for the e-service provider.
25.		The e-service provider offers after-sales support.
26.	Payment methods	The website contains accurate bank details.
27.		The customer has the option to choose the payment method.
28.		The customer has the option to choose the "cash on delivery" payment option.
29.		The customer has the option to choose various forms of electronic payment.
30.		The transaction on the website is fast and efficient.
31.	Security	The website requires a reasonable amount of personal data.
32.		The website has a security system that protects all customer information.
33.		Financial transactions on the website are secure.
34.		Information about customer's credit/debit cards is secure.
35.		The website protects all information about customer behavior during online shopping.

### 3. Methodology

The research was commissioned by an e-shop. It was conducted twice, which was related to the introduction of changes to the functioning website of the e-shop. These changes were made by an external company, also commissioned by the surveyed e-shop, and included a wide range of new solutions related to improving the appearance of the website itself, its functionality, content, as well as the purchasing process. It was decided to introduce a more subdued colour scheme, high contrast, and solutions that would facilitate the use of the website by people with special needs. Although the investigated e-commerce store is a private enterprise, the management decided that the new website would be designed according to the WCAG 2.1 standards, which would allow the e-commerce store to open up to a group of people with special needs and be more competitive on the market. Attention was also paid to user safety, and greater options were introduced regarding payment and delivery methods.

Customers of the e-shop, who used the website before and after the changes, were asked to evaluate its performance. The assessment was carried out using a questionnaire, the attributes of which were presented earlier in Table 1.

Customers were asked to assess individual attributes on a scale of 1-7, where 1 meant "completely disagree" and 7 meant "completely agree." Additionally, they had 100 points to allocate among the different groups of attributes to indicate their importance. The survey also included basic characteristics of customers, which allowed the profile of customers of the surveyed e-shop to be determined. The characteristics included gender, age, social/professional status, education, and residence. The survey was created using a Google survey form, which facilitated collecting responses from customers.

The Servperf method was used to analyze the obtained results. Due to the length of the survey, which contained 35 attributes divided into 8 groups, more commonly used methods

such as Servqual or IPA, where customer expectations are taken into account in addition to the actual service evaluation, were not used.

The Servperf method was developed by Cronin and Taylor, and its name comes from the words Service Performance (Cronin, Taylor, 1994; Anand, Selvaraj, 2013). It is considered an attempt to overcome some of the weaknesses of the Servqual method (Dziedzic, 2015; Lupo, 2015). The authors of this method questioned the measurement of customer expectations, as they believe that expectations are an ambiguous and variable category. Although the authors of the method took into account the importance of individual attribute groups during the research to indicate what is most important to customers when it comes to the functioning of e-commerce websites.

The Cronin and Taylor concept is based on the assumption that perceiving the actual service is sufficient to provide a measure of service quality evaluation (Guglielmetti Mugion, 2010). Therefore, this concept emphasizes measuring and evaluating the current state - only measuring and evaluating the level of quality of the performed service in relation to individual categories, and then relating it to the ideal image (Cronin, Taylor, 1992; Cronin, Taylor, 1994; Cronin et al., 2002; Jain, Gupta, 2004). This method is most commonly used when there is a high probability of relatively maximum customer expectations for each of the analyzed criteria (Czajkowska and Ingaldi, 2021).

The first study was conducted between May-October 2020 and involved 267 customers. Afterwards, an external firm started working on changes to the e-commerce website (between March-October 2021). The second study was conducted between September-December 2022, this time involving 327 customers. It was assumed that only responses from adults would be taken into account for the analysis, as only such persons have legal capacity. The authors decided that

the second study would not take place immediately after the website changes, but after a few months. Most people are resistant to change, including customers, so they needed time to become familiar with the new website of the e-commerce store being studied, as well as its features.

After checking the responses, only 244 surveys from the first research period and 307 from the second research period were taken into account. The analysis of the results began with conducting a Cronbach Alpha test and calculating basic statistics for all attributes together (separately for each stage of the study). The obtained results were interpreted according to the assumptions presented by (Hair et al., 2003), where data suitable for analysis were those for which the test result was at least 0.7.

Then, an analysis of respondents participating in both stages of the study was performed. The average ratings were calculated for individual attributes and groups of attributes, as well as for all responses combined. The average importance for customers was also calculated, which allowed for the calculation of the weighted average of all attributes together. The results were presented in the form of bar charts and radar charts.

#### **4. Results and discussion**

Due to difficulties in collecting results related to low willingness of customers to participate in the research, it was not possible to verify the same respondents in both research periods.

In Table 3, the results of the Cronbach Alpha test and basic statistics are presented. According to the assumptions, data with a Cronbach Alpha test result of at least 0.7 should be considered reliable. In both cases, the result was above 0.7, which means that all the dimensions obtained can be further analyzed.

The initial results of the study already allowed to indicate that the respondents assessed the e-commerce website much better after the changes were introduced (a difference of over 1.7 points). This means that the changes were well-received by the

customers and had the expected effect. However, the standard deviation decreased, which means that in the second research period, the respondents were more consistent in their answers.

**Table 3.** Cronbach Alpha and statistical analysis (own study)

	<b>Cronbach Alpha</b>	<b>No of items</b>	<b>Mean</b>	<b>Standard deviation</b>
Assessments before the website change	0,726	35	4.129	1.3901
Assessments after the website change	0,803	35	5.849	0.9188

In Table 4, data on the respondents are presented. Proportional shares were calculated for each characteristic before and after the website change.

There were some minor differences in the structure of respondents in both research periods. However, it should be emphasized that they were similar to each other. Among the respondents, women predominated, most of them were young, under 40 years of age,

with secondary or higher education, working or studying, and living in larger cities. Such a structure of respondents is dictated by the nature of the research object. It is an e-commerce platform where purchases are made online. Statistics emphasize that it is usually young, educated people from larger cities who make online purchases (Raport o stanie sektora małych i średnich przedsiębiorstw w Polsce).

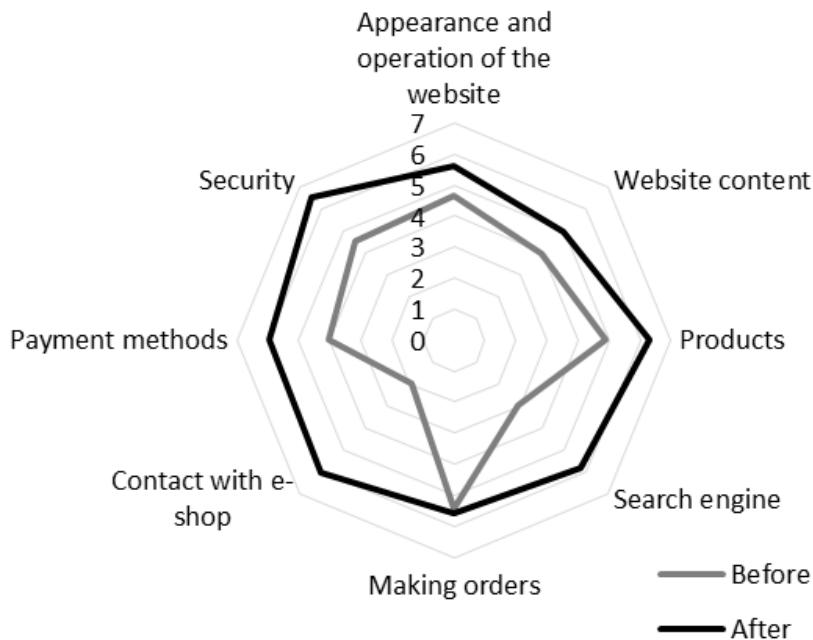
**Table 4.** Characteristics of the respondents (own study)

<b>Feature</b>	<b>Answer</b>	<b>Percentage</b>	
		<b>Before the website change</b>	<b>After the website change</b>
Gender	female	56.1	64.6
	male	43.9	35.4
Age	up to 20 years	24.2	25.4
	21-30 years	29.3	26.2
	31-40 years	28.7	29.3
	41-50 years	14.3	13.3
	51-60 years	5,4	3.2
	61-70 years	3.4	2.6
	Over 70 years old	0.1	0.0
Social / professional status	pupil/ university student	37.2	33.2
	I work	38.1	41.6
	unemployed	9.3	8.1
	entrepreneur	12.8	14.7
	pensioner	2.6	2.4
Education	primary education	0.3	0.2
	lower secondary education	2.6	2.1
	vocational education	15.8	17.4
	secondary education	47.4	43.2
	higher education	33.9	37.1

Residence	village	8.1	9.4
	city up to 50k residents	13.2	12.6
	city 51 to 100k residents	10.3	8.6
	city 101 to 200k residents	20.8	18.4
	city 201 to 400k residents	23.4	27.2
	city with over 300k residents	24.2	23.8

At the beginning, the average assessment for each group of attributes were also calculated for both research periods and presented in Figure 3. Before the changes were made to the e-shop website, respondents assessed products the highest, followed by the appearance and operation of the website. They were least satisfied with their contacts with the e-shop. After the changes were implemented, the average ratings improved significantly. Respondents assessed security

and products the highest, followed by contact with the e-shop. Thanks to the fact that the research was conducted twice, both before and after the changes, the company could take the customer's voice into account when designing the new website. It can be seen, for example, that the average rating for contact with the e-shop was lowest before the changes, but after the changes, this attribute was highly assessed.



**Figure 3.** Average assessment for individual attribute groups of attributes: a) before the website change, b) after the website change (own study)

Then, the mean values of the ratings for individual attributes for both research periods were calculated. These results were presented collectively in Figure 4.

Before the changes were introduced, only four attributes received average assessments above 6, i.e., 15. The website includes price information; 14. The website contains photos

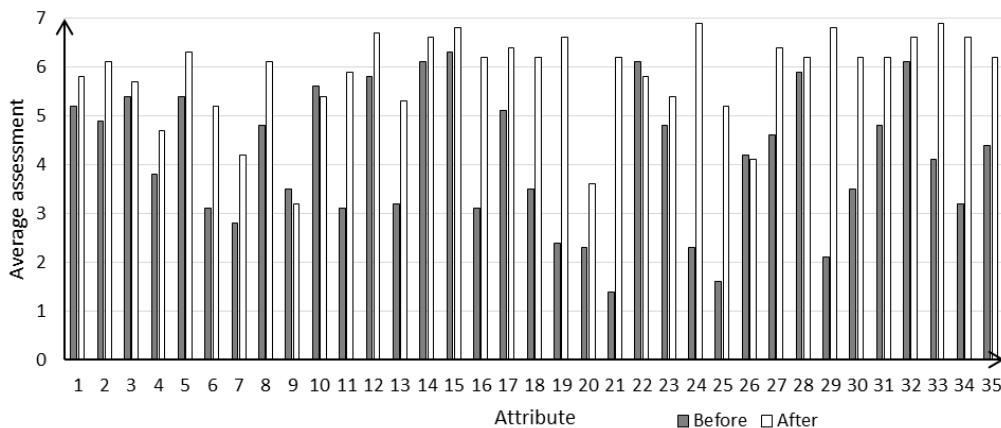


of the products; 22. Registration on the website is not mandatory to place an order; 32. The website has a security system that protects all customer information. This meant that respondents were very satisfied with the performance of the website in these four areas. Moreover, for most of them, the changes resulted in an even greater level of satisfaction, except for attribute 22. Registration on the website is not mandatory to place an order. It should be emphasized, however, that this decrease was small and could have been due to changes in the structure of the respondents. Especially since virtually nothing changed on the website in this area.

Two attributes were assessed below 2 before the website changes, namely 21. The website includes order history options; 25. The e-service provider offers after-sales support. This information was obtained by the company responsible for the changes on the e-shop website. Importantly, in the second research period, the rating for both attributes increased to over 5. Therefore, customer satisfaction in these areas increased, and the

changes implemented can be observed, although the average rating level shows that there is still room for improvement in this area.

Analyzing the average results for the second research period, a certain correlation was noticed: 21 out of 35 attributes obtained average scores above 6, which means high or very high satisfaction with the functioning of the new website of the researched e-shop. This indicates that the changes introduced contributed to increasing its attractiveness in the eyes of customers. Two attributes received scores below 4, i.e. 7. The regulations of the e-shop are accessible and understandable; 20. The website has personalized selection features. Respondents often complained in their emails about difficulty finding the regulations of the e-shop on the website during both research periods, as it was not intuitive for them. The lack of personalization of selected features makes it difficult for customers to find and choose products offered by the researched e-shop. These are potential areas for improvement and further changes.



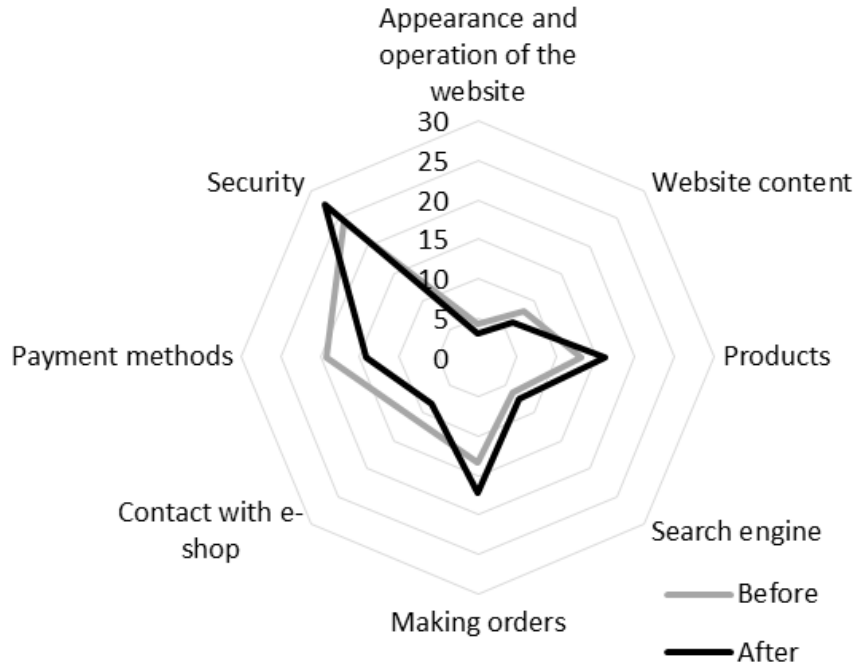
**Figure 4.** Aggregate results of survey research using the Servperf method (own study)

Next, the average weights of each group of attributes for both research periods were calculated, as shown in Figure 5. One can notice a certain correlation. In both research

periods, respondents indicated that the most important thing for them is the security of using the website. It can be assumed that this is related to frequent customer data leaks or

financial frauds on the Internet. Next, respondents pointed out payment methods, placing orders, and products as important factors. The appearance and functioning of

the online platform are the least important for customers. In both periods, despite small differences, the structure of importance is similar.



**Figure 5.** Weights of individual attribute groups of attributes: a) before the website change, b) after the website change (own study)

The mean assessments for all attributes were also calculated. These calculations were done in two ways: as the arithmetic mean  $X_A$  and as the weighted mean  $X_W$ . The means for data collected before the website change were calculated (before the website change):

$$X_{AB}=4.129$$

$$X_{WB}=4.179$$

The difference between the two averages was small. However, it should be noted that customers did not assess the e-shop's website very highly before the changes were made.

And the averages for data collected after the website change are as follows:

$$X_{AA}=5.849$$

$$X_{WA}=6.025$$

In this case, a greater difference was observed between the arithmetic mean and the weighted average. This is due to the fact that customers gave high ratings to attributes that were very important to them.

Overall, it can be said that the average rating is quite high, although it is not the maximum rating. However, it can be concluded that the investment in improving the website by the surveyed e-shop has yielded expected results. Respondents rated the website better after the changes were implemented than before the changes were made.

## 5. Conclusion

To meet the demands of today's customers and remain competitive in the marketplace, it is crucial for store owners to embrace electronic access channels and digitize various processes, including the purchasing process.

E-commerce offers a vast array of benefits, from increased competitiveness to enhanced shopping convenience, which can significantly improve customer satisfaction. Nonetheless, a well-designed and functioning website remains a critical factor in determining the success of an e-shop.

The article describes a study conducted to assess the operation of a selected e-shop's website before and after making changes to it. The study involved gathering feedback from respondents who evaluated 35 attributes related to the website's performance, and the Servperf method was used to analyze the results.

The Servperf method is a tool used to measure service quality. The overall results of surveys conducted using this method show service quality from the customer's perspective. The survey results allow for an assessment of how well a company meets the needs and expectations of its customers in terms of the services provided. Individual service

attributes as well as overall service quality are analyzed. Based on the results, it is possible to determine which attributes are most important to customers and which require improvement. The results of surveys conducted using the Servperf method are often used by companies to make strategic decisions on improving service quality. This tool allows companies to better understand the expectations of their customers and adjust their services to meet their needs.

The study's findings enabled researchers to identify the changes that were particularly well-received by customers and gain insights into the additional changes they expect to see in the future.

However, there are limitations associated with the study, such as the potential subjectivity of the survey and the small research groups used for analysis. Nonetheless, the authors believe that the amount of data collected was sufficient to conduct a reliable analysis.

To maintain the website's performance and attractiveness to customers, it is essential to conduct periodic research aimed at assessing its effectiveness and identifying areas requiring improvement. This will enable businesses to remain competitive and meet the ever-evolving needs of their customers.

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## ELECTRONICS MARKETING STRATEGY OF KULIT LUMPIA BEUNTUNG BANJARMASIN BUSINESS IN INCREASING SALES VOLUME

**Abstract:** *The purpose of this study is to identify and analyze the marketing strategies implemented by Kulit Lumpia Beuntung. Using the SWOT analysis technique, we use models commonly referred to as inner and outer factor matrices, or IFAS and EFAS matrices. This study uses a non-probabilistic sampling method with an aggregate sampling technique. Based on the results of the internal factor analysis strategy (IFAS) matrix analysis, the strengths, weaknesses, opportunities, and treatments (SWOT) plots of the product, price, promotion, and location variables are known to be in quadrant I. That is, the position between the opportunity axis and the strengths axis. The External Factor Analysis Strategy (EFAS) matrix analysis results show that the SWOT diagrams for the product, price, promotion, and location variables also exist in quadrant I. This position lies between the opportunity and intensity axes.*

**Keywords:** *Marketing Strategy, SWOT Analysis, IFAS Matrix, EFAS Matrix*

### 1. Introduction

Indonesia is a resource-rich developing country with the fourth largest population of any country. A country's development certainly reflects the well-being of its people. However, the Indonesian economy experienced a very bad crisis at the end of 1997. At that time, all economic sectors experienced decline, but small and medium enterprises (MSMEs) and various industrial companies survived. To use one's own capital without capital or investment. I owe the bank (Arizal et al., 2021). The failure of a pattern of economic development centered on large firms has led economic policy makers to turn to economic development that strengthens small and medium enterprises (Rahmadani et al., 2022). SMEs are the largest group of

economic actors in the Indonesian economy and have proven to be not only the engine of economic growth after the economic crisis, but also a safety valve for the national economy during the crisis (Gunartin, 2017; Ramadhani et al., 2021).

When running a business, business people really need to understand which strategy is right for their business. According to Sunyoto (2019) in his Gultinan and Gordon (1990), this marketing strategy is a basic statement of expected effectiveness with respect to a particular target market demand (Rizal et al., 2020). Especially in the field of marketing, marketing strategy plays a very important role for business success (Fadilurrahman et al., 2021). Established marketing strategies should be reviewed and further developed according to market trends and market

environment (Rizani et al., 2022). Therefore, your marketing strategy should be able to provide a clear and focused picture of what is being done when taking advantage of each opportunity (Saputra et al., 2020). A strategy widely used by MSMEs is the marketing mix strategy (Habibah et al., 2021).

Kulit Lumpia Beuntung is a SME engaged in cottage industry located at Jalan Samudra Komplek Untung Jaya 61C, Banjarmasin. Kulit Lumpia Beuntung is Banjarmasin's first luxury spring roll (kulit) crust (Shaddiq et al., 2021). This spring roll skin is a casing made of flour, water, oil and salt and is typically used to make spring rolls and various snacks such as meatballs, chocolate bananas, martabak and samosas (Handayani et al., 2022).

Kulit Lumpia Beuntung has played a role in the development of the local economy since the start of the Kulit Lumpia business, as the Kulit Lumpia business owners have always held training courses for those who want to learn how to make spring roll wrappers (Hidayat et al., 2021; Wanidison & Shaddiq, 2021). I learned that she can use her open own business. Her business activity, which started as a hobby, has grown into this company, Kulit Lumpia. The number of requests from spring roll vendors in Kulit Lumpia has not decreased and continues to increase, not only from vendors of spring rolls, but also food products such as fried foods, maltabak and caramelized bananas, so the demand is too high. is also increasing (Surti et al., 2022). There are many things that skin owners cannot meet (Irpan et al., 2021; Shaddiq & Handayani 2021). Kulit Lumpia, due to poor management of human resources, this Kulit Lumpia production is made with limited product capacity and distribution area. Currently Kulit Lumpia Beuntung only produce about 15,000 pieces per day, but the demand of sellers is about 50,000 pieces per day for her (Iyansyah et al., 2021; Wagiono et al., 2022). Consumers of Kulit Lumpia Beuntung come not only from the

Banjarmasin area but also from outside the area such as Palangkaraya and Samarinda.

**Table 1.** Kulit Lumpia Beuntung Spring Rolls Sales Volume Data 2016-2021 period

Years	Omzet
2016	Rp 1,611,475,000
2017	Rp 1,421,675,000
2018	Rp 1,496,500,000
2019	Rp 1,275,675,000
2020	Rp 930,750,000
2021	Rp 1,235,525,000

From the above sales data, we can see that the Lumpia Beuntung leather business experienced volatile sales from 2016 to 2021. Additionally, 2020 marks the most for owners of Clitlum Pier since the outbreak of coronavirus disease (COVID-19) in 2019 and the introduction of Massive Social Restrictions (PSBB) in his April and his May. severe impact. On average, ministry of small and medium enterprises (MSMEs) recorded a decline in sales during the COVID-19 pandemic (Joko et al., 2022). This is due to reduced out-of-home activities, difficulties in sourcing raw materials due to transportation restrictions, and declining public confidence in out-of- home products (Kurniawan et al., 2021; Wijaya et al., 2021). At the end of 2021, the price of flour and oil raw materials increased again. As a result, Kulit Lumpia business owners were unable to meet the demand of too many consumers due to limited production. From our observations, it is clear that not all MSMEs will have to close their stores. There are his MSMEs surviving declining sales, like this Kulit Lumpia Beuntung shop. Product related tweaks and some marketing strategies to survive (Norrahmi et al., 2021).

The current marketing strategy for Kulit Lumpia Beuntung products is for consumers to come directly to the owner's home to purchase the spring roll skins, place an order through WhatsApp media, and have it delivered by taxi based on consumer demand.



Against the background of the above issues, the authors are interested in conducting a study titled "Marketing Strategies of Kulit Lumpia Beuntung Banjarmasin Business in Increasing Sales Volume".

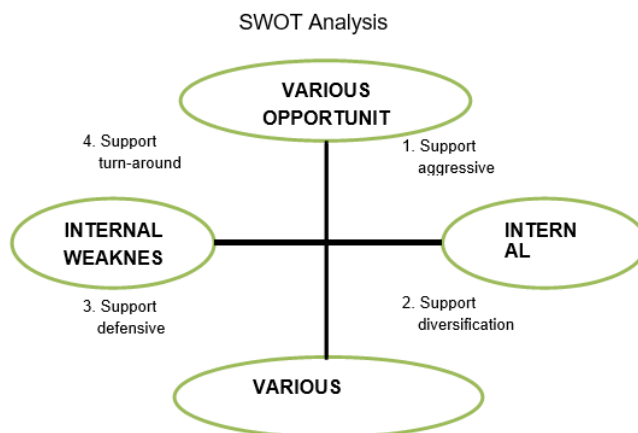
## 2. Literature review

Kotler and Keller (2009), et al. (2020:147), the American Marketing Association (AMA) provides the following formal definition: In a way that benefits the organization and its stakeholders.

Assauri (2017), a marketing strategy is a set of goals, guidelines, and rules that provide direction, references, and attributes for marketing activities at each level, particularly

as a company's response to its environment and competitive conditions. This is constantly changing.

Assauri (2017), the marketing mix is the set of variables or activities that form the core of a marketing system and variables that a company can control to influence buyers or consumers in its target market. The marketing mix consists of everything a company can do to influence demand for its products. It consists of his 4P's of product, price, location and promotion (Putera et al., 2022). According to Rangkuti (2017), SWOT represents not only the external environment of opportunities and threats facing the business world, but also the internal environment of strengths and weaknesses.



**Figure 1.** SWOT Analysis (Rangkuti, 2017)

### Quadrant 1:

It's a win-win situation. Companies have the opportunity and strength to capitalize on existing opportunities. The strategy adopted by this state is to support aggressive growth policies.

### Quadrant 2:

Despite the various threats, the company has an inner strength. The strategy to pursue is to take advantage of long-term opportunities through diversification strategies (products/markets). Quadrant 3:

The market opportunity facing the company is enormous, but it also faces some internal limitations/weaknesses.

### Quadrant 4:

It is a very unfavorable situation and the company faces various internal threats and weaknesses.

The model used in this phase consists of a matrix of internal strategy factors and a matrix of external strategy factors.

#### a. Matrix of internal strategic factors

Before creating an internal factors matrix, we first need to know the internal strategy factors (IFAS). A table was then developed to formulate the internal strategy factors within the framework of firm strengths and weaknesses. The stages are:

- 1) In column 1, identify the factors that describe your company's strengths and weaknesses.
- 2) Weight each factor on a scale of 1.0 (most important) to 0.0 (less important) based on the impact of these factors on the company's strategic position. (All of these weights should not exceed 1.00 of the total score.)
- 3) Calculate a score (3rd column) for each factor using a scale of 4 (very good) to 1 (bad) based on the factor's impact on the state of the business in question. Positive variables (all variables in the strengths category) are rated from +1 to +4 (very good) compared to the industry average or leading competitors. The variable is negative, but vice versa. For example, if the company's weaknesses are significantly greater than the industry average, the score is 1, and if the company's weaknesses are below the industry average, the score is 4.

#### External Strategy Factor Matrix

Before creating the external strategy factor matrix. You need to know your External Strategy Factors (EFAS) in advance. There are the following methods of determining external strategic factors:

- 1) Sort by Column 1 (5-10 Opportunities and Risks)
- 2) Weight each factor in column 2 from 1.0 (very important) to 0.0 (not important). These factors can influence strategic factors.
- 3) Calculate a score (3rd column) for each factor using a scale of 4 (very

good) to 1 (bad) based on the impact of these factors on the situation of the company in question. Opportunity factors have a positive rating value (larger opportunities give a +4 higher rating, smaller opportunities give a + 1 higher rating). Specifying a threat rating value is the opposite. For example, if the threat value is very high, the rating is 1. Conversely, if the threat value is low, the rating is 4.

- 4) Multiply the column 2 weight by the column 3 rating to get the column 4 weighting factor. The results are weighted values for each factor ranging from 4.0 (excellent) to 1.0 (bad).
- 5) Use column 5 to provide any comments or notes on why a particular factor was chosen and how the weighted score was calculated.
- 6) Sum the weighted points (column 4) to get the total weighted points for the company in question. This aggregate score indicates how a particular company is responding to external strategic drivers. This overall score can be used to compare this company to other companies within the same industry group. Similarly, once the strategy manager has finished analyzing the internal strategic factors (strengths and weaknesses), they should also analyze the external strategic factors (opportunities and threats). See her EFAS table below for clarity. Therefore, before implementing any strategy, strategic planners must analyze the external environment to find various potential opportunities and threats. These issues may impact your business in the future, so you should identify strategic issues that need to be monitored. For this

reason, we strongly recommend using quantitative techniques such as extrapolation, brainstorming, statistical modeling, and operations her research to make predictions and assumptions.

### 3. Research methods

The variables in this study are marketing strategies including products, prices, promotions, and locations. The data source for this study is the subjects whose data were collected, how the data was obtained and how it was created. Primary data are special data that researchers create to solve the problem they are working on. A source of data collected directly by a researcher from a research subject. The data that can be extracted in this study are: Respondent's identity, such as name, age, and address. An overview of the analysis of marketing strategies to increase the sales volume of Lumpia Beuntung Leather Banjarmasin products. Secondary data sources for research data are literature, articles, journals, and the Internet related to the research conducted.

The number of people surveyed is his 25, which consists of Lumpia Beuntung Leather business owners and Lumpia Beuntung Leather employees, and he is also 25 in this survey sample. Data analysis in qualitative research is the process of organizing data sequences and organizing them into patterns, categories, and basic descriptions. The data analysis method used in this research is a descriptive method using SWOT analysis. The analytical technique used in this study is

SWOT. An analysis of the data from this study yields the following:

- 1) Conduct an analysis of the company's internal and external environment, which is the basis for conducting a SWOT analysis.
- 2) A SWOT analysis is performed using an EFAS (External Strategic Factor Analysis Summary) matrix describing the company's external factors (opportunities and threats) and an IFAS (Internal Strategic Factor Analysis Summary) matrix describing the largest will be Write pros and cons. . Company. A SWOT matrix is a tool for formulating alternative business strategies based on a company's strengths, weaknesses, opportunities and threats.

### 4. Research results and discussion

In the first phase, an investigation conducted by Lumpia Buntong, a leather shop in Banjarmasin, revealed the problems faced by Krit Lumpia Boontung Banjarmasin's shops. Soaring material prices, difficulty in obtaining materials, lack of manufacturing facilities, etc. The current strategy is to use only direct sales through Whattshap and a pre-order system, but the packaging is still simple for the product strategy offered by Kulit Lumpia Beuntung Banjarmasin. The Internal Factor Analysis Summary (IFAS) matrix of internal strategic factors for Lumpia Buntong Leather Banjarmasin business is presented in the table below.

**Table 2. Product IFAS table (Rangkuti, 2019)**

Internal Strategy Factors	Weight	Relatively	Rating	Score	Comment
Product Strength					
1. Already have their own brand and name	5.28	0.29	1.80	0.52	Must be easy to remember Should be done
2. Have a different packaging design from competitors	5.40	0.29	1.84	0.54	
Average amount of strength	10.68	0.58	3.64	1.06	
Product Weakness					
1. Not well-known brand	3.88	0.21	2.84	0.60	Need to fix
2. Packaging is still simple	3.80	0.21	2.60	0.54	Must be improved
Average Number of Weaknesses	7.68	0.42	5.44	1.14	
Total	18.36	1.00	9.08	2.20	

**Table 3. IFAS price table (Rangkuti, 2019)**

Internal Strategy Factors	Weight	Relatively	Rating	Score	Comment
Price Power					
1. Increase sales profit	5.04	0.28	1.80	0.50	Should be done
2. Increase customer	5.16	0.29	1.88	0.54	Should be done
Average Amount of Strength	10.2	0.57	3.68	1.04	
Price Disadvantage					
1. If the price of raw materials goes up, the selling price also goes up	4.12	0.23	2.76	0.63	Need to fix
2. Customers are reduced	3.72	0.21	2.92	0.60	Must be added
Average Number of Weaknesses	7.84	0.44	5.68	1.23	
Total	18.04	1.00	9.36	2.27	

**Table 4. Promotional IFAS table (Rangkuti, 2019)**

Internal Strategy Factors	Weight	Relatively	Rating	Score	Comment
Promotional Power					
1. Consumers buy products directly to the place of production	4.80	0.29	1.96	0.56	Need to fix
2. Promotion through social media (Whattshap, Instagram, and Facebook)	4.96	0.30	2.44	0.73	Should be done
Average amount of strength	9.76	0.59	4.40	1.29	

Promotion Weaknesses					
1. Don't have your own shop yet	3.20	0.19	2.60	0.50	Need to fix
2. Not maximal in promotion on social media	3.72	0.22	2.72	0.61	Must be improved
Average Number of Weaknesses	6.92	0.41	5.32	1.11	
Total	16.68	1.00	9.72	2.40	

**Table 5.** IFAS place table (Rangkuti, 2019)

Internal Strategy Factors	Weight	Relatively	Rating	Score	Comment
The Power of Place Have own production site	5.48	0.58	1.84	1.07	Upgrade again
Average amount of strength	5.48	0.58	1.84	1.07	
Weakness of Place The place of production is not strategic	3.96	0.42	3.00	1.26	Upgrade again
Average Number of Weaknesses	3.96	0.42	3.00	1.26	
Total	9.44	1.00	4.84	2.33	

As a result of the first phase research conducted by Lumpia Beuntung Leather Business of Banjarmasin, there is a problem that Kulit Lumpia Beuntung Business of Banjarmasin faces in running the business, namely lack of human resources, Die Consumer It became clear that the demand could not be met. Sufficiently filled, raw material prices are soaring and difficult to obtain, and production facilities are

inadequate. The current strategy is to use only direct sales through Whattshap and a pre-order system, but the packaging is still simple for the product strategy offered by Kulit Lumpia Beuntung Banjarmasin. The IFAS (Internal Factors Analysis Summary) matrix of the internal strategy factors of Banjarmasin Lumpia Beuntung leather business is presented in the table below.

**Table 6.** Product EFAAS table (Rangkuti, 2019)

External Strategy Factors	Weight	Relatively	Rating	Score	Comment
Product Opportunity					
1. Change the product name to make it easier to remember	4.04	0.24	2.12	0.51	Need to fix
2. Creating attractive product packaging	4.56	0.27	2.56	0.70	Should be done
Average number of opportunities	8.60	0.51	4.68	1.21	
Product Threat					
1. Compete with famous product brands	3.84	0.23	2.76	0.64	Be careful
2. Other products have more attractive packaging	4.20	0.25	2.96	0.75	Be careful
Average number of threats	8.04	0.48	5.72	1.39	
Total	16.64	1.00	10,4	2.60	

**Table 7.** Price EFAS table (Rangkuti, 2019)

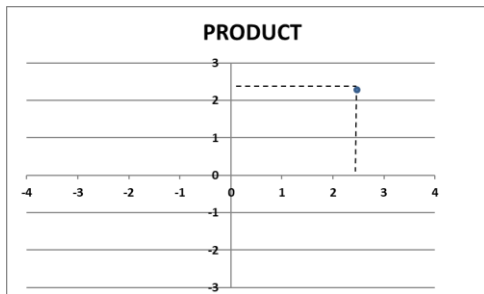
External Strategy Factors	Weight	Relatively	Rating	Score	Comment
Pricing Opportunity					
1. Selling products at affordable prices	5.00	0.27	2.24	0.62	Should be done
2. The market is still wide open					Should be done
	4.96	0.27	2.12	0.58	
Average number of opportunities	9.96	0.54	4.36	1.20	
Price Threat					
1. Competitors sell products at more affordable prices	4.16	0.23	2.64	0.62	Be careful
2. High level of competition					
	4.08	0.22	2.60	0.58	Be careful
Average number of threats	8.24	0.45	5.24	1.20	
Total	18.2	1.00	9.60	2.40	

**Table 8.** Promotion EFAS table (Rangkuti, 2019)

External Strategy Factors	Weight	Relatively	Rating	Score	Comment
Promotion Opportunity					
1. Open your own shop	4.72	0.26	2.44	0.62	Must be improved Must be improved
2. Adding a Marketplace account	4.84	0.26	2.16	0.57	
Average number of opportunities	9.56	0.52	4.60	1.19	
Promotion Threat					
1. Competitors have their own shops	4.44	0.24	2.52	0.61	Be careful
2. Other products already have social media and marketplace accounts	4.44	0.24	2.40	0.58	Be careful
Average number of threats	8.88	0.48	4.92	1.19	
Total	18.44	1.00	9.52	2.38	

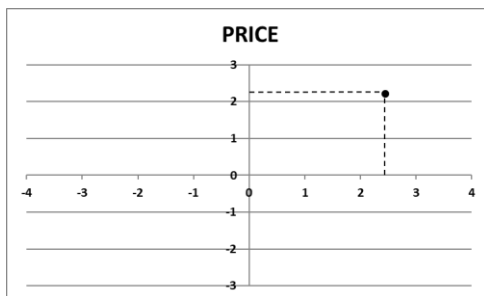
**Table 9.** EFAS place table (Rangkuti, 2019)

External Strategy Factors	Weight	Relatively	Rating	Score	Comment
Opportunity Place Open a branch	5.32	0.53	2.52	1.35	Should be done
Average number of opportunities	5.32	0.53	2.52	1.35	
Threat Place Competitors open branches in various places	4.64	0.47	3.04	1.42	Careful
Average number of threats	4.64	0.47	3.04	1.42	
Total	9.96	1.00	5.56	2.77	



**Figure 2.** Product SWOT

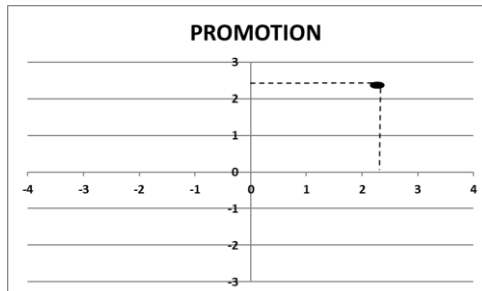
Using chart 4.1, it can be seen that the variable position of Lumpia Beuntung Leather Business Banjarmasin products lies between the Opportunity Axis and the Strengths Axis or Quadrant with an IFAS Total Score of 2.20 and an EFAS Total Score of 2.60 1 . So the product variable Kulit Lumpia Beuntung describes a very good situation. We encourage you to pursue progressive strategies by leveraging the company's internal strengths to seize external opportunities and drive business growth.



**Figure 3.** SWOT price

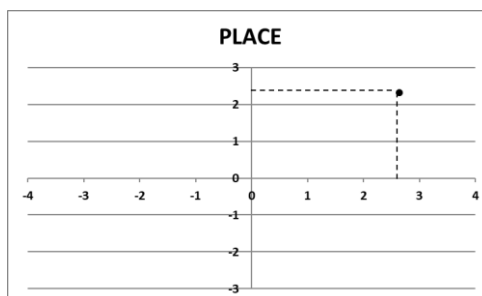
Using chart 4.2, we can see that the position of the price variable for Banjarmasin's Kulit Lumpia Beuntung business with an IFAS total score of 2.27 and an EFAS total score of 2.40 is between quadrant 1 of the opportunity axis and the strengths axis. Lumpia Consulting Business is a price variable and encourages adopting progressive strategies by leveraging the company's internal strengths to seize external opportunities and drive

business growth.



**Figure 4.** SWOT promotion

Using Chart 4.3, we can see that the position of the promotion variables for Kulit Lumpia Beuntung Business Banjarmasin lies between the Opportunity and Strengths axes with a total IFAS score of 2.40 and a total EFAS score of 2.38. That is quadrant 1. As Kulit Lumpia Beuntung business is subject to price fluctuations, it is recommended to pursue progressive strategies by leveraging the company's internal strengths to capitalize on external opportunities and drive business growth.



**Figure 5.** SWOT promotion

Referring to chart 4.4, we can see that the variable position of Lumpia Beuntung leather business in Banjarmasin with an IFAS total score of 2.33 and an EFAS total score of 2.77 lies between the opportunity axis and the strengths axis, quadrant 1. This means that Krit Lumpia Counseling is in a variable position to pursue progressive strategies by

leveraging the company's internal strengths to capitalize on external opportunities to drive business growth.

## 5. Conclusion

Based on the results of the analysis conducted at Banjarmasin's Kulit Lumpia Beuntung store, some conclusions were drawn:

- 1) As a result of SWOT analysis using IFAS (Internal Strategy Matrix Factor), product 2.20, price 2.27, behavior 2.40, location 2.33.
- 2) His SWOT analysis using EFAS (External Strategy Matrix Factor) shows Product 2.60, Price 2.40, Promotion 2.38, Location 2.77.
3. From the SWOT diagram for the variables Product, Price, Promotion and Place we can see that they have the same position in quadrant 1. That is, at the location between the Opportunity and Strength axes, the Sum Product IFAS Score is 2.20 and the Price is 2.27, promotion 2.40, rank 2.33, overall EFAS product rating 2.60, price 2.40, promotion 2.38, rank 2.77. Lumpia Beuntung Leather Business Banjarmasin describes a

very good situation for executing a progressive strategy by leveraging the company's internal strengths to capitalize on external opportunities and drive business growth . Here are some suggestions for managers of Lumpia Beuntung Leather Business in Banjarmasin:

- 1) One of the weaknesses of Banjarmasin's Kulit Lumpia Beuntung Business is that he doesn't have his own store and has only a three-day shelf life for his spring roll skin products. Longer and better packaging improvements.
- 2) Add Lumpia Beuntung Leather Business branches to new areas to meet consumer demand.
- 3) In order to make it easier for consumers to purchase spring roll wrappers, owners must provide home delivery services or be registered with GrabFood or GoFood retailers.
- 4) Maximize your promotion on social media such as Instagram, Facebook, WhatsApp, etc. to reach more people.

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## CUSTOMER SEGMENTATION AND PROFILING FOR E-COMMERCE USING DBSCAN AND FUZZY C-MEANS

**Abstract:** *The Rapid Industrialization has led to a sudden overwhelming boost in business. With growing advancements in technology and the fast-paced growth of users that have access to said technology everything reaches customers faster. Businesses have also tried their hand at being better at technology and thus boosted growth by appealing to a much larger customer base. Market segmentation is an increasingly important part of a strong marketing strategy and can make all the difference for companies in competitive market landscapes, such as e-commerce. To be in business today means much more than quality of the product and a brand name. It involves the right kind of marketing to the right kind of people. This project focuses on creating a tool to enable businesses to understand the various customers it has, by segmenting them into groups and providing a detailed statistical model for analysing where the marketing is needed the most and what would be the best offers the company can afford.*

**Keywords:** *Customer Segmentation, DBSCAN, Fuzzy C-Means, Clustering, RFM*

### 1. Introduction

All businesses want to grow, develop and build a community of loyal customers who improve your business by advertising, promoting and come more often. Such a community of loyal customers can't be found naturally. Targeting an entire mass of audience is not an effective marketing strategy instead First we need to understand the customers we are selling to and therefore be able to target them effectively which drives greater loyalty. Understanding the customers will allow you to prevent the negative experience, provoke positive emotions and lets you identify the most effective marketing ways. To achieve this customer segmentation comes into picture. Customer segmentation is mainly about who you target, where you

reach them and how you talk to them. This mainly helps to understand the target audience more clearly and create customisation to them accordingly. It is more effective to target your customer by aligning your tactics and strategies which helps you market and sell more effectively. This will lead to develop a better understanding of your customer's needs and desires more efficiently.

Customer segmentation is a way of splitting customers into groups based on their similar and shared characteristics. Some basic customer segmentation categories mainly include, geography, products or service purchased, how customers found you, device used by customers including device type / brand / browser, payment method, etc. Companies may collect customer information during purchase or checkouts by which even

more segmentation can be carried out by knowing the reason for purchase, what drove them to purchase, etc which will help you increase customer lifetime value. Most obviously well implemented segmentation will improve your marketing performance. We can perform customer segmentation by using any data available about them. Creating customer profiles or buyer persona helps you understand who you're current or ideal customers are. Based on the actual data they segment customers who act and think similarly. By grouping them to different categories, we can focus on them according to their needs and desires and approach them differently.

As of today the general segmentation seems to be too narrow and a bit old fashioned. The general segmentation will be too basic to understand your customers deeply. That's when the customer profiling takes the stage. Customer profiling is mainly about the customers' experience and a better way for its improvement. In this approach we use segmentation characteristics and perform segmentation accordingly but we also pay more attention to the customer's previous experience, pain points, plus points, opinions, etc. The main aim is to understand customers more effectively, offer a better experience, services or products.

Hence in this project we are collecting the data from various resources, transferring them into understandable format. We perform data preprocessing to remove all the null missing values to make it a clean data. The preprocessed data is fed into the RFM model to carry out the recency, frequency and monetary which will segment our valuable customers. After extracting the valuable customers clustering methods are applied and characteristics of each customer groups are segmented and analyzed to which we are using DBSCAN and Fuzzy C-Means algorithm. The proposed approach is designed in python and the performance of the proposed approach is evaluated in the UK

e-commerce dataset.

## 2. Methodology

All forms of data undergo 4 main stages in their life cycle. Data Collection followed by its preprocessing. Once said data is cleaned and essential data is grouped together, data is manipulated and is analysed to produce a statistical record and observations are made on the usefulness of data and how it can impact the growth or sales of a certain product. To simplify the complicated algorithms and observations, the user is presented with a visualised model including various kinds of graphs and an attractive User Interface that helps them be in control. The project follows a similar trajectory where we utilise various algorithms and combine the power of these into a single product that aims to provide the maximum coverage of segments that can help a business owner maximise his growth and minimise his churn rate.

The dataset we will be using is from a UK e-commerce website. The workflow of the project includes the following steps:

### 2.1. Preprocessing

Data that is available to us in the raw format is corrupted and unclean, that is, data is usually very inconsistent when stored in databases. Since databases focus on minimising the redundancy they might eliminate data that is useful to conduct a thorough analysis, and thus effect the efficiency of the work done. Applying data mining algorithms on this noisy data would not give quality results as they would fail to identify patterns effectively. Data Processing hence, is crucial for maintaining data quality. Data Preprocessing can be defined as the necessary steps that are taken to transform or encode data so that it may be easily parsed by the machine. This process plays a key role in

the final results of the project and is the starting point of all data. Hence we focus on removing the null values and rid the data of missing values and other inconsistencies and outliers to make it as clean as possible and ready for the next steps.

## 2.2. RFM analysis

The pre-processed data is now fed to the RFM system. RFM stands for ‘Recency, Frequency and Monetary’. In order to track this a quantitative analysis technique used rank and group customers based on the RFM approach for the net total of their recent transactions. Thus identifying the best customers and performing targeted marketing campaigns to these segmented groups. The system assigns each customer numerical scores based on these factors to provide an objective analysis. RFM analysis is based on a belief that a few customers (about 20 percent) make up the the maximum profits of your business (upto 80 percent). Explaining the three terms Recency, frequency and Monetary and what it means in business technology.

Predictive Segments (RFM)



Figure 1. Recency, frequency and Monetary terms

Recency defines how recent was the customer’s last purchase. It targets the mentality of the customers who recently made

purchases and are in the initial stages where the product and the company is still on their mind. These customers can be targeted to make similar purchases or suggested new things from the same brand. Recency is usually measured in days but depending on the depth of the analysis a more exhaustive or relaxed system can be designed, where they may measure it in years, weeks or even hours.

v

Frequency defines how often the said customer makes a purchase in a given time period. The logic being, customers who purchased once are often are more likely to purchase again. Additionally, targeting new customers or first timers for a follow-up advertising is universally exercised to convert them into more frequent customers.

Monetary stands for how much money a customer spends in a given period. Customers who spend a lot of money are more likely to spend money in the future and in turn be valuable assets to the business.

## 2.3. Customer Segmentation

The primal techniques of boosting trade and growing a business involve maintaining an excellent customer relationship. Communication is the bridge that is to be built to ensure a business reaches its customer base and the customers believe that they are being heard on a personal level. However, in case of big e-commerce websites, creating a space for a one-on-one connection with each and every customer is not feasible. This is where Customer Segmentation comes into effect. Segmentation according to Collica is a process to categorize or classify an item into a group that has a similarity in characteristic and in CRM (Customer Relationship Management) segmentation is used to classify customer based on some similarities

by segmenting the records of customer database.1

Clustering Algorithms can be applied for grouping these customer into broadly classified segments so that the target market is created. In this project, we apply clustering methodologies on the data that is retrieved from RFM models and characteristics of each customer group is analysed. The clustering mechanism commonly known as the DBSCAN clustering is applied with Fuzzy C-Means algorithms. A detailed description of these is mentioned further in the document.

Segmentation Model:

Segmentation is the process of dividing your customer base into smaller segments. Segmentation can be of various types and there are innumerable ways to segment your customers. Some of those include the infamous:

1) *Behavioural analysis :*

This tests the way a customer purchases and tracks out details of what chronology or factors affect the purchases made by the user.

2) *Demographic analysis :*

This is the most popular kind of segmentation done. It uses the demographic description of customers to categorize them into gender, or age based groups or segments and uses different approaches on said customer.

3) *Psychographic analysis:*

This categorizes a customer on the psyche or personality traits, It traces the beliefs and values and lifestyle of a customer and provides necessary recommendations. This type of segmentation is much more difficult as compared to others.

4) *Geographic analysis :*

This analysis categorizes customers into groups based on their geographical location on the map. If a business supplies world wide a much broader classification can be done. If it is internalized in cases of businesses limited to a particular country it is more detailed.

**2.4. Evaluation of the Model**

The simulation of the proposed model will be design using python programming language and with the help of the various libraries it provides to make visualizations easier in data mining and machine learning algorithms. The cluster performance can be measured by evaluating intra-cluster performance Silhouette Index and Calinski-Harabasz Index, Iterations, Time (in seconds). Various graphs and a statistical page is provided to the admin with administrator privileges that can be accessed only with a secret code.

**3. Customer segmentation**

Customer Segmentation is carried out using the below mentioned algorithms. There are 4 main parts to this and are explained in details below.

**3.1. DBSCAN Clustering Algorithms**

DBSCAN stands for Density-Based Spatial Clustering of Applications with Noise, which is a typical representation of density algorithms. The data points are divided into multiple distinct bunches or groups using the unsupervised learning technique or clustering analysis, such that the data points within the same group have similar properties and the data points within different groups have somewhat dissimilar attributes. The reason we prefer DBSCAN clustering over the various other clustering algorithms is because unlike K-means clustering algorithm, we need not specify the number of clusters in this

algorithm. It also produces a more reasonable result over a variety of different distributions. Density-Based Clustering concept that is responsible of forming a cluster in data space that is a contiguous region of high point point density, separated from other similar clusters by contiguous regions of low point density, in an unsupervised learning approach that result in unique groups/clusters in the data.<sup>2</sup>

Density-Based Spatial Clustering of Applications with Noise (DBSCAN) is a base algorithm for density-based clustering. It can discover clusters of different shapes and sizes from a large amount of data, which is containing noise and outliers. The DBSCAN algorithm uses two parameters: minPt: The minimum number of points (a threshold) clustered together for a region to be considered dense. eps (): A distance measure that will be used to locate the points in the neighborhood of any point. The above parameters are directly related to Density Reachability and Density Connectivity. Reachability in terms of density establishes a point to be reachable from another if it lies within a particular distance (eps) from it. Connectivity, on the other hand, involves a transitivity based chaining-approach to determine whether points are located in a particular cluster.

There are three types of points after the DBSCAN clustering is complete:

- Core — This is a point that has at least  $m$  points within distance  $n$  from itself.
- Border — This is a point that has at least one Core point at a distance  $n$ .
- Noise — This is a point that is neither a Core nor a Border. And it has less than  $m$  points within distance  $n$  from itself.

The algorithm steps are as follows:

- First, we input the minimum radius along with the minimum density threshold minPt.

- The data is then sequentially read into a text file and the results are plotted along a X and Y co=ordinates that hold the Point Structure.
- The final step involves determining if the point is a core point. We first read a point (data from the dataset) and analyse if the point is marked or not. If it is marked, which means it is part of a cluster, the distance between this point and all its immediate neighbours or the Density Connectivity is found. Based on how close the value is to that of the radius . The clusters are then created and a merged result list is generated.
- Fuzzy Clustering
- Fuzzy c-means (FCM) is a data clustering technique in which a data set is grouped into  $N$  clusters with every data point in the dataset belonging to every cluster to a certain degree. For example, a data point that lies close to the center of a cluster will have a high degree of membership in that cluster, and another data point that lies far away from the center of a cluster will have a low degree of membership to that cluster.<sup>4n</sup>
- It starts with a random initial guess for the cluster centers; that is the mean location of each cluster. Next, fcm assigns every data point a random membership grade for each cluster. By iteratively updating the cluster centers and the membership grades for each data point, fcm moves the cluster centers to the correct location within a data set and, for each data point, finds the degree of membership in each cluster. This iteration minimizes an objective function that represents the distance from any given data point to

a cluster center weighted by the membership of that data point in the cluster.

- Each cluster is defined as the largest set of dense connected points, and each point in a cluster has a minimum number of neighbors of MinPts or greater in a given radius Eps. The time complexity of DBSCAN is  $O(n \cdot \log n)$  [5].

#### 4. Result and future scope

##### 4.1. Results

The primary results of the project include various graphs and analytics that are represented on a website to the administrator with only admin privileges. In this paper DBSCAN algorithm identifies objects based on bivalent logic. The existing techniques have not focused on the hybridization of DBSCAN with fuzzy if then rules. DBSCAN will be combined with fuzzy if then rules. The hybridization will allow DBSCAN to decide the cluster in more efficient manner. The simulation of the proposed approach will be designed in python. The cluster performance can be measured by evaluating intra-cluster performance Silhouette Index and Calinski-Harabasz Index, Iterations, Time Taken (in seconds).

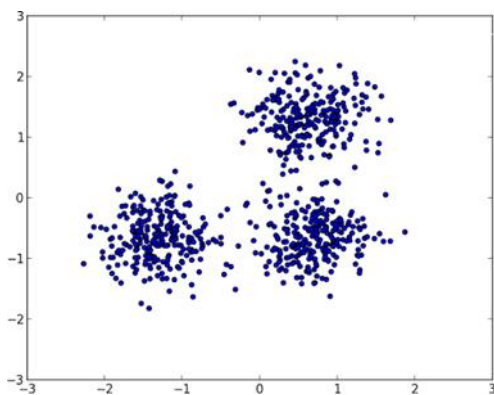


Figure 2. DBSCAN Clustering results

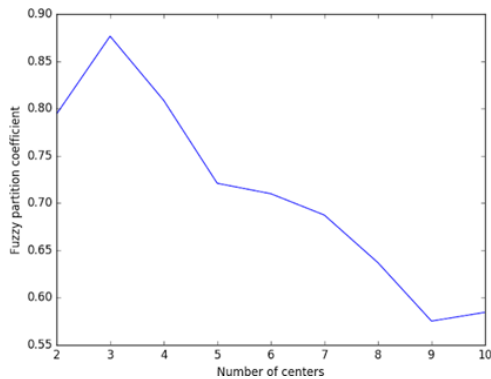


Figure 3. DBSCAN Fuzzy partition coefficient

In this paper, we have tried to implement a model that will perform clustering techniques apart from the existing clustering algorithms. We also perform a comparison check against the accuracy score of all the conventional algorithms mentioned above with the accuracy score of the model that we have developed. This enables the users to understand the credibility of our enhanced model.

##### 4.2. Future Scope

The future Scope involves creating a comprehensive system to enable these companies or E-commerces to directly send targetted customers periodic advertisements and be a more evolved system to not only display the data in a static web application. However, the results obtained from our model are purely visualizations which will visualize the consumers of an e-commerce into clusters according to the information provided in the dataset. The future improvements would be to generate insightful information from the already available visualizations. This would help generate reports which could be useful for further stages.



## 5. Conclusion

Customer segregation is a way to improve customer communication, customer awareness, customer service to build effective communication. Customer segregation is required for use by businesses to maximize profits. Potential customer data can be used to provide the customer with features that include e-commerce services such as online media buying and selling. Knowing the customer base is crucial to any business. The segments result in a better understanding of where the company isn't meeting the customer demands or needs and these observations will help reduce the churn rate of the customers. This paper discusses a few aspects of performing customer segregation, namely:

- Customer segregation is the task of separating customers or an object into groups with similar characteristics.
- Data needed to differentiate between internal and external data sources

and consumers. External data comprises cookies and server logs, whereas internal data contains statistical data and data purchase history. External data can be obtained through a web server or other source, whereas internal data can be accessible on a website where a client registers or transacts.

- Customer Separation Methods can be categorized into simple method, RFM method, targeted method, and unchecked method. In Targets, the researcher focuses on one exception, either product or purchase. An unsupervised method was used when the integration process researcher had many variables
- The Customer Classification process could be simplified to describe business purpose, data collection, data preparation, dynamic analysis, data processing, and performance evaluation.

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## USAGE E-WALLETS OR DIGITAL WALLET AS TOOL TRANSACTION REPLACEMENT MONEY CASH FOR UMKM PATNAM COFFEE SHOP BANJARMASIN

**Abstract:** *This study done and for know use Electronic Wallet (E-Wallet) or Digital Wallet as tool transaction replacement money cash for Micro, Small, and Medium Enterprises (UMKM) Patnam Coffee Shop in Banjarmasin. This study characteristic descriptive with technique and type of qualitative data. Data is processed with technique analysis. Results and discussion that is that UMKM Patnam Coffee Shop push development digital wallet in Banjarmasin. This study prove that digital wallet as tool transaction non-cash payments for Small and Medium Enterprises help they for apply system cashless.*

**Keywords:** *E-Wallet, MSMEs, qualitative, digital, cashless*

### 1. Introduction

Increasing technology develop mature this create breakthrough increasingly new make it easy society. Life interaction social daily, selling buy, service and finance using non-cash or digital based. Transaction this normal called Financial Technology (Fintech). According to Bank Indonesia (2019) Fintechis results combined service finance with technology is changing business models cash be cashless as well as change system transaction payment in society. One of them is the moment this currently loved is digital wallet or e-wallets. Digital wallet or e-wallet that comes in the middle public moment This very make it easy various transaction and selling process buy. The conveniences offered by digital wallet this is the end make technology and this very in demand in society (Fadilurrahman et al., 2021). Especially for those who like something practical, because with community digital wallet only need prepare sufficient balance. For transact with wallet digital and scan Quick Response/QR code then the

transaction process is complete, without need to bother removing wallet or wait change if money paid more big of the required nominal paid (Putera et al., 2022).

Current society and this already start move to digital wallet or e-wallets push efforts like SMEs for follow development in the middle society. Has many SMEs are on finally apply payment through digital wallet or e-wallet to use fulfil need consumers (Norrahi et al., 2021).

One of the current SMEs This Enough proliferated in society is Coffee Shop. Coffee Shop moment and this become wrong one choice child young for relax together friends, even do task or finish job. Food and delicious drink as well as impressed atmosphere calm and relax make many coffee shops in demand by child young with promotion (Habibah et al., 2021). Height enthusiasts among child young make Coffee Shop moment. These apply payment with digital wallet or e-wallets (cashless).

Based on exposure about digital wallet and MSMEs above so writer interested For make

work write with title “Usage E-Wallets or Digital Wallet as Tool Transaction Replacement Money Cash for UMKM Patnam Coffee Shop Banjarmasin”.

## **2. Formulation of the Problem**

- 1) How application digital wallet or e-wallet on Patnam Banjarmasin Coffee Shop?
- 2) How digital wallet helps Banjarmasin Patnam Coffee Shop in management finance the business?

## **3. Research Methods**

Method research used and the type of data collected that is technique qualitative. Studies descriptive is methodology study in objective study This because data and the analysis refer on method qualitative. According to Sugiyono (2018), method study qualitative is method based research on philosophy, which is used for researching on condition scientific (experimental) where researcher as instrument.

## **4. Discussion**

### **4.1. Digital Wallet**

In regulation (Bank Indonesia, 2016) number 18/40/PBI/2016 Article 1 Paragraph 7 concerning maintenance processing transaction payment explain that wallet the next electronic wallet called wallet electronic is service electronic For store instrument data payment these include: tools payment with use card and/or money electronic, which can also accommodate funds, for do payment.

#### ***Use E-Wallets or Digital Wallet on Patnam Banjarmasin Coffee Shop***

Patnam Coffee Shop is an established MSMEs since beginning 2022 that sells And offer various type special coffee drink

concoction they alone. This MSME still counted in scale small And Still have staff limitations. This coffee shop own quite place and no too big and also closes with schools and offices until tour area. These coffee shops suitable for all circles from young until adults want enjoy while relax in place or with takeaway. The visitors or buyer usually offered by 2 systems payment, yes do payment through cash or with Quick Response Code Indonesia Standard/QRIS (digital wallet).

Development digital wallet too develops since 2017, here means development grows rapidly in the Banjarmasin area during a number of year last. Superiority digital wallet felt practical by SMEs and usually ease buyer or consumer in do transaction payment. Although sometimes Still there is error constraints, hard signal, and disturbance system no too hinder in its application at the Patnam Coffee Shop, Banjarmasin.

### **4.2. Management Finance on Patnam Banjarmasin Coffee Shop**

Business growing coffee shop Lots caused by increasing interest public in start coffee business, because treat coffee drink can enjoyed together friend nor family. So that for business people want start it need For do bookkeeping or management good finances. Sale coffee shop for SMEs such as Patnam Coffee Shop. This no require too much capital big and also have lots profit, the price offered to buyers also vary and affordable. So that owner shop or manager can apply management appropriate finances and practical. Bookkeeping for business this coffee shop easy in its application with make notes shopping, sales daily, inventory & stock item, budget current cash until bookkeeping profit loss. After do recording the owner shop can know is currently in condition profit or loss. Besides it, also made report neat finances and easy for understand for convenience in reporting and the analysis.

## 5. Conclusion

Conclusion in this paper journal is use digital wallet or e-wallets as tool transaction replacement Money on Patnam Coffee Shop Already applied with okay. Although sometimes happen disturbance system on system payment, the easy too overcome for them. Besides that, the use of QRIS or this

digital wallet make it easy owner shop for do transaction payment, because no need accept money decent cash lots as well as make it easy for buyer for apply system cashless. Secondly, management finance in SMEs Patnam Coffee Shop already reasonable good with do recording bookkeeping, making report finance until profit make a loss and cash flow his so that make it easy the owner for analyze management finance on shop.

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## HOW TO MAINTAIN A QUALITY ENVIRONMENT IN HOSPITALS

**Abstract:** *The study examined the impact of an intervention program based on cognitive-behavioral principles on improving monitoring, regulating, and self-management skills, as well as the impact on the emotional and social climate of the classroom and on student feelings and functioning. It was conducted over one year with 30 fourth grade students in an elementary school and included the purchase, establishment, and implementation of an intervention program, as well as monitoring and follow-up through interviews, questionnaires, and participant observation. The results of the study demonstrate the success of an intervention program, which includes behavioral components as well as cognitive components, on the social and emotional climate while reducing violence and increasing students' well-being, sense of protection, belonging, and classroom skills.*

**Keywords:** : *behavioral problem, behavioral disorder, classroom climate, quality of life, cognitive behavioral theory, elementary school*

### 1. Introduction

Behavioral problems and disorders are terms that combine problematic or disruptive behavior, defiant, oppositional behavior, and antisocial disorder among them. Disorder refers to the violation of social rules and negative actions toward others such as aggressiveness, lying, and stealing (Fossum et al., 2008). Evidence gathered in studies over the years indicates that a high percentage of elementary school children are at high risk of developing a conduct problem during their school years (Duchnowski, Kutash, & Friedman, 2002; Rubin & Balow, 1978). According to Loeber, Burke, & Pardini (2009) behavior problems among students in the classroom can arise for a variety of reasons. Some are related to environmental factors, others to factors related to the individual. They can be influenced by developmental background, various types of

learning disabilities, emotional state, difficulty driving, sense of competence, sense of belonging, educational challenges, mismatch of learning with the student's aptitudes, and other external and internal factors (Wells et al., 2019).

Conduct disorder in childhood can be an early sign of the development of conduct disorder in adolescence and adulthood (Liber et al., 2013). It can be associated with negative long-term outcomes, difficulties in child-parent interactions, early school dropout, vandalism, and lying (Loeber, Burke, & Pardini, 2009) and can negatively affect the child's development.

The effects of conduct disorder on the child may be manifested in impaired social status, expression of personal identity, self-image, sense of ability and belonging, shaping of interactions with peers and teachers, adjustment to the school environment, and success in developmental tasks of the age

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level. Behavioral disorders can interfere with adjustment and lead to social and behavioral deficits (Smith et al. 2014), challenges, and delays in various areas of functioning. They can act like a vicious cycle and, in the absence of remedies, lead to developmental withdrawal and a steady increase in negative behaviors. A situation that increases the likelihood of school dropout and at-risk situations (Danielson et al., 2018).

Erickson sees school as a significant and crucial factor in this stage of development, as it is able to identify and diagnose deficits in cognitive and academic skills. It is also a source of discipline, requiring the mobilization of "self-control" that help develop the ability to restrain and postpone rewards, as well as organizing children into a group, changing egocentric patterns, and teaching reciprocity as a value and behavior. In addition, the school setting separates the child from the home during activity periods and challenges the child to engage with new authority figures (ibid.).

Behavior problems in the classroom present numerous and varied challenges to the educational system. Their effects are felt directly and indirectly, manifesting in both academic and emotional-social domains, classroom climate, and students' sense of safety and belonging (Mooney et al., 2005).

Cognitive-behavioral intervention is based on an approach that incorporates cognitive and behavioral components and aims to effect change in student behavior. It utilizes basic cognitive processes that are responsible for successful problem-solving processes (Smith & Daunic, 2006; Smith et al., 2012). Studies have shown that this type of intervention is able to improve self-monitoring mechanisms and thus social problem-solving skills in a variety of situations and structures. Therefore, this type of intervention helps to reduce the risk of developing behavioral problems (Daunic et al., 2006, 2012; Smith, Graber & Daunic, 2009). Several studies have found that programs of this type can be

beneficial and help with both treatment and prevention of conduct problems (Sukhodolsky, Kassinove & Groman, 2004; Waschbusch, Pelham & Massetti, 2005).

Studies of various types of school-based intervention programs have shown a small but positive effect on aggressive behavior and conduct disorders. The positive effects have also been found to be long lasting (Dymnicki, Weissberg & Henry, 2011; Wilson & Lipsey, 2007). In a study examining the effects of school-based intervention programs on student behavior problems, it was found that two types of prevention efforts were implemented within the school over the years: a classroom intervention program and a targeted individual intervention program. The latter were significant and contributed to reductions in behavioral problems. School-based interventions using the cognitive behavioral approach have been found to produce positive results in both the short and long term (Mytton et al., 2006). It was also found that interventions that focused on a specific goal showed more significant results than general school-based intervention programs (Liber et al., 2013).

The complexity of addressing behavioral disorders, their negative effects, and the importance of effective and adaptive developmental outcomes underscore the importance of studying and developing tools and responses to this complex issue.

## **2. Behavior problems in the classroom**

Externalizing behavior problems and disorders manifest in the violation of social rules and negative actions toward others (Fossum et al., 2008).

Violence is an extroverted behavior characterized by the exertion of an unpleasant stimulus, physical or verbal, toward the other (Buss, 1961; Kazdin et al., 1987). The discussion of the phenomenon of violence is



divided into two general categories: Conduct disorder, which is a disruption of social, academic, and occupational functioning and, in an adolescent who has not reached the age of 18, is characterized by patterns that have been repeated for at least 12 months and includes behaviors that are a violation of rights or norms and involve threats, fighting, cruelty, the use of weapons, theft, or forced sexual acts. (Moore et al., 2011). Oppositional Defiant Disorder is characterized by negative patterns of behavior that have been repeated for at least six months and include at least four of the following behaviors: Loss of control, persistent arguing, and lack of cooperation, bullying, accusations, anger and hostility, obsessive preoccupation with the other's behavior (APA, 1994, DSM IV). The first category emphasizes intense engagement in violating rights, norms, and laws (ibid.) and is considered more difficult (Moore et al., 2011). However, untreated oppositional behavior can develop into a conduct disorder (Scotti, Mullen & Hawkins, 1998). It is important to note that a child who struggles with a violent problem usually suffers from disorders associated with the conduct disorder, such as attention and concentration problems, hyperactivity, impulsivity, and social problems. (Moore et al., 2011).

Eliram (1982) distinguishes three types of violent behavior in children: reactive violence, which does not necessarily result from a violent personality, but from activating events that cause the child to act violently. Instrumental violence, which helps the child meet his needs when he is unable to achieve his goal in an acceptable and moderate manner; and violence for its own sake, which arises from severe emotional problems that are sometimes a consequence of his environment. Gendreau & Archer (2005) made a later subdivision, distinguishing between violence that leads to physical harm and violence that leads to psychological harm. This type of division

focuses on the secret motives that cause violence, the motivation for violent action, and the degree of harm to the other (Gendreau & Archer, 2005 in Moore et al., 2011). This division led to examining violence not only in terms of the dimensions of harm inflicted on others, but also at the level of the factors that underlie it. Ronen, Rahav & Moldawsky (2007) identified three distinct profiles of children: the aggressor who engages in violent behavior toward the other on their own initiative, the aggressed who is a victim of violence, and the neutral who is not involved in instances of violence. In the literature based on frustration-anxiety theory (Vitaro & Brendgen, 2005 in Moore et al., 2011), violence is divided into reactive and proactive violence. Reactive violence occurs in response to violence that causes anger and frustration and aims to reduce the level of anger and frustration by hitting the perpetrator. This type of violence has a more positive prognosis than initiated violence (Ibid.).

Initiated violence depends on a relationship that exists between two independent behaviors. Through past experiences, the individual has learned that a violent response helps him or her achieve various goals, and thus it is activated whenever the child wants to achieve his or her goals (Crick & Dodge, 1996; Hubbard et al., 2001; Vitaro & Brendgen, 2005). Other subdivisions refer to the differences between the behaviors that characterize violence, distinguishing between direct violence and indirect violence, and between verbal violence and physical violence (Bjoerkqvist et al., 2001; Yudofsky et al., 1986; Ronen et al., 2007).

### **3. Patterns of victimization during the elementary school years**

Victimization is a common stressor in school-aged children and can affect the child's future development (Giesbrecht et al., 2011). Children who suffer from persistent bullying

and an unprotected social-emotional climate (Rudnicka et al., 2020) are at increased risk of developing psychological and behavioral adjustment problems such as loneliness, low self-esteem, anxiety, depression, externalizing problems, and school dropout (Hanish & Guerra, 2002; Kochenderfer-Ladd & Skinner, 2002; Leadbeater & Hoglund, 2009). Violent behavior is detrimental not only to the violent child's environment, but also to the development and functioning of the violent child, who is at risk of social rejection, dropping out of school, and developing criminal patterns (Loeber & Farrington, 2000; McGinnis & Goldstein, 1997; Pope & Bierman, 1999).

A relationship has been found between an early victimization experience during the elementary school years and the continuation of the pattern of bullying victimization in later years (Kochenderfer-Ladd & Wardrop, 2001; Schwartz, Proctor & Chien, 2001). The early years of elementary school are a significant and important time to observe the child's developmental process and understand why certain children are victimized and others are not, and how the change in victimization patterns is related to their behavior and its context over time (Giesbrecht et al., 2011). In addition, the early years of elementary school are of great importance for social, emotional, cognitive, and personal development. Intervention programs can have a positive impact on reducing peer victimization before it takes root (Ladd, 1996; Olweus, 1994).

Research today seeks to understand the components of personality development, focusing on the emotional and cognitive factors that predispose a child to violent behavior (Tremblay et al., 2005). Several studies have shown that the social biological basis of certain children influences the way they interpret their behavior, the behavior of others, and the extent of their influence on a given situation, exposing them to risk and dangerous situations early in life (Anderson

& Bushman, 2002; Dodge & Pettit, 2003). The child's information processing model in these situations influences the interpretation they give to the social situations around them, tends to attribute negative intentions and hostility to them, and influences the development of violent behavior (Crick & Dodge, 1996). Examining the individual versus the effects of the environment in relation to violent behavior assumes that an individual has an innate personality tendency toward violence that may predict violent behavior later in life (Brendgen et al., 2006). Therefore, individuals must acquire tools and skills to help them control their tendency (Moore et al., 2011). A somewhat more moderate approach also asserts that there is an innate tendency toward violence. At the same time, it believes that after age six, environmental influences and cognitive abilities determine the developmental trajectory (Rhee & Waldman, 2002). Another study considers violence as a tendency rather than a personality trait or hidden instinct. According to this study, the social environment, skills, and tools acquired by the child during his integration into that environment determine whether his violent traits will be reinforced and influence his behavior and social affiliation (Nagin & Tremblay, 2005). Another model to explain violent behavior assumes that this behavior contains behavioral, emotional, and cognitive components that are interconnected. According to this model, the anger people feel mediates between their hostile thoughts and their violent behavior. The behavioral component is expressed physically in physical violence and verbally in violent verbal behavior. The emotional component is expressed in anger in response to a particular stimulus and the cognitive component is expressed primarily in thoughts that manifest in negative thinking, a negative attitude, and a negative perception in relation to people and situations (Buss, 1961, Buss & Perry, 1992).

As the child progresses through the

developmental stages of acquiring complex cognitive skills, patterns of violence decrease. It is likely that there is a relationship between these two processes (Seguin & Zelazo, 2005). Cognitive skills are related to mechanisms of self-control, information processing, and emotion control. These mechanisms enable individuals to control and regulate their behavior and moderate the relationship between sensitivity and aggression (Apple, 2007; Weisbrod, 2007). Violence control and behavior regulation become possible for a child when he or she acquires tools and skills that enable him or her to behave socially.

The development of self-control skills enables the child to activate mechanisms of observation, monitoring, and self-reinforcement, to use accepted social models, and to control his or her behavior (Moore et al., 2011).

The presence of behavior problems in the classroom poses a significant challenge to the educational system, affects the emotional and social climate, academic achievement, and students' sense of safety and belonging in the classroom (Mooney et al., 2005).

The complexity of dealing with behavior problems, their negative effects, and the importance of effective and adaptive developmental outcomes underscore the importance of studying and developing tools and methods

#### **4. Body of the paper**

Cognitive-behavioral intervention relies on an approach that incorporates cognitive and behavioral components to change student behavior through its influence on basic cognitive processes responsible for successful problem-solving processes (Smith & Daunic, 2006; Smith et al., 2012). Studies have shown that this type of intervention is able to improve self-monitoring mechanisms and thus social problem-solving skills in a variety of situations and structures. Therefore, this

type of intervention helps reduce the risk of developing behavior problems (Daunic et al., 2006, 2012; Smith, Graber & Daunic, 2009), contributes to positive social functioning, and promotes a visible and/or hidden impact on individual development (Kazdin et al., 1992; Lochman & Wells, 2004). Several studies have found that programs of this type can be beneficial and help in the treatment and prevention of behavioral disorders (Ukhodolsky et al., 2004; Waschbusch et al., 2005). Studies of school-based intervention programs have shown a small but positive impact on aggressive behavior and conduct disorders. The positive effects have also been found to be long lasting (Dymnicki et al., 2011; Wilson & Lipsey, 2007). In a study examining the impact of these programs on student behavior problems, it was found that two types of prevention interventions were implemented in schools over the years: a classroom intervention program and a targeted individual intervention program. The latter were significant and contributed to the reduction of behavior problems. School-based interventions using the cognitive-behavioral approach have been shown to produce positive results in both the short and long term (Mytton et al., 2006). Interventions that focus on a specific goal have also been found to show more significant results than general school-based intervention programs (Liber et al., 2013).

The complexity of dealing with behavioral disorders, their negative effects, and the importance of effective and adaptive developmental outcomes underscore the importance of studying and developing tools and responses to this complex issue.

The first wave of behavior therapy was, in part, a revolution of sorts against existing clinical concepts and their scientific weakness (Hayse, 2004). This wave involved the application of learning principles to develop an established method aimed at changing overt behavior (Hayse & Hoffman, 2017) by focusing on learning theories based

on stimulus-response and classical and operant conditioning (David & Hofmann, 2013). Behavioral therapy interventions focused directly on behaviors and feelings that were perceived as problematic and aimed to achieve adaptive behaviors (Hayse, 2004). In the late 1960s, the second wave began to develop after neo-behaviorists realized that stimulus-response theory was unable to provide an adequate empirical analysis of language and cognition. They began to adopt more flexible principles for learning based on the metaphor of a computational mechanism. The failure of the behaviorist streams to provide insights into cognition and human language led to a second wave that used the seeds sown by Bandura (1969) for a cognitive approach to behavior change. This soon evolved into the cognitive therapy movement (Beck et al., 1979; Mahoney, 1974; Meichenbaum, 1977). Skinner's (1974, via behaviorism) radical understanding that objectivity can occur in the analysis of private events and scientific subjectivity can occur in the analysis of observed public events led to changes in perception. His analysis of language and cognition led him to conclude that scientifically valid exploration of emotions and thoughts was possible but not necessary to visibly understand behavior. This conclusion led behavioral therapists to recognize that they needed to address thoughts and feelings more centrally and directly (Hayes, 2004). Early proponents of the cognitive-behavioral stream treated cognition from a direct and clinically relevant perspective. Researchers in this stream identified specific cognitive errors and their prevalence in therapeutic groups. Studies began to address the identification of these errors and methods to correct them. Some of the central tenets of the first wave of behavior therapy were adopted by the second wave, including an emphasis on changing the content of thoughts or behaviors, their form or frequency, the so-called "first-order change" (Hayes 2004).

Behavior therapy expanded, behavioral principles became much less emphasized and cognitive principles much more emphasized, and so the first wave was largely assimilated into the second wave. Behavioral therapy methods and conditioning models were replaced by cognitive change methods and models that focused on cognitive variables. The emergence of constructivism and similar postmodern theories weakened the notion that scientific theories identify discrete parts of reality that can be organized into a comprehensive model (Hayes et al., 1993). This shift in the philosophy of science gradually weakened the assumptions that underpinned the first and second waves of behavior therapy and cognitive therapy and their underlying theories in favor of integrated tools and approaches that emphasize the broader context (Moore, 2000). The classic "cognitive-behavioral" model was developed in recognition of the interrelationships between cognition and behavior, as well as the emotional state and general functioning of the organism, and assumes a connection between the way individuals perceive events in their lives and their feelings, physiological responses, and behavior. According to this concept, a person's feelings and behavior are influenced by the interpretation he or she gives to the events in his or her life, rather than by the events themselves (Beck, 1964; Ellis, 1962). Cognitive-behavioral intervention methods use strategies aimed at bringing about change in thinking, feelings, and behavior (Kendall, 2012). Their foundation is the individual's belief system, behavioral strategies, and the person's understanding of the beliefs and behaviors that characterize them (Alford & Beck, 1997). A cognitive-behavioral intervention program addresses the acquisition and establishment of a cognitive change in the thinking and belief system to bring about stable emotional and behavioral change (Beck, 2014). The model represents a combination of cognitive strategies based on

reflexive and metacognitive skills, behavioral strategies, emotion-focused strategies, and social strategies to build a cognitive infrastructure that leads to effective behavior (Kendall, 1993).

Cognitive behavioral Intervention with children focuses on the acquisition, practice, and assimilation of cognitive strategies that help the child cope effectively with events and solve problems. The child acquires cognitive strategies through experience, observation of experience, and interaction with the environment (Ingram, Miranda & Segal, 1998). The differences between creating an intervention plan for children and implementing it with adults arise mainly from the significant involvement of environmental factors in shaping the way the child interprets and responds to various situations, as well as the fact that children usually come to the intervention at the initiative of their environment, often without being aware of the problem that requires it (details in Moore et al., 2011). One of the main issues in child care is the issue of cognitive processing and the distinction between "cognitive impairment" and "cognitive distortion." Processing impairment is caused by a lack of attention to information and a lack of foresight that affects behavior and its outcomes. Cognitive distortion means a disturbance in the thinking processes (Kendall, 2015). The terms impairment and distortion both refer to a disturbance in cognition (Kendall, 2000). According to Spivack & Shure (1982), deficits in processing interpersonal situations are etiological in nature. Barkley (Barkley, 1997) refers to impulsivity as a consequence of mediation deficits (Kendall, 2015). According to him, impulsive behavior results from cognitive impairment manifested by an inability to let thought precede action, as opposed to cognitive bias indicating active but distorted processing (ibid.).

Studies have shown that by applying cognitive-behavioral principles, self-

monitoring processes and problem-solving strategies can be accomplished. These processes lead to the improvement of self-management and self-regulation skills (Daunic et al., 2006; Daunic et al., 2012; Smith, Graber, & Daunic, 2009).

Self-management is a general term that refers to a variety of components used to outline an internal locus of control (Chafouleas et al., 2011). Self-management is expressed in the influence a person has on events and situations around them and their outcomes (Barlow, & Chorpita 1998) and includes actions on reality (Ajares, 2007a). Self-regulation is an active process of self-management (Pintrich, 2000).

According to Baumeister & Heatherton (1996) and Carver & Scheier (1981), self-regulation includes three main components: setting standards for thoughts, feelings, or behaviors that individuals commit to and self-monitor in order to achieve them; motivation to make an effort to reduce the discrepancy between norms and actual behavior; the ability to achieve goals despite failures and temptations along the way.

The self-regulatory system is at the heart of any daily process. Its components mediate the influence of the external environment on the individual and provide him or her with the basis for goal-directed action. (Bandura, 1991).

Consistent, reliable, and frequent self-observation leads the individual to success in self-regulation (Bandura, 1991). The use of self-observation can enable individuals to evaluate the relationship between thoughts, behaviors, physiological sensations, and emotions and their consequences (Moore et al., 2011).

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Consistent, reliable, and frequent self-observation leads the individual to success in self-regulation (Bandura, 1991). Through self-observation, individuals can evaluate the relationship between thoughts, behaviors, physiological sensations, and emotions and their consequences (Moore et al., 2011).

The child's self-regulation skills can influence his or her adjustment to the school environment in which he or she must function independently without dependence on the presence of his or her primary caregivers (Sawyer et al., 2015).

The experiences the child has in his or her first years of school can have long-term effects on his or her behavior, mental health, relationships with children and teachers, and sense of belonging and attachment to school (Belsky & MacKinnon, 1994; Entwisle & Alexander, 1989; Finn, 1989; Hamre & Pianta, 2001; Ladd & Dinella, 2009; Luster & McAdoo, 1996). Studies indicate a negative relationship between the child's level of self-regulation and behavior problems (Belsky et al., 2007; Eisenberg et al., 2010; Hill et al., 2006; Kochanska & Knaack, 2003; Murray & Kochanska, 2002; Olson et al., 2005; Riggs et al., 2004).

Self-management strategies have been shown to be effective for both the individual and the class as a group for adjustment and success (Glynn & Thomas, 1974).

The development and building of self-monitoring skills and abilities allow the child to activate mechanisms of observation, monitoring, and self-reinforcement. By activating the acquired mechanisms, the child is able to self-regulate and conform to accepted social models while controlling his or her behavior (Moore et al., 2011).

## **5. Quality of life**

The concept of quality of life refers to the degree of well-being and happiness of the individual. It is defined by the WHO (1996)

as an individual's perspective on his or her life in the context in which he or she lives and in relation to the goals, expectations, values, and standards he or she sets for himself or herself. In childhood, quality of life is defined as subjective perceptions of well-being and happiness (Davis et al., 2008)

Almost all definitions of quality of life refer to physical, social, cognitive, and psychological dimensions (Hutting et al., 2022). Quality of life is influenced by both close indicators, such as family and friends, and more general indicators, such as socioeconomic status and culture (ibid). Physical or emotional-mental disabilities have been found to have the greatest impact on quality of life (Kourkouta et al., 2021).

Lack of support, protection, emotional and behavioral difficulties, and lack of infrastructure to realize potential are considered factors that significantly affect quality of life (Wallander, 2015). The child is considered an individual with equal rights and a future citizen who has influence in shaping society, and therefore there is concern for his or her quality of life (Ben-Arieh et al., 2014). The quality of life is considered his natural right and is considered an important factor in his development and future prognosis (Ben-Arieh & Frønes, 2011).. According to the World Health Organization, mental health and emotional well-being are factors that affect the quality of life of the student and his ability to achieve his developmental goals in school (Rudnicka et al., 2020).

At school age, the child is at a developmental stage where he or she is confronted with the demands of learning together in society, following rules and routines, and participating in a group. Achievement, a sense of competence, and the ability to control become essential to the self-image the child builds (Tiano, 2010).

School provides developmental opportunities for the child, but it can also present challenges that can interfere with normal development.

Classroom climate has an impact on student achievement in the classroom.

In the study of Hachoen & Ronen (2011) school climate is defined as the quality of school life. According to the researchers, students' perception of the quality of school life represents their satisfaction with the school and classroom, their sense of their social place, their emotional attitude towards the educator and teachers, and their emotional and behavioral attitude towards studying, showed a relationship between students' perception of class climate and sense of belonging, educational process development, personal development, integration, and effective behavior in the school environment and routine (Zedekiah, 1988; 1996. Urdan et al., 2004) found that positive interaction between class members increased students' social competence in the lower grades of elementary school (Hoglund & Leadbeater, 2004). School climate is based on norms, relationships, goals, values, and organizational structure (Cohen & Geier, 2010). In addition, it influences students' social, psychological, and academic outcomes (Glisson, 2007). Interpersonal interactions, as a key component of school climate, influence behavioral norms and a sense of protection. A relationship has been found between positive interactions, avoidance of disruptive behavior, and good academic performance (Crosnoe, 2004; McNeely, Nonnemaker, & Blum, 2002; Powers, Bowen, & Rose, 2005; Whitlock, 2006) when the student perceives the school as a protected place where he or she can develop optimally. Similarly, the social-emotional climate creates insecurity, and the presence of verbal or physical violence poses the risk of interfering with student development and achievement, even if they are not directly affected by violence (Rivers et al., 2009)

## 6. Body of the paper

### *The purpose of the study*

The purpose of this study was to examine the extent to which a classroom intervention program based on cognitive behavioral principles affects students' acquisition of self-regulation skills, behavioral problems, social and academic emotional climate in the classroom, and quality of life in the classroom.

### *Study Population*

The sample consisted of thirty 4th grade students in an elementary school in the city of Jerusalem. The vast majority of children in the class have been learning together as a group for about five years, i.e., since pre-compulsory kindergarten. Of these, 8 are girls and 22 are boys, aged 9-10 years, who live in or around Jerusalem. 16 of the children in the class were diagnosed with learning disabilities or ADHD, and 14 of the children were not diagnosed (Table 1).

**Table 1.** Study Population – children

	N	%	Mean
Gender			
Girl	8	26.66	
Boy	22	73.33	
Age			9.4
Origin			
Abroad	2	6.66	
Israel	28	93.33	
Place			
Jerusalem	24	80	
Outside Jerusalem	6	20	
Adhd	9	30	
learning Disability	7	23.3	
undiagnosed	14	46.7	

Five school employees also participated in the study. 3 women and 2 men, all with academic degrees and working at the school. 4 with more than 10 years of experience in education

and one with 2 years of experience. 4 of them were born and raised in Israel. 3 of them are

married and 2 are not married (Table 2).

**Table 2.** School employees

	<b>N</b>	<b>%</b>	<b>Mean</b>
Gender			
Female	3	60	
Male	2	40	
Age			37.21
Education			
Academic	5	100	
Origin			
Abroad	1	20	
Israel	4	80	
experience in education			
More than 10	4	80	
Less than 10	1	20	
Marital status			
Mrried	3	60	
Not married	2	40	

**Research tool**

*In-depth interviews:* semi-structured in-depth interviews to capture and observe staff feelings towards the class before and after the intervention program. In addition, open-ended face-to-face interviews were conducted on predetermined general topics to understand students' feelings and needs.

*Participant observation:* participant observation was conducted in the classroom, involving directly and personally in the lives and processes of the students and experiencing the reality in the classroom together with them. Observations focused on events that took place during common class time related to self-management and self-regulation, as well as in the general atmosphere of the classroom during class time and extracurricular activities.

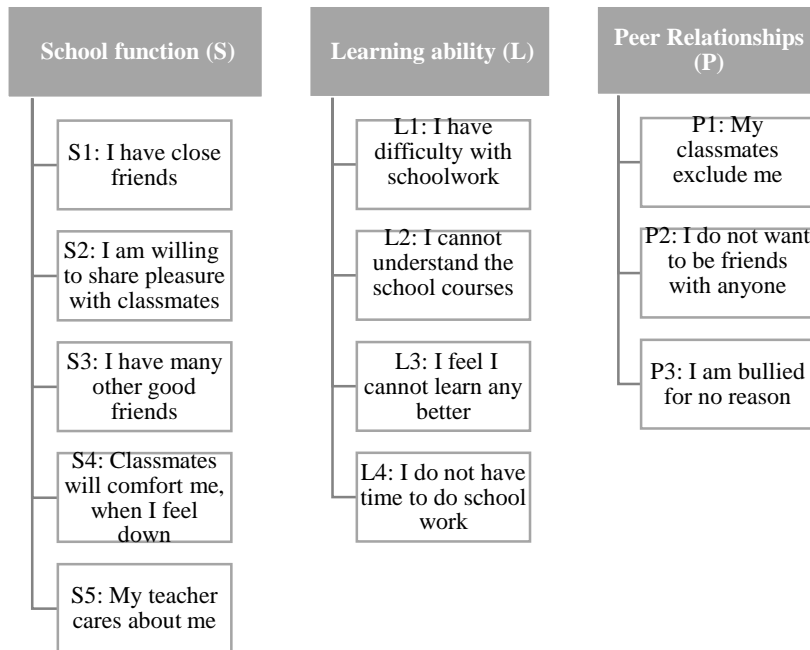
In addition, class discussions were recorded with students during designated class periods to implement and monitor the program and its outcomes.

*Open-ended questionnaires:* open-ended questionnaires were distributed twice a year before the end of each semester. Students were asked to rank various verbs on an axis

according to their personal feelings and to put their choice into words.

*Quality of life questionnaire components:* the ESQoL questionnaire (Yuen et al., 2022) is a 21-item questionnaire developed and validated for elementary school students in Taiwan. The questionnaire was developed with the aim of bringing to light the differences between age levels and the impact that developmental stage may have on quality of life (Wee, Chua, & Li, 2006). The components of the questionnaire help assess factors related to students' emotional well-being and relate to functioning in school and other areas of the student's life. This study examined the effects on 12 of the 21 components of the questionnaire that relate directly to the educational framework. The questionnaire was developed in Taiwan, a culture where the academic achievement of their children is very important to parents (Chan et al., 2014, Tzeng, 2007), similar to Israel. The questionnaire proved to be an effective instrument for measuring the quality of life of elementary school students and has high validity and reliability.





**Figure 1.** Quality of life 12 components

## Research process

Initial data collection occurred during the academic year prior to the year in which the study was conducted through information collected in reflection sheets completed by students at the end of the year, classroom observations, and information provided in a final team meeting. The data collected indicated an abusive climate in the classroom. This manifested itself in reports of an impaired sense of safety, ability, and motivation among students and teachers teaching in the classroom. All teachers reported that, in their opinion, the academic level in the current class did not reflect its potential. There were also reports of verbal and physical bullying and social boycott.

A joint analysis of the members of the educational staff along with the behaviors that emerged from classroom observations and routine student complaints led to the hypotheses that: Classroom challenges are affected by difficulty in postponing a response and impulsivity.

Dealing with challenges on a daily basis affects students' quality of life and their ability to use resources for optimal development.

At the outset of the study, open-ended face-to-face interviews were conducted with the students and with five staff members who provide regular support to the class, including the principal, who was personally involved in the implementation of the program.

The course of the investigation included the implementation of a classroom intervention program based on cognitive-behavioral principles with the students, as well as scheduled meetings with staff for the purpose of induction, assimilation, ventilation, and implementation.

During the intervention, regular classroom meetings were held and recorded to practice and monitor assimilation.

Reflective questionnaires were distributed at the end of the program to capture the personal

process and general feeling in the classroom. The pages contained a limited number of closed-ended questions on a response scale as well as open-ended explanations. The use of behavior mapping charts helped to observe the behavioral changes that occurred in the class throughout the period. Pre-intervention and end-of-intervention questions were asked about feelings in the school setting to observe changes in students' quality of life related to their functioning and feelings in the classroom.

### **The components of the intervention program**

The intervention included the use of cognitive and behavioral therapy tools. The goal was to teach strategies and tools to strengthen and develop monitoring, management, and self-regulation skills in the first phase.

In the second phase, they were to be applied to defined goals that would support the creation of a positive social and emotional classroom climate and improve the quality of life for students in the classroom.

This, while continuing the processes of establishing and assimilating tools and semantics.

The program was established and implemented using a variety of tools:

Tools for assimilation: with the beginning of the school year, the schedules, the system of hours and the accompanying lessons were created in terms of the intervention plan to create a unified and consistent language and a sense of framework and security.

Permanent Lessons: Three permanent weekly lessons were incorporated into the system to learn and use program language, role play, learn tools and strategies, learn through stories, practice social discourse, practice reflection skills, reflect, and create daily report pages.

Monitoring boards: behavior boards were created and posted in the classroom for consistent, orderly, and mandatory

monitoring of the behavior process.

Self-management wheel board: based on the cognitive behavioral model derived from the emotional-rational method a self management board was created. The board is divided into quarters to distinguish between an event, a thought, an emotion/feeling, and a reaction.

To allow the model to be applied using routine events and role-plays, each quarter was assigned its own color and a set of cards of the same color was included. The cards included events, thoughts, emotions/feelings, behaviors, and blank cards for self-completion (figure 2).

Reaction stages: A reaction stages axis was placed below the circle for the practice of monitoring behaviors and responses (figure 3).

Board of Sentences and proverbs: the board with the collected Sentences and proverbs was placed under the level of the answers and on it the Sentences and proverbs were hung throughout the year to support and perfect the internal dialog. The Sentences and proverbs helped students solve events and situations. In addition, the board included alternative verbs for practiced situations.

Throughout the process, a goal was set once a month to guide the class according to the goals - based on the needs established in advance. Each goal was assigned a time range. The first overarching goal was familiarity with the plan and ways to implement it. Familiarity with the auxiliary panels that accompany the behavioral program, experience with pre-dictated chance events, experience with the panels in everyday situations, experience in role-playing and using the auxiliary panels and the semantics derived from them in everyday behavior in real time. Another overarching goal was proper speech and included using navigation tabs to monitor speech patterns in real time, behaving according to the speech rules used in the classroom, speaking in class when given permission to speak, developing

the ability to listen to each other, listen to what adults say, express oneself clearly and in an appropriate tone of voice, respond to what friends say out of respect and politeness, treat a friend's words with respect and politeness even when there is an argument, and use language appropriate to the time and place. Another overarching goal was defined as reflection as a foundation for behavior regulation and included familiarity with the concept of restraint, reflection on situations and situations where students have had to restrain themselves in the past, knowledge of different ways to help avoid an immediate reaction, familiarity with the concepts of self-management, self-regulation, reflection, and self-control, identification of past thoughts and physiological signs of behavior that may lead to an impulsive response, application of behaviors and phrases that help students choose and manage their thinking and behavior in real time, understanding of the emotional impact of success in regulating behavior as opposed to an impulsive response. Another overarching goal was a positive classroom climate and included: learning about the concepts of empathy and intervention, practicing recognizing and expressing the feelings and thoughts of others through role-playing, intervening in a social situation in an appropriate way, acting from the perspective of others, understanding the differences between different individuals' feelings and thoughts about the same situation while having respect for others and their feelings.

Each objective was composed of the phases of the program: Defining a need, identifying automaticity at the level of feelings, thoughts, and actions, suggesting possible responses, choosing a behavior, choosing a word that supports the behavior, and reinforcements.

During the year, specific goals were also defined, based on specific needs - individual and group - that came up in discussions with the group of children.

Reinforcement plan for defined goals: A pool of High goals and personal and group goals are set and rewarded according to progress. Blackboards accompanied the program and allowed for the accumulation of reinforcers of various types and to varying degrees individually or in groups.

Individual processes were conducted with a number of children that were found to have a significant impact on the atmosphere and feeling in the classroom. These processes included phases that were identical to the phases of group work and related to personal goals, goal refreshment, monitoring, and regular updating of all staff involved in the program.

Work with educational staff included recruitment of appropriate staff, ongoing dialog, maintaining consistency in classroom work, and regular meetings within the system. The meetings included acquiring the principles of the program, a discussion of possible courses of action, and airing, sharing, and brainstorming. Times were also set aside for regular and periodic reporting on classroom behavior.

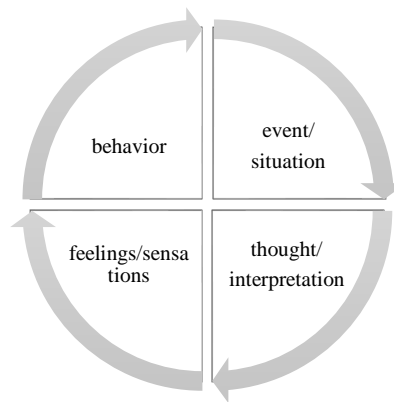


Figure 2. Self management wheel

## 7. Results

The results obtained combine data suggestive of qualitative processes that indicate a change

in perceptions and experiences with measurable data that indicate a reduction in maladaptive behaviors, an improvement in adaptive behaviors, and an increase in the quality of life for individuals in the classroom.

*Analysis of social climate results:*

The results describe a comparison between the responses on the reflection questionnaires completed by the children at the end of third grade before the intervention program and at the end of fourth grade after the program

The questionnaires completed by the children contained closed and open-ended questions. The closed questions were rated on a scale of 1-5: 1 - never, 3 - sometimes, 5 - always, 2,4 - intermediate situations between always and sometimes or between sometimes and never.

**Table 3.** Reflection sheets comparison

	<b>Mean - Before</b>	<b>Mean - After</b>
"I choose my friends by myself"	1.76	4.33
"My friends respect me and my opinions"	2.63	4.43
"I manage to avoid conflicts and arguments with friends and reach a solution in pleasant ways"	1.53	4.36

The results describe a comparison between the answers to the reflection sheets filled out by the children at the end of the third grade before the intervention program and at the end of the third grade after it. The questionnaires included closed and open questions. The closed questions are given a quantitative score on a scale of 1-5: 1 - never 5 - always respectively.

In reference to the saying "*I choose my friends and girlfriends*"



**Figure 3.** Reaction stages

**Numerical results :** in 70% of the students a numerical increase was observed in legitimacy and in their ability to choose their friends, in 30% the group was ranked at the beginning of the program with the highest score and the result was kept. 60% of the children rated the statement with the maximum number of points at the end of the year compared to 30% at the beginning of the year.

**Literal results:** at the beginning of the year, 70% of the subjects reported a certain difficulty in connecting with a friend with whom they would like to play. At the end of the year, all the children testified about an improvement in their feeling towards their social status in the class. 40% of the children

testified about a personal process they went through regarding their personal responsibility in choosing friendships. In reference to the saying "My friends respect me and my opinion"

**Numerical results:** in 80% of the subjects a numerical increase in the feeling of being respected was observed, in the remaining 20% no change was observed, while in 10% of them from the beginning the saying was rated with the highest score and in another 10% it did not apply Improvement in the feeling that they are respected in the classroom. 60% of the subjects scored the statement with the maximum number of points at the end of the year compared to 10% at the beginning of the year.

**Literal results:** at the beginning of the year, 80% of the subjects expressed dissatisfaction with the degree of respect they receive among their classmates and 10% stated that they do not know how to refer to a verb. At the end of the year, 80% of the subjects indicated that a change could be felt in the general classroom climate. 10% reported that their feeling in the class is not good.

In reference to the saying "I manage to avoid fights and arguments with friends and reach a solution in pleasant ways".

**Numerical results** 50% of the subjects observed a numerical increase in the feeling that they manage to conduct themselves better in conflict situations. In the remaining 50%, no change in the result was observed. 60% of the subjects rated the statement with the maximum number of points at the end of the year compared to 10% at the beginning of the year. No drop in score was observed in any of the subjects.

**Literal results:** At the beginning of the year, 50% of the subjects testified about the lack and need for conflict management tools. 30% did not see personal responsibility in their involvement in fights. 30% referred to their personal responsibility. 20% stated that they have tools that help them solve problems. 10% referred to their general feeling regarding interactions and communication in the classroom. At the end of the year, all the subjects reported an improvement in dealing with conflicts. 70% of the subjects testified to purchasing tools that help them manage conflicts and solve problems. 30% of the subjects responded positively to the process and the general atmosphere in the class and said that they expanded their social circles.

In the next question, the students were asked to say what they would preserve in the class and what they would improve in it. The question included only a verbal description without a numerical representation. At the beginning of the year, 90% of the subjects thought that there was something to improve

in the class in the social aspect. 60% of them experienced the class as an unsafe place and reported bullying behavior towards them or their classmates. 10% reported feeling disrespected. 20% stated that they would like to expand their social circles and the possibilities of playing with friends.

20% reported noise and anger affecting the atmosphere. 10% said they did not know what they would like to improve. 10% said they would like to improve everything in the classroom. At the end of the year, 30% of respondents felt there was nothing left to improve. 10% felt everything should be improved and 60% mentioned specific changes that should be made. Compared to the beginning of the year, only 10% said that the attitude of the children towards each other should be improved.

In terms of things students wanted to keep in the classroom: At the beginning of the year, 70% of subjects wrote that they would keep their best friends. 30% did not find anything on the social level in the class that they would like to keep. At the end of the year, 70% of the children referred to the flow in the class and the general social climate, 40% of the subjects described the improvement of the children's behavior towards each other. 20% of the subjects the presence and effectiveness of the acquired tools for self-management and problem solving. 30% mentioned the good atmosphere and pleasant feeling in the class. 75% of the 30% who did not find what they wanted to preserve at the beginning of the year found things they would preserve.

At the level of the defined goal of social climate and social communication, there was a significant improvement in how children felt about their social status and an increase in their overall good feeling in the classroom. 20% reported noise and rioting affecting the atmosphere. 10% said they did not know what they would like to improve. 10% said they would like to improve everything in the classroom. At the end of the year, 30% felt there was nothing left to improve. 10% felt

everything should be improved and 60% mentioned specific changes that should be made. Compared to the beginning of the year, only 10% said that the attitude of the children towards each other should be improved.

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At the level of the defined goal of social climate and social communication, a significant improvement was observed in the children's feeling of social status and an increase in their overall good feeling in the classroom.

*Results of a circle for self-management, guided discovery, and mantras:*

The results describe a comparison between the content brought up during observations, conversations with children, and class discussions at the end of third grade before the intervention program and at the end of fourth grade after the program.

At the level of the defined goal of habituation and internalization and application of the principles of the program and the reference tables: At the end of the year, most children had acquired the circle of self-management and the tools for observation, internalized the stages at the cognitive level and the emotional level, and used them to achieve defined behavioral goals, such as: social climate, rules of discourse, social play.

At the defined goal level of rules of discourse, significant improvement was observed in the ability to engage in attentive, appropriate, and respectful classroom discourse. Prior to the intervention, classroom discourse was characterized by outbursts and speaking without permission, rejecting the opinions of others, language that was not respectful and appropriate to the time and place, and verbal violence towards class members and staff. In the observations conducted at the end of the implementation of the intervention program, students in the class waited for permission to speak to express their opinions in class, listened to their classmates and the teacher, expressed themselves clearly, in an appropriate tone of voice and in appropriate and respectful language, and the level of verbal violence decreased significantly.

At the level of the defined goal of a social game, the intervention helped in acquiring tools to manage a social game: observations conducted prior to the intervention found that students were disrespectful of the rules of the game, failed to divide into game groups, gave up the game before they lost, and many conflicts occurred. After the intervention, observations showed that students invited friends to play, managed to play together for a long time, enjoyed playing together, cooperated, followed the rules, lost respectfully, and won without humiliating the other person.

*Reaction stages results:*

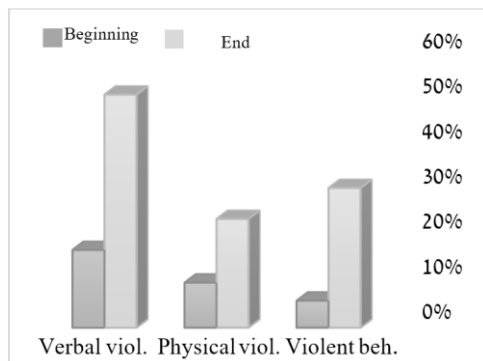
according to students' reports, using the Reaction stages as an available, practical and clear tool has helped them avoid impulsive and violent behavior. At the beginning of the year, 51.7% of the children reported being victims of verbal violence, expressed in humiliation, insults, threats, social ostracism and boycott, compared to 17.24% at the end of the year.

At the beginning of the year, 24.13% of students reported suffering physical violence, compared to 10% at the end of the year.

At the beginning of the year, the percentage of children who required repeated treatment and activation of personal programs due to violent behavior was 30%, compared to 6% at the end of the year.

**Table 5.** Violent and victims compression

	Percent – before	Percent – after
Violent behavior (physical or verbal)	30%	6%
victims of physical violence	24.13%	10%
victims of verbal violence	51.7%	17.24%



**Figure 4.** Violent and victims compression

In terms of behavior, the reinforcement program was implemented: Throughout the intervention program, the process of self-monitoring became more accurate, honest, and realistic through written reflections. Students received more and more positive reinforcements for achieving the set goals. After goals were met and behaviors improved, the demand for positive behaviors was increased to maintain the reinforcements.

*Table Results Quality of life:*

The impact of the intervention program on students' quality of life and well-being was measured using student reports and twelve items related to three quality of life indicators related to the school environment. The indicators were selected from the QQL

questionnaire, which contains 21 items and a total of six quality of life indicators

**Table 6.** School function 5 -High QoL

School function (S)	Mean - Before	Mean - After
S1: I have close friends	3.6	4.13
S2: I am willing to share pleasure with classmates	3.6	4.1
S3: I have many other good friends	2.6	3.03
S4: Classmates will comfort me, when I feel down	2.9	3.86
S5: My teacher cares about me	3.6	4.23

**Table 7.** Learning ability (L) & Peer Relationships (P)

Learning ability (L) & Peer Relationships (P)	Mean – before	Mean – after
L1: I have difficulty with schoolwork	3.03	3
L2: I cannot understand the school courses	3.03	3.03
L3: I feel I cannot learn any better	3.1	3.06
L4: I do not have time to do school work	2.5	2.3
Peer Relationships (P)		
P1: My classmates exclude me	3.16	2
P2: I do not want to be friends with anyone	3.1	2.53
P3: I am bullied for no reason	2.73	2

1 -High QoL

*In terms of quality of life:*

Indicators related to functioning in school. Answer 5 means a high level of quality of life (Table 6).

For the index: I have close friends, the average of students' responses before the intervention program was 3.6. After the intervention program, the average of responses increased to 4.13.

In the index: I am willing to share joy with classmates, the average of students' responses

before the intervention program was 3.6. After the intervention program, the average of responses increased to 4.1. In the index: I have many other good friends, the average of students' responses before the intervention program was 2.6. After the intervention program, the average of responses increased to 3.03. In the index: classmates comfort me when I feel down, the average of students' responses before the intervention program was 2.9; after the intervention program, the average of responses increased to 3.86. For the index: my teacher cares about me, the average of students' responses before the intervention program was 3.6; after the intervention program, the average of responses increased to 4.23.

In all indicators of school functioning (s), an increase was observed after the intervention program. For the indices related to learning skills ((l) and relationship with peer group ((p), the response 1 indicates a high standard of living. (Table 7) In the indicators related to the ability to learn: For the index: I have difficulty with schoolwork, the average of students' responses before the intervention program was 3.06, and after the intervention program, the average of responses decreased to 3. The average response of the index: I cannot understand school subjects was 3.03 before the intervention program and remained unchanged after the program. In the index, I feel I cannot learn better, the average of students' responses before the intervention program was 3.1. After the intervention program, the average of responses decreased to 3.06. In the index I do not have time for school, the average of students' responses before the intervention program was 2.5. After the intervention program, the average of responses decreased to 2.3.

For the indices related to the relationship with the peer group. For the index: my classmates exclude me, the average of students' responses before the intervention program was 3.16. After the intervention program, the average of responses decreased to 2. In the

index: I do not want to be friends with anyone, the average of students' responses before the intervention program was 3.1. After the intervention program, the average of responses decreased to 2.73. In the index: I get bullied for no reason, the average of students' responses before the intervention program was 2.53. After the intervention program, the average of responses increased to 2.

## **8. Discussion**

School climate is influenced by a sense of support and responsiveness to individual needs, as well as fair and clear rules, order, discipline, organization, and care for the physical environment. Disorder, disciplinary problems, and a sense of alienation and lack of protection significantly affect the climate and do not allow the school to achieve its goals for development, teaching, and learning (Benvanishti et al., 2008). The intervention program primarily required the organization of the classroom, that is, the creation of the weekly and daily schedule and the creation of regularities and routines in the classroom. The organized and orderly structure of the environment is an important and central element in building a framework that facilitates productive learning academically and socially (Allen, 2010). Studies have shown a clear relationship between classroom organization, the establishment of clear and consistent rules and expectations, and an infrastructure that allows for student participation in decision-making, and a decrease in violence and bullying (Safran & Oswald, 2003). It can be concluded that maintaining an organized and orderly work environment has helped to improve classroom climate, which is reflected in the improvement of how students feel in the classroom by making more connections to learning and having a sense of safety.

The uniqueness of action research was demonstrated by activating a cognitive-



behavioral intervention program in a school setting with a large group of 30 students. Studies point to the power of the group and its influence on the effectiveness of any cognitive-behavioral intervention program (Wiborg, et al., 2015; Skjemov, et al., 2015). In addition, intervention programs that work at the level of groups of children have been shown to be particularly effective intervention tools for reducing behavior problems and improving prosocial behavior (Yavuzer & Karatas, 2013; Bowman-Perrott, et al., 2015).

Giesbrecht, Leadeater & Macdonald (2011) attribute great importance to the influence of the early elementary school years and the sense of security during those years on children's social, emotional, cognitive, and personality development. Many studies have found that in a situation where there is no protection, both the victim and the bully are at increased risk of developing social, emotional, and behavioral problems (Hanish & Guerra, 2002; Kochenderfer-Ladd & Skinner, 2002; Kochenderfer-Ladd & Wardrop, 2001; Leadbeater & Hoglund, 2009; Loeber & Farrington, 2000; McGinnis & Goldstein, 1997; Pope & Bierman, 1999). At the beginning of the year, prior to the start of the program, there was a significant disconnect between the high cognitive and academic abilities of the group and the students in it and their lack of implementation. This, along with social, emotional, and behavioral skills that were below their age. According to Apple (2007) and Weisbord (2007), there is a relationship between cognitive skills and self-control, information processing, and control over emotions as mechanisms that allow an individual to control and regulate their behavior and moderate the relationship between emotions and aggression. Behavior regulation and control of violent behavior allow individuals to acquire tools that help them behave socially using accepted social models (Moore et al., 2011). Going through

the process and internalizing the language resulted in significant improvement in the level of violence in the subject and feelings of protection. The reflective and metacognitive work impacted automatic responses and the system of beliefs and perceptions. It also helped students discover for themselves, for the first time, skills and potential in several areas, including mastering appropriate social discourse and finding a place in the social group.

The goal of the intervention program was to develop self-management skills in students through cognitive and behavioral tools to improve classroom climate and the quality of life and well-being of students in the class.

The intervention program led to an improvement in the students' regulation and self-monitoring skills. Something that expanded their awareness and personal responsibility (Kaniel, 2013). The results of the intervention plan illustrate the importance of teaching effective problem solving skills in various situations through a self-management circle. According to Smith & Daunic (2004), problem-solving skills can help monitor thoughts, i.e., act according to reality, monitor the results of monitoring, and manage the results of responding accordingly. The use of cognitive behavioral principles has the potential to change the way students think. Changing thinking and learning thinking and observation skills allow for the development and implementation of an independent self-management system and the learning of new behaviors (Harris & Pressley, 1991).

The results of the study show how through a slow and structured process, through small successes and reinforcements, self-management skills were acquired in the students. Self-management skills are a tool that students can use to deal with different situations and work on different defined goals. Through these skills, students were able to create a calm climate, regain a sense of protection and belonging compared to the stormy climate that characterized the class at

the beginning of the year.

Kaniel (2006) defines self-reflection in terms of "metacognition" or "inner eye." It can be assumed that the writing of daily reflections, monitoring, and daily use by students helped to acquire and internalize the tools. According to Kaniel (2006), the need for reflection and metacognition arises in complex situations that require a combination of cognition, emotion, and behavior. The requirement to conduct daily and aggressive reflections helped to internalize and work on reflective observation as a tool to examine thoughts, feelings, and behaviors. Several studies indicate the relationship between negative automatic thoughts and feelings of anger and violent behavior (Yavuzer & Karatas, 2013). The process of internalization and establishment involved regular classes in the system in which automatic thoughts, belief systems, perceptions, and cognitive patterns, feelings, and emotions that arise as a result and their effects on behavior were brought into awareness. Research results show that by changing automatic thoughts, students were able to moderate the emotion of anger and, as a result, moderate behavioral responses according to the level of reactions and broaden the range of possible responses in a given situation. This contributed to a positive classroom climate and an increase in the feeling of safety. The improvement in climate was reflected in student reports, a reduction in the percentage of physical and verbal violence, and a positive change in quality of life indicators related to school functioning.

## **9. Conclusion**

The purpose of the study was to examine the effect of an intervention program based on cognitive-behavioral principles on classroom climate, classroom interactions, the sense of safety of the students in the class and the teachers who teach in the class, the quality of life and well-being of the students in the class,

and the extent to which the students relate to social-emotional development and learning.

Prior to the start of the program, the classroom climate was turbulent, unyielding, and disrespectful. Students in the class reported a lack of a sense of belonging and a sense of protection, as well as a constant feeling of noise and disorder. These feelings prevented the implementation of interventions that would enable and promote learning. Students in the class and teachers reported a lack of legitimacy to express themselves in front of the class and a violation of their sense of competence, self-esteem, and ability to express skills in the cognitive domain. Students indicated that they found it difficult to initiate and sustain social activities in the classroom, such as conversations or social games. This reality caused a sense of constant frustration and a lack of appropriate response. Behaviors indicative of cognitive deficits and biases led to misinterpretation of everyday situations and maladaptive and disruptive behavioral responses, as well as a noticeable lack of reflective and metacognitive strategies. Over the years, the struggles described led to the development of negative social roles and images, associations based on a false background and having a negative and offensive effect. These reinforced the behavioral problems and created a closed circle that determined the fate and place of the individual in the class and the class as a group.

The intervention plan developed for the class was based on cognitive behavioral principles. The initial goal of the program was to build and establish a management and self-regulatory system in the students to provide them with tools to monitor their goals versus their actions, monitor the cognitive and emotional factors that influence behavior, and advocate for intentional self-change based on their will and their personal and group goals.

Through a long and consistent process, consistent semantics were established, tools were practiced and their use adapted, group

and personal goals were established, all with shared thinking, clear definition, and limited time. All children in the class acquired management and self-regulation skills at different levels. The individual work built the group and the group work supported the individuals.

There was an improvement in class climate, sense of security, quality of life indicators related to the school environment, legitimacy and belonging of the children in the class, and motivation to maintain and act for a positive atmosphere. Social interactions were created on a positive basis, social circles were expanded, and appropriate and respectful discourse skills and rules were established. Consistent facilitation improved feelings of support and belief in the ability to handle conflict and challenges, calmed the classroom atmosphere, and allowed for learning, initiative, and personal expression.

The study was conducted over one year and demonstrated the positive results of an intervention program based on cognitive behavioral principles for management and self-regulation skills, as well as the impact of the program, along with the acquired skills, on student performance in various domains. The approach proved to be appropriate, the process was successful and provided resolution. In addition, the degree of effectiveness of the group intervention program varied among the children and about 10% of the students in the class needed an individual intervention program at the same time.

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The study did not include a control group to examine the effectiveness of another program or the natural developmental processes of puberty without the implementation of a program

The initiative to set up the program, its creation, implementation, monitoring, and analysis and drawing of conclusions were in the hands of the researcher. However, it must be remembered that this is one of the limitations of any action research (Shakdi, 2011).

In the future, it would be worthwhile to examine the impact on the specific group over time to assess long-term reasonableness and to examine the acquisition and implementation of the tools and their independent use. In addition, to provide continuity, self-management skills will need to be adjusted and the possible tools to manage additional situations will need to be expanded as students mature and enter adolescence.

It would also be interesting to adapt and study the functioning of the intervention program and its outcomes at different levels and for groups with different needs, as well as for prevention in groups without behavior problems

In addition, it is important to conduct a comparative study that examines the effectiveness of the specific intervention program compared to other intervention programs.

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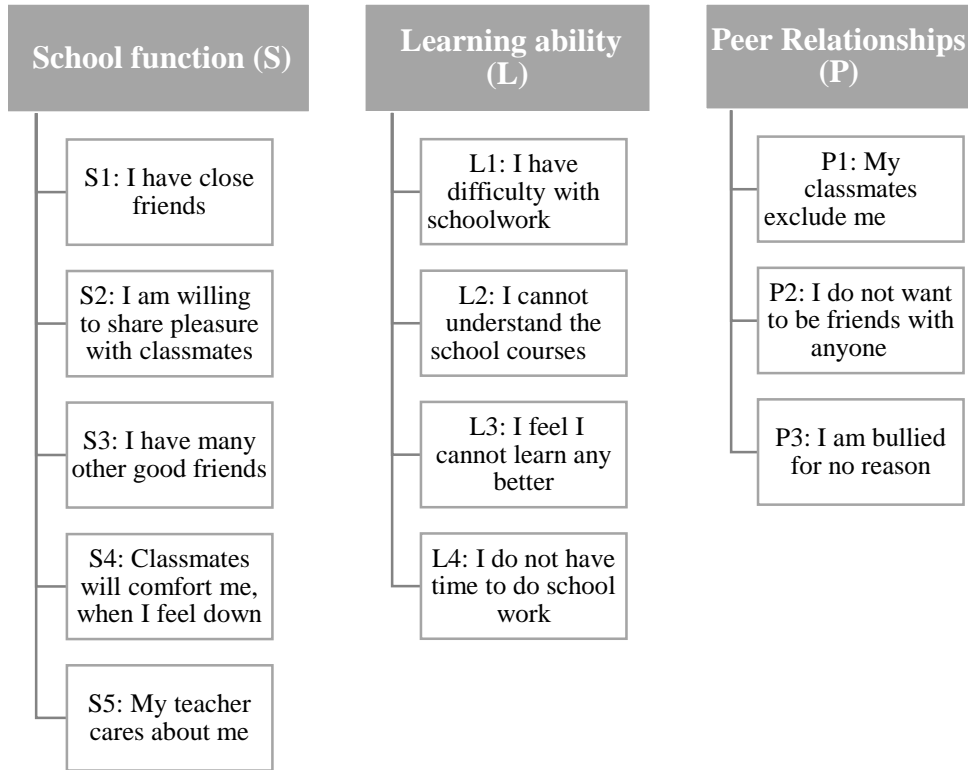
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## **DETERMINANTS OF SUPPLY CHAIN MANAGEMENT PRACTICE IN HEALTH CARE: EVIDENCE FROM MIZAN-TEPI UNIVERSITY TEACHING HOSPITAL**

**Abstract:** *Supply chain management practices play a significant role in improving organizations' service delivery performance and keeping them competitive in the global marketplace. Taking this into account, the primary goal of this research is to examine the factors that influence supply chain management practice at Mizan-Tepi University's teaching hospital. This is the only study on supply chain management practices that has been conducted in the teaching hospital where the current study is being conducted. To achieve the study's goal, data was collected from 249 sample respondents using a simple random sampling technique. Furthermore, the data was examined using a variety of linear regression models. With the exception of transportation management, the research reveals that the explanatory variables: customer relationship management, quality information sharing, inventory management, and facility management all have a positive and statistically significant relationship with supply chain management practice. Distribution management, on the other hand, has been found to have a negative impact on supply chain management practices. Following the study's findings, the organization under consideration must prioritize the acquisition of reliable information in order to make the best supply chain management decisions. Furthermore, the hospital should use cutting-edge technology and implement an inventory control system. Finally, employees at Mizan-Tepi University Teaching Hospital involved in supply chain management practices should be trained about supply chain management, forecasting, and acquiring essential materials for teaching programs, medical services, and other laboratory equipment in order to apply effective supply chain management practices.*

**Keywords:** *Customer Relation, Supply Chain, Quality information, inventory management*

### **1. Introduction**

The supply chain is a subject that has been discussed inside institutions due to its importance in corporate management. By seeking out devoted suppliers,

manufacturers, and distributors who can assist them optimize their revenue, they seek to integrate the organization's internal divisions. A supply chain is typically described as an integrated system that coordinates a number of interconnected

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processes in order to: generate demand for products; acquire raw materials and parts; transform these raw materials and parts into finished products; add value to these products; distribute and market these products to either retailers or end-customers; and facilitate information exchange among various interrelated organizational entities (like suppliers, manufacturers, distributors, third-party logistics providers, and retailers (Ledlow, Professor, Manrodt, & Schott, 2016). A supply chain is a network of businesses, individuals, events, information, and assets used to move goods from a supplier to a customer. Every production system needs a flawless method of supplying its goods to customers and retailers (Bhuniya, Pareek, & Sarkar, 2021). Many healthcare organizations over the years have become involved in the routine tasks of acquiring the necessary medical tools and supplies, storing the necessary medications, distributing the proper medical supplies, and scheduling patient services without properly coordinating and synchronizing those tasks. When these tasks are handled as distinct organizational responsibilities, we run the risk of overspending on pharmacies and medical supplies, maintaining antiquated technology and medical equipment, and underutilizing healthcare personnel. In other words, by duplicating organizational efforts and resources, a lack of connectedness among various operations can result in the sub-optimization of corporate goals and inefficiency. It is must to recognize the strategic significance of planning, controlling, and creating a healthcare supply chain as a whole if we are to fully achieve the synergy of inter-functional and inter-organizational integration and harmonization across all healthcare activities (Al-Saa'da et al., 2013a).

### 1.1 Statement of the problem

Hospitals all around the world are under increasing pressure to save expenses and better manage their operations while still meeting the requirements of an increasingly demanding population. Logistics activities, which can account for up to 46 percent of the hospital budget, account for a major amount of hospital costs (Ledlow et al., 2016).

To deal with financial challenges in the midst of an economic downturn and budget cuts, many healthcare organizations have made deliberate efforts to cut costs by lying off healthcare workers; deferring investment in equipment and technology modernization; and improving the accuracy of demand forecasts for medical supplies and pharmaceuticals.

Although it sounds plausible, this traditional way of saving healthcare costs can backfire because staff reductions through layoffs can exacerbate worker (especially nurse) shortages; the failure to upgrade necessary medical equipment and technology can undermine productivity; and a reliance on forecasts can increase risk and uncertainty associated with the volatile and unpredictable aspects (e.g., emergent care and massive disease outbreaks) of medical supplies and pharmaceuticals. People must develop "more inventive and leaner" substitutes in light of the aforementioned possible drawbacks of conventional cost-saving techniques.

By removing non value-adding practices like "never events" (such as redundant medical procedures, unnecessary surgeries, excessive inventories of medical supplies, and outdated drugs), administrative red tape, and ambiguous healthcare pricing mechanisms, these alternatives should be created to improve patient value.

Adopting supply chain concepts is a possible approach that has just been suggested. Simply put, supply chain principles seek to

eliminate wasteful spending, investments, and activities in order to streamline all healthcare processes related to locating required medical supplies or pharmaceuticals, producing healthcare goods or services, marketing (selling) healthcare, and delivering healthcare goods and services. The supply chain principle is regarded as a new method of conducting business because it no longer heavily relies on forecasts; fulfills medical orders as they are needed rather than requiring patients to follow predetermined routine but unnecessary medical procedures; and enables both patients and healthcare professionals to make informed healthcare decisions(Souza, Guilherme, Antunes, & Grutzmann, 2022). With the goal of enhancing operations, enhancing service delivery, and lowering costs, supply chain management includes actions involved in regulating the flow of information, products, services, and finances among supply chain participants (Odhiambo, 2014).

In the healthcare industry, supply chain management is a complex system that handles the resources and services associated with patient care. Enabling product visibility in the distribution network and ensuring timely delivery are the two main goals of supply chain management in the healthcare industry. The healthcare industry consists of businesses that produce drugs and medical devices, offer healthcare services and insurance, and support the delivery of healthcare to patients. The healthcare industry has two purchasing alternatives depending on the type of supplies. One option is to buy through a primary distributor with a contract, and the other is to buy through a government medical organization that contracts with a manufacturer and purchases on behalf of a number of people(Achuora, Arasa, Ochiri, & Muangangi, 2010).

The total end-to-end visibility of information among suppliers, manufacturers, distributors,

and customers should be guaranteed via supply chain management in the healthcare industry. The health care supply chain is more complex due to the involvement of the government, regulatory bodies, and insurance providers(Phyllis, 2021). A well organized and connected supply system must be in place in order for the healthcare service providers to be able to get treatment supplies and the equipment required for the patients' healthcare.

The supply chain is an important platform to deliver daily life necessities in the current abnormal situation(Management, 2021). Understanding Supply chain Practice is essential in the modern world if you want to increase supply chain performance. Supply chain Practice Metrics Clearly Demonstrate How Well An Institution Handles Its Customers In Terms Of Quality And Efficiency To Increase Customer Value For Goods And Services, An Institution's Ability To Meet Their Needs(Wong, Tan, Lee, Ooi, & Sohal, 2020).

In order to fully satisfy a customer's desire and request, a supply chain that includes all levels of manufacturers and suppliers, transporters, warehouses, retailers, as well as the end users, is ultimately linked to customer satisfaction and meets their needs, which in turn generates profits for the company itself. Service sectors in Africa and Ethiopia in particular, are currently facing challenges similar to those that exist anywhere else in the world where competition is fierce. As a result, multinational corporations and other import-substitute businesses, whose profitability is significantly influenced by the caliber and standard of the supply chain, are required to improve the quality of their products, reduce costs, offer better services, and supply a wider range of products, all fulfilled at competitive price (Farzianpour, Hosseini, Amali, Hosseini, & Hosseini, 2012).

According to the statement (Babbar, Addae, Gosen, & Prasad, 2008) of many businesses

are unable to expand the potential of their supply chains since performance indicators and metrics intended to integrate the chain more effectively were not implemented, which might have improved the efficacy and efficiency of the businesses. Despite the fact that many people are aware of the advantages of supply chain management in the normal course of business, there are still many more who are unaware of just how crucial and helpful it is to connect chains and monitor performance using metrics. According to household surveys conducted in southern Africa, about 20% of patients who visit public health facilities are discharged without receiving any medication as a result of stock outs and shortages.

Numerous studies have been conducted to examine how supply chain management practices affect how well organizations perform. From these studies, (Refera, 2019) examined the impact of service supply chain management practices on the organizational performance of the public health care sector and discovered a favorable correlation between them (Refera, 2019) investigated the impact of supply chain management on the caliber of healthcare services.

With regard to supply chain management practice, Mizan-Tepi University Teaching Hospital has various problems. The following are the main issues with the Mizan-Tepi university teaching hospital supply chains management practice, as identified by the hospital's SWOT analysis. The work is not patient-centered because there is a lot of paper work for the auditable pharmaceutical transaction service, which results in a high work load on the professionals. Most of the time, essential medicines for the hospital are out of stock, bin cards are not properly filled out, there is a shortage of qualified staff at the supply position, there is inadequate storage space for the medicines, there are no standardized shelves for the medicines, there is forecasting, procurement, and quantification

problems.

Therefore, the hospital's practice of efficient and effective supply chain management is hampered by this and other unmentioned issues. As a result, the focus of this research is to analyze the factors that affect Supply chain management Practice: evidence from Mizan-Tepi University Teaching Hospital. Moreover, this study is framed with three major objectives; the first objective is to analyze factors affecting supply chain management practice of the study organization. The second is to describe which factors highly influence supply chain management practice in the study area. Finally, the research's practical implications should be communicated to relevant stakeholders. The researcher attempted to fill the following gap: some of the explanatory variables included in this study were not considered in previous studies. Furthermore, prior research did not consider how the variables listed in this manuscript interact; as a result, the researcher does so in this manuscript. Due to the region's recent establishment and a lack of research, this is the only study on the supply chain management practices of Mizan-Tepi University's teaching hospitals in south-west Ethiopia.

The fact that professionals in the sciences, technology, and business must collaborate with great expertise and coordination to provide cutting-edge medications to service organizations motivates the researcher. However, by beginning to consider supply chain management (SCM) at the very beginning of the service delivery cycle, it may be possible to significantly improve the success of those efforts. The researcher hopes to help the management of the Mizan-Tepi University teaching hospital and other readers realize their full potential by focusing on a variety of levels.

The study's contribution is that appropriate supply chain management aspects must be designed and implemented by managers.

Second, the study can be used by managers to develop strategic plans for hospital supply chain management in general, and specifically for Mizan-Tepi University Teaching Hospitals. Furthermore, the study may pave the way for additional research by other researchers and the scientific community in the future.

## 2. Literature Review

### 2.1 Definition of supply chain Management

The goal of industry managers is to increase profit while maintaining client satisfaction. In modern times, a shorter lead time is one of the most important criteria for client satisfaction. Lead time and variance are regarded as controllable factors that can be altered in order to acquire a precise cost rather than a rough estimate. To produce more accurate findings, the marginal inventory and marginal backorder were estimated (Dey, Bhuniya, & Sarkar, 2021). So do get benefit of all those things the managers of organization should understand the determinants of supply chain management practice.

The term "supply chain management" became popular after a flurry of articles and books on the subject were published in the mid-1990s. Supply chains were originally defined as all activities associated with the flow and transformation of goods from raw materials to the end user, as well as the associated information flows. Supply chain management was defined as the integration of supply chain activities through improved supply chain relationships to gain a competitive advantage (Alhassan & Akudugu, 2020)

Supply chain management in business refers to the regulation of the movement of goods and services between organizations and locations. This can involve the transportation and storage of raw materials, inventories for

work-in-progress and finished goods, and the complete order fulfillment process from the point of origin to the site of consumption. Networks, channels, and nodes that are interconnected, interrelated, or linked operate together to deliver goods and services to end users in a supply chain (TA, BUI, CANH, DANG, & DO, 2020).

Supply chain management has been defined as the "design, planning, execution, control, and monitoring of supply chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply with demand, and measuring performance globally" (Hrinchenko & Economics, 2017). SCM practice is heavily influenced by industrial engineering, systems engineering, operations management, logistics, procurement, information technology, and marketing (Parfenov, Shamina, Niu, & Yadykin, 2021) and it aspires to be an integrated, multidisciplinary, multi method approach (Blecker, Kersten, & Ringle, 2015)

The Council of Supply Chain Management Professionals (CSCMP) defines supply chain management as the planning and management of all activities related to sourcing, procurement, conversion, and logistics management. Coordination and collaboration with channel partners, who could be suppliers, intermediaries, third-party service providers, or customers, is also included. The integration of supply and demand management within and across organizations is referred to as supply-chain management. The Extended Enterprise is a network of companies that work together to provide loosely coupled and self-organizing goods and services (Prakash et al., 2021).

### 2.2 Historical Development of SCM

Keith Oliver coined the term "supply chain management" in 1982. The concept of a supply chain, however, was important in

management long before that, particularly with the invention of the assembly line in the early twentieth century. The need for large-scale changes, re-engineering, and downsizing driven by cost-cutting programs, as well as widespread attention to Japanese management practices, define this era of supply-chain management. However, the term became widely used following the publication of the seminal book *Introduction to Supply Chain Management* by (Schredelseker & Hauser, 2008).

The era of supply chain management integration began in the 1960s with the introduction of electronic data interchange (EDI) systems and ended in the 1990s with the introduction of enterprise resource planning (ERP) systems. With the expansion of Internet-based collaborative systems, this era has continued into the twenty-first century (Techt, 2015).

Higher value-added and cost reduction through integration distinguishes this stage of supply chain evolution (Alifia, 2021). A supply chain network has three stages: stage 1, stage 2, and stage 3. In a stage 1 supply chain, systems such as production, storage, distribution, and material control are not linked and operate independently. In a stage 2 supply chain, these are combined into a single plan, and enterprise resource planning (ERP) is used (Becker et al., 2021)

The globalization era, the third stage of supply-chain development, is distinguished by a focus on global systems of supplier relationships and the expansion of supply chains beyond national boundaries and into other continents. Despite the fact that global sources have been used in organizations' supply chains for decades (for example, in the oil industry); it wasn't until the late 1980s that a significant number of organizations began to integrate global sources into their core business (Wood & Duong, 2022). This era is defined by the globalization of supply-chain management in organizations with the goal of increasing competitive advantage,

adding value, and lowering costs through global sourcing (Fitoussi & Saraceno, 2013).

In the 1990s, businesses began to emphasize "core competencies" and specialization. (Wood & Duong, 2022) They abandoned vertical integration in favor of third-party outsourcing of non-core operations. Management requirements changed as the supply chain expanded beyond the company's walls and management was distributed across specialized supply-chain partnerships. This transition also refocused the fundamental perspectives of each organization (Aminata, 2017).

### 2.3 Supply chain Management theories

#### Theory of Constraints on Supply Chain

Goldratt's Theory of Constraints is by far the most popular approach to supply chain management (Triestch 2005). The theory of constraints is a management paradigm that views any manageable system as being limited in achieving more of its goals by a very small number of constraints. As such, TOC employs a focusing process to identify the constraints and restructure them in order to increase system throughput (Jell-Ojobor & Raha, 2022) This is consistent with the views of (Al-Saa'da et al., 2013b), an early proponent of the theory of constraint, who identified bottlenecks as the underlying inefficiencies of most processes. The theory of constraints is based on the premise that a goal-oriented system's ability to achieve its goals is limited by at least one constraint (Junge, 2020).

Overall output and system goals can only be achieved by increasing flow through the constraint(s) (Fung, Korhonen, Li, & Ng, 2012). Assuming the system's goal and measurement have been articulated, the steps include identifying the system's constraint, deciding how to exploit the constraint, subordinating everything else to align the

entire system, and making changes (Prakash et al., 2021). According to Jell-Ojobor & Raha, (2022), constraints can be external or internal to the system and include phenomena such as equipment constraints, policy and regulation, a lack of skilled people, and so on. The theory of constraints has been used in supply chain management to provide solutions for increased inventory availability and flow by identifying and managing constraints such as replenishment time, lead time, and late deliveries (Brzeziński & Cyplik, 2020). Any advancement in these areas will increase the availability of products and services to customers.

### General Systems Theory on Supply Chain

Helou & Caddy, (2006) indicated that Von Bertalanffy 1969 developed the general systems theory in the field of biology, and (Yourdon, 2006) extended it into management paradigms. (Helou & Caddy, 2006), a biologist who discovered that given the interaction between a system's components, a system was frequently more than just the sum of its components; it involved the interaction of components differently within the larger system.

Most real-world systems, according to (Helou & Caddy, 2006), are open systems that interact with, and are frequently influenced by, the external environment. Another crucial system concept is the definable boundary, which separates a system from its surroundings while allowing inputs and outputs into and out of the system (Ullman & Kleidon, 2019) The general systems theory, according to (Wang, Heng, & Chau, 2006) identifies four general systems principles. These are the guiding principles: The more specialized or complex a system is, the less adaptable it is to its environment; the larger the system, the more resources are required to support the system; systems frequently contain other systems and

are components of larger systems; and systems grow in proportion to the resources allocated to the system.

Supply chains are defined as systems that provide a continuous flow of goods, products, or services to consumers (Schredelseker & Hauser, 2008). The contribution of general systems to the supply chain can be seen from the perspective that the supply chain is a system with inputs and expected outputs to inform supply chain management. According to Sangode, (2016), the supply chain includes the management of information systems, sourcing and procurement systems, logistics systems, and order and customer service systems, and integration of these activities can be used to gain a competitive advantage through improved relationships between these systems. The general systems theory allows for the differentiation of subsystems and variables that operate within a supply chain, resulting in a better understanding of the supply dynamics for further study and improvement.

### 2.4 Empirical Review

Global markets offer a diverse range of products of varying quality and price. As a result, organizations are constantly competing to reduce costs while improving quality. Customers want more options, better service, higher quality, and faster delivery, according to (Donaldson, 2012) Relationships with customers have evolved into a strategic issue for today's businesses. In order to meet the demand for smart products on the worldwide market and increase profits, the supply chain members look at a number of difficulties, including producing goods, transporting them, and delivering them to customers on time (Management, 2021).

The most important performance driver in the SC is information sharing (Fawcett, Osterhaus, Magnan, Brau, & McCarter,

2007). Information links various SC partners and enables them to coordinate their activities. Information is critical to daily operations at each stage of the SC. An information system can assist a business in quickly delivering a wide range of customized products to customers as well as understanding changing customer tastes and preferences (Marinagi, Trivellas, & Reklitis, 2015).

Continuously sharing new information with key individuals in a timely and qualitative manner assists managers in making better decisions, which leads to improved performance (Kembro, 2015). Many benefits of information sharing in SCs include reduced bullwhip effect, better coordination among various activities, making better decisions, and reducing uncertainties in SCs (Yucel, Cebi, Hoege, & Ozok, 2012). By making information available and sharing it with partners, an organization can increase the flow of information within SC, improve productivity and effectiveness, and reduce response time to market.

As a result, information sharing provides a competitive advantage to SC partners (Fawcett et al., 2007). Sharing information reduces uncertainty in SC, reducing the need for safety stock. Lee, Lee, & Schniederjans, (2011) investigated the impact of information sharing in a divergent SC and discovered that it reduced costs by 22% on average.

Inventory control entails ensuring that the correct goods are on hand to avoid stock-outs, shrinkage, and incorrect accounting. The costs incurred must be balanced against the costs saved by stockpiling the material. There are two basic decisions that must be made for each item kept in inventory (Brzeziński & Cyplik, 2020). These decisions concern both the timing and size of orders for the item. As a result, decisions about "when" and "how much" to order are included in the inventory control mechanism. Independent-demand inventory

systems are classified into two types: periodic review and continuous review. The inventory position is reviewed at regular intervals (during review periods) in the periodic review system, and an appropriate quantity is ordered. So, periodic inventory review entails counting and documenting inventory at predetermined intervals (Philippines, 2019). A retail store with a periodic review policy, for example, might count inventory at the end of each month. Periodic inventory reviews reduce the amount of time a business owner or manager spends analyzing inventory counts, giving them more time to focus on other aspects of the business (Parfenov et al., 2021). However, for businesses with high-volume sales, it may not provide accurate inventory counts. Between inventory review periods, the owner or manager must make assumptions about inventory counts (Brzeziński & Cyplik, 2020).

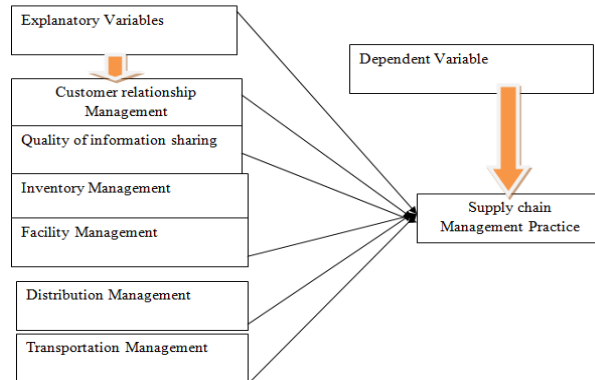
In Ghana and Guatemala, researchers compared the inventory performance of centralized and decentralized warehouse management models. The findings indicate that using centralized guidelines and standardized processes such as SOPs and clear stock cards improved performance (Fung et al., 2012). The findings are consistent with those of Postacchini, Ciarapica, Bevilacqua, Mazzuto, & Paciarotti, (2016) who discovered that inventory management is critical to the function of commodity management because a bullwhip effect is likely to occur and impede health service delivery without proper inventory systems.

Limited funds for vehicle purchase, maintenance, repairs, fuel, and driver salaries are some of the transportation and distribution challenges (Brilka & Clausen, 2021). Logistics costs account for 13% of the stock value of essential health commodities in Ghana. Low distribution costs and high service quality are competing interests. When distribution frequency is



high, transportation costs are high, but the demand planning horizon is more reliable,

with fewer stock-out situations (Parfenov et al., 2021).



**Figure 1.** Conceptual frame work

Source: Developed by researcher from theories (2022)

### 3. Method and Materials

This study was conducted at Mizan-Tepi University teaching hospital, which is located in Bench-Sheko zone, Mizan-Aman city administration, SNNPRS. The hospital staff members who participated in this study are the respondents, and they range from front-line employees to senior managers. Medical professionals, office personnel, procurement department employees, budget and planning program office, cafeteria workers, instructors, and head department.

According to, explanatory research designs "attempts to clarify why and how there is a relationship between two aspects of a situation or phenomenon." The purpose of this research was to examine factors affecting supply chain management in Mizan-Tepi University teaching hospital and their effect on hospital performance. The study adopted a descriptive and inferential mixed research approach (both quantitative and qualitative) to gain information about research in the organization. According to (Muthoni & Maitho, 2019), mixed approach research involves combining or integration of qualitative and quantitative data. Qualitative data tends to be open-ended without predetermined responses.

Quantitative data usually includes closed-ended responses, such as those found on questionnaires or instruments, such as in epidemiological studies.

A structured questionnaire was used to collect data, and it contained pertinent questions about the Mizan-Tepi University teaching hospital's supply chain management practice. Besides, interviews with employees of the teaching hospitals, supply chain management, procurement department, and each department head were asked to acquire information on the topic. A questionnaire makes it possible to structure the questions and gather responses without directly speaking to each respondent. It is a very adaptable instrument with the benefits of a structured style, ease of use for responders, affordability, and speedy administration for a large number of cases (Almalki, 2016). In order to gather data for this study, the researcher constructed Likert scale questionnaires. Interviews made more sense for questions that needed to be probed in order to get enough information. Interviews assist in collecting both verbal and nonverbal inquiries and maintaining concentration while gathering data. The benefit of employing interviews is that they enable the introduction of variance and on-the-spot

explanations (Betcheva, Erhun, & Jiang, 2021).

Thus, interviews were given purposively to some selected hospital employees in order to supplement the data gathered through questionnaires. It was employed to translate the information gathered via questionnaires. Additionally, it was utilized to supplement data that was not gathered through the use of a questionnaire or secondary sources.

### 3.1. Population, Sample and Sampling Techniques

Out of the 660 total populations, 249 employees were chosen using the Yamane formula cited by (Sustainability, 2014). The employees had to be selected as respondents because of the nature of sampling techniques, which give equal chance to all respondents.

$$n = \frac{N}{1 + N(e)^2} = \frac{660}{1 + 660(0.05)^2} = 249$$

### 3.2. Method of Data Analysis

When assessing the items on the questionnaire for validity, the researcher used a five-point Likert scale. The researcher additionally used the interview method of data collection to triangulate with the findings of the data acquired via the questionnaire in order to validate the final results. Reliability is the quality of a measurement tool's consistency or dependability. The internal consistency of the instrument's parts was assessed using Cronbach's alpha. The reliability was then evaluated in light of the estimated means for each variable. The reliability of the instrument was evaluated using the SPSS program and the Cronbach's coefficient-alpha. If the measurement is reliable, there is a lower chance that the resulted score is the consequence of random factors and measurement error as (Ayalew, 2021) cited

Kothari 2004. Depending on the objective of the study, a variety of regression, correlation, and descriptive models were utilized in the analysis. The data to be gathered from the respondents was examined using the Statistical Program for Social Science (SPSS) version 24.

The collected data was analyzed using descriptive statistics and empirical statistics. Before analyzing the data, it was sorted and entered into SPSS software. Of the interview were analyzed using triangulation with the findings of questionnaires and document analysis. Through the use of correlation analysis, the relationship between two or more variables was determined in this study. A statistical technique called correlation can be used to ascertain whether there is a relationship between two variables.

The amount, direction, and severity of the association (from -1 to +1) are revealed by the Pearson correlation coefficient. The researcher could use the outcome to calculate the regression on the dependent variable. Because Pearson correlation coefficient approaches typically produce statistically accurate findings, they are one of the most widely utilized types of correlation coefficients. The symbol for the person correlation coefficient is r. The following correlation coefficient value ranges illustrate the strength of correlation according to (Samuels, n.d.) Suggestions: Both descriptive statistics and empirical statistics were used to analyze the data that was gathered. The data from the interview was triangulated with the results of questionnaires and document analysis before being analyzed using SPSS software. In this study, the association between two or more variables was established using correlation analysis. To determine whether there is a relationship between two variables, correlation statistical analysis can be employed. The Pearson correlation coefficient reveals the size, direction, and strength of the link (ranging from -1 to +1).

The results could be used to calculate the regression on the dependent variable by the researcher. One of the most commonly used types of correlation coefficient is the Pearson correlation coefficient technique, which typically yields statistically reliable results.

The letter *r* is used to represent the Pearson's correlation coefficient. The following correlation coefficient value ranges demonstrate the strength of correlation, in accordance with (Canberra Group, 2011) recommendations: A method for estimating or forecasting the value of some dependent variables based on the value of one or more independent variables is called linear regression analysis. Similar to correlation, statistical regression looks at how different variables are related to one another. But prediction is the main goal of regression. Multiple regressions were used in this

analysis the inter-correlation of all the variables involved is considered in multiple regression analysis.

The dependent variable (organizational performance) and the six determinants make up the majority of the regression equation used in this study (inventory management, quality of information sharing, facility management, distribution management, customer relationship management, and transportation management). Regression analysis is being used in this study with the primary goal of improving the study's ability to describe, comprehend, and forecast the stated variable. The following equation represents the multiple regression equation for the chosen variable:

$$\text{Model equation: } Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + e$$

**Table 1.** Comparison Table with the previous work

Variables			Model					
Dependent variable			Supply chain Management practice			$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + e$		
$\beta_0$			Constant term					
E			Error term					
Coefficients of independent variables			$\beta_1$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_6$
Independent variable			X1	X2	X3	X4	X5	X6
Source			-	-	-	-	-	-
X1	Customer relationship management	Saad, Elgazzar, & Mlaker Kac, ( 2022)	Yes	Yes	No	No	No	No
X2	Quality information sharing	Nouranian, Saghaeiannejad Isfahani, & Memarzadeh, ( 2021)	Yes	No	No	No	No	No
X3	Inventory Management	(Gebisa & Ram, 2021)	No	Yes	Yes	No	No	No
X4	Facility Management	(Dusitin, 2018)	No	No	No	Yes	No	
X5	Distribution Management	(Crainic & Laporte, 2016)	No	No	No	No	Yes	No
X6	Transportation Management	(Serdaris, Antoniadis, & Tomlekova, 2014)	No	No	No	No	Yes	Yes
Contribution of author in this research			Yes	Yes	Yes	Yes	Yes	Yes

**Note:** - ((Yes) indicates that the previous researcher took the variable into account, and (No) indicates that they did not include the variable in their respective model.

**4. Analysis and Discussion**

**4.1 Descriptive Analysis**

In order to show the degree of agreement or disagreement among respondents with reference supply chain management determinants and their effect on booming hospital performance in the case of Mizan-Tepi University teaching hospital, descriptive statistics is presented in the form of mean and standard deviation. On a five point Likert scale, the respondents' responses to the variables listed below were evaluated. According to the (Mulugeta, Gsd, & Chane, 2017) cited (Zaidatol and Bagheri 2009), summary, using Likert scales, mean values of less than 3.39 are considered low, 3.4 to 3.79 are considered moderate, and greater than 3.8 are considered high. Thus Given the precise description of collective elements in table 1 below, the mean score indicated that these factors had an impact on Supply chain management Practice. According to the table, the overall perceived mean value and its standard deviation for customer relationship management are 4.09 and 0.604; for quality information sharing it is 3.98 and 0.459; for inventory management it is 4.09 and 0.499; for facility management it is 3.74 and 0.562; for distribution it is 3.89 and .947; and for transportation it is 3.75 and .484. In keeping with the aforementioned premise, the six components' overall perceived mean score is 3.95. The hospital's Logistic and Supply chain management Practice is described by the descriptive result of 4.12. Summarized by (Mulugeta et al., 2017) mean values of greater than 3.8 are considered high. As a result, the Mizan-Tepi University Teaching Hospital's Supply chain management Practice is high. According to the results of descriptive statistics, the following elements might be ranked in the order of importance for supply chain management in hospitals: management support, reward, employee perception,

teamwork, communication, and training.

**Table 2.** descriptive statistics of factor affecting Supply chain management Practice

Statistics	Descriptive		
	N	Mean	Std. Deviation
Customer relationship management	249	4.09	.604
Quality of information sharing	249	3.98	.459
Inventory management	249	4.09	.499
Facility management	249	3.74	.562
Distribution management	249	3.89	.947
Transportation management	249	3.75	.951
Supply chain management Practice	249	4.12	.484
Valid N (listwise)	249		

Source: own survey of 2022

**4.2 Inferential Analysis**

**4.2.1 Correlation Analysis**

The association between the two sets of data is stronger when the correlation value is larger. A perfectly linear positive or negative relationship exists when the correlation is 1 or -1. There is no association between the two sets of data when the correlation is 0 (Bušatlić & Musić-Kilic, 2018). The Pearson's Product Moment method was used to obtain the inter-correlation coefficients (r). According to (Gu, Schniederjans, & Cao, 2015), the correlation coefficient (r) indicates no correlation if it is between + 0.00 and + 0.20; weak correlation if it is between + 0.21 and +0.40; moderate correlation if it is between + 0.41 and +0.60; strong correlation if it is between + 0.61 and +0.80; and very strong correlation if it is between + 0.81 and + 1.00. The association between the two sets of data is stronger when the correlation value is larger. A perfectly linear positive or negative relationship exists when the correlation is 1

or -1. There is no association between the two sets of data when the correlation is 0 (Fakhimi & Raisy, 2013). The Pearson's Product Moment method was used to obtain the inter-correlation coefficients (r).

**Table 3.** Pearson's product Moment correlation coefficient

Range	Relationship strength
±0.81 to ±1.00	very strong
± 0.61 to ± 80	Strong
± 0.41 to ±60	Moderate
± 0.21 to ±0.40	Weak
± 0.00 to ±20	None

Source: (Guilbault & Hjelm, 1989) and (Gu et al., 2015)

The following section presents the results of Pearson's product moment correlation on the relationship between Customer Relationship Management, Quality Information Sharing, Inventory Management, Facility Management, Distribution Management, and Transportation Management with Hospital

Supply chain management Practice. The study tried to measure the relationship between predictor variables and Supply chain management Practice. The correlation reveals that inventory management (r = 0.907), quality information sharing, and customer relationship management (r = 0.867 and 0.835) are strongly correlated with Supply chain management Practice, respectively. This implies that improvement given in the areas of inventory management, quality information sharing, and customer relationship management can bring remarkable results in Supply chain management Practice in the study area. Similarly, facility management was moderately correlated with Supply chain management Practice with an r = 0.564. And distribution management is weakly correlated with Supply chain management Practice (r = 0.342).

**Table 4.** Correlation coefficient of the dependent and independent variables (SPSS result data,2022)

		Correlations						
		SCMP	CRM	QISH	IM	FM	DM	TM
SCMP	Pearson Correlation	1	.835	.867	.907	.564	.342	.033
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.602
	N	249	249	249	249	249	249	249
CRM	Pearson Correlation	.835	1	.704	.837	.406	.545	.049
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.445
	N	249	249	249	249	249	249	249
QISH	Pearson Correlation	.867	.704	1	.781	.529	.251	.023
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.722
	N	249	249	249	249	249	249	249
IM	Pearson Correlation	.907	.837	.781	1	.491	.471	.083
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.194
	N	249	249	249	249	249	249	249
FM	Pearson Correlation	.564	.406	.529	.491	1	.058	.062
	Sig. (2-tailed)	.000	.000	.000	.000		.365	.328
	N	249	249	249	249	249	249	249
DM	Pearson Correlation	.342	.545	.251	.471	.058	1	.066
	Sig. (2-tailed)	.000	.000	.000	.000	.365		.298
	N	249	249	249	249	249	249	249
TM	Pearson Correlation	.033	.049	.023	.083	.062	.066	1
	Sig. (2-tailed)	.602	.445	.722	.194	.328	.298	
	N	249	249	249	249	249	249	249

Where: SCMP (Supply chain management practice), CRM (Customer Relationship Management), QISH (Quality Information Sharing), IM (Inventory Management), FM (Facility Management), DM (Distribution Management), and TM (Transportation Management).

The customer relationship management and Supply chain management Practice correlation analysis in Table 3 was ( $r = 0.835$ ,  $p < 0.000$ ), indicating a favorable and significant link with supply chain performance. This suggests that variables will be crucial in improving future supply chain performance. This study's findings were supported by earlier research done by (Nwachukwu & Hieu, 2021). Their study found that Supplier and customer relationship management practices are significantly related to financial health, market and sales performance, and operational performance. Furthermore (Gu et al., 2015) found the perception of direct and indirect network externalities has the potential to moderate technology adoption relationships in supply chain organizations, suggesting the impact of other moderating variables should be considered as factors in adoption and diffusion of technologies in supply chains.

The correlation analysis between quality information sharing and Supply chain management Practice on Table 3 was positive and very strong relationship ( $r = 0.867$ ,  $p < 0.000$ ). This indicates that quality information sharing has great role to enhancing Supply chain management Practice. This finding is in line with finding of (Marinagi et al., 2015), they suggests that Higher overall performance is made possible by partners along the supply chain sharing information. Information quality and reliability have improved as a result of essential supply chain management practices. Whereas, (Gebisa & Ram, 2021)'s analysis reveals that there is no direct relationship between information sharing and organizational effectiveness. Its linkage is mediated by supply chain partners' collaborative activities. This implies that although information sharing is important, it is not sufficient to enhance performance significantly by itself.

The correlation analysis between Inventory management Supply chain management Practice was positive and strong with ( $r = 0.907$ ,  $p < 0.000$ ). Inventory management also have great role for increasing Supply chain management Practice as previous variable. (MENG, 2006) as recommend in 2006 Inventory management that is efficient allows for speedy achievement of the procurement objective. Inventory serves as the link in the supply chain as a whole. When inventory management is optimized, upstream activities will operate efficiently and downstream activities will continue without interruption.

The correlation analysis between Facility management and Supply chain management Practice is ( $r = 0.564$ ,  $p < 0.000$ ) the positive and moderate relationship results. This indicates that the variables are plays a moderate role to enhancing for Supply chain management Practice in the future. The correlation analysis between distribution Management and Supply chain management Practice is ( $r = 0.342$ ,  $p < 0.000$ ) the positive and weak relationship results. This indicates that the variables are plays a minor role in enhancing Supply chain management Practice. The finding is supported by researchers like Distribution and Supply Chain Management (Stobbe, 2008) a strategic collaborative approach with customers and suppliers can deliver even greater benefits. Distribution can also play a major role in making the firm more environmentally responsive. All channel and supply chain efforts are designed to increase customer service. The intent is to delight the customer.

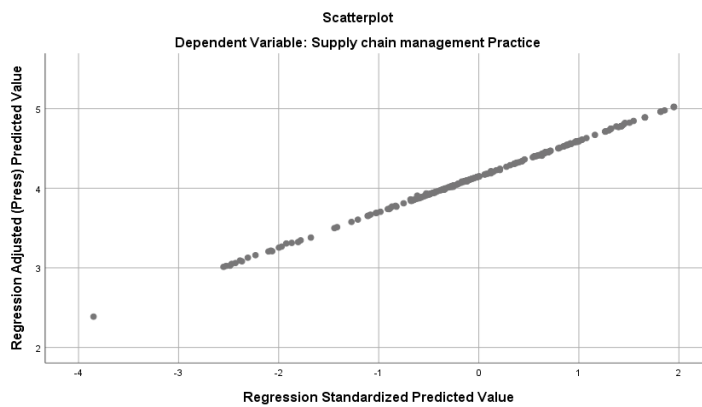
The correlation analysis between transportation and Supply chain management Practice is ( $r = 0.033$ ,  $p < 0.602$ ) is not correlated. This indicates that these variables do not have impact on Supply chain Practice in the study area. But the study conducted by (Crainic & Laporte, 2016) stated that we wish to focus on the distribution

management activities of the supply chain that happen between manufacturing sites and end users in "Transportation in Supply Chain Management." This is a rapidly expanding field with major economic and scientific implications.

### Multiple Regression Analysis

Major assumptions should be used to test multiple regression models. The outcomes of the researcher's testing of the main hypotheses, including the linearity assumption, multi co linearity, outliers, normality, and Homoscedasticity assumption, are as follows.

Assumption #1: Linearity test the relationship between IVs and the DV is linear.



**Figure 1.** Scatter plot dependent variable with one of independent variable

SPSS output (2022)

According to the scatter plot created by SPSS, a straight line might be used to model the relationship between the IV and DV, indicating that it is a linear relationship. The assumption of linearity is that there is a linear relationship between two variables. In a scatter plot, the data will fall in a straight line or a cluster that is nearly straight if the

variables are linearly connected (Nancy, Karen, and George, 2005). With this thought in mind, it would be possible to comprehend the data in Fig. 4.1, which depicts a relatively shaped fall in a cluster rather than a curve or bend line. The data is linear as a result.

Assumption #2: Multicollinearity Test

**Table 5.** Multicollinearity Statistics

		Coefficients <sup>a</sup>	
Model	Co linearity Statistics	Tolerance	VIF
		1	Customer relationship management
	Quality of information sharing	.356	2.806
	Inventory management	.226	4.418
	Facility management	.712	1.405
	Distribution management	.640	1.563
	Transportation management	.978	1.022

a. Dependent Variable: Supply chain management Practice  
 Source: SPSS result (2022)

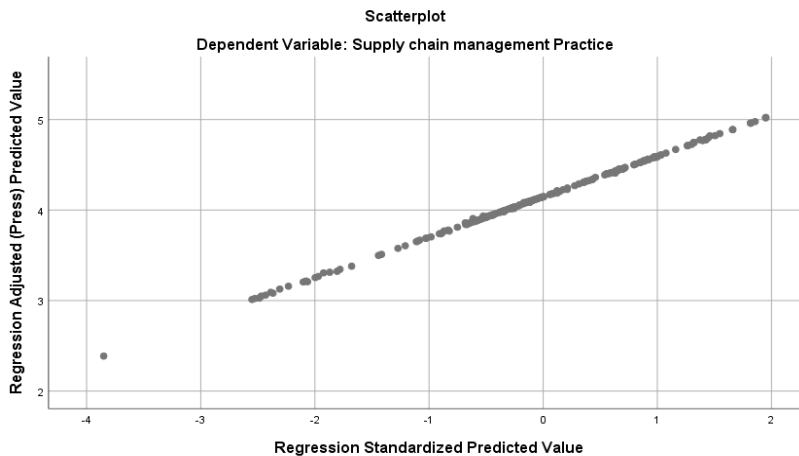
If your predictors are correlated, the VIF quantifies the increase in variance of an estimated regression coefficient (De Leeuw, 2009) Multicollinearity (also known as collinearity and inter-correlation) the researcher used the variance inflation factor approach to determine whether the explanatory variables were multicollinearity. When VIF is greater than 10 and tolerance is less than 20%, there is a chance of multicollinearity. The VIF value for this study is 4.41, which is lower than the 10 and tolerance greater than 0.27. As a result, there is no multicollinearity issue, even though variables have a loose correlation.

Assumption #3: The values of the residuals are independent

The Durbin-Watson statistics showed that this assumption had been met, as obtained the value range from 1.5- 2.5 ,Durbin Watson =1.831 (Chatfield, 2014).

Assumption #4: Homoscedasticity test

At every point along the model, the same basic assumption is tested to determine how much the residual (or amount of error in the model) varies. The scatter plot that was generated at the outset can help us understand this. Plotting the standardized value our model would predict against the standardized residuals found will allow us to evaluate the assumption.



**Figure 2.** Scatter plot of supply chain performance  
 Source: SPSS output (2022)

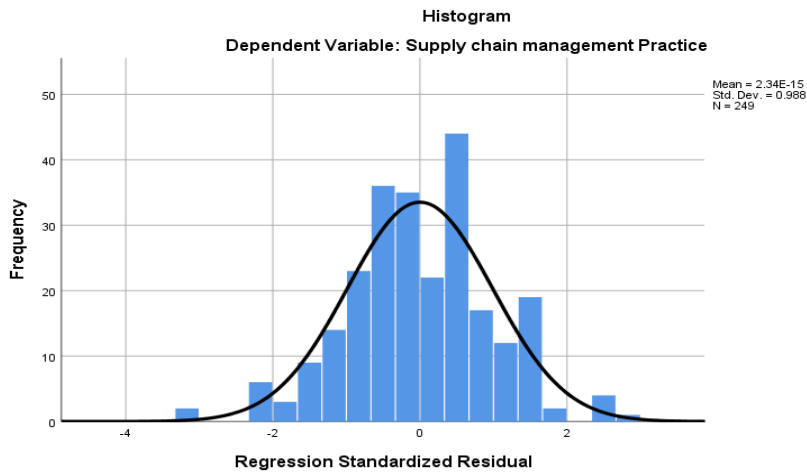
Our plot of the standardized residuals vs the standardized predicted values revealed no strong indications of funneling, indicating the Homoscedasticity assumption has been satisfied. Plotting the residual versus the expected value is one way to identify Homoscedasticity. Consequently, look for a modification in the distribution of the

depicted dots (La Moreaux & Doe, 2012).

Assumption #5: Normality test

Normality relates to the shape of the data distribution for an individual metric variable and its relationship to the normal distribution. One of the methods that will determine normality is the assessment of the variable level of skewness and kurtosis.

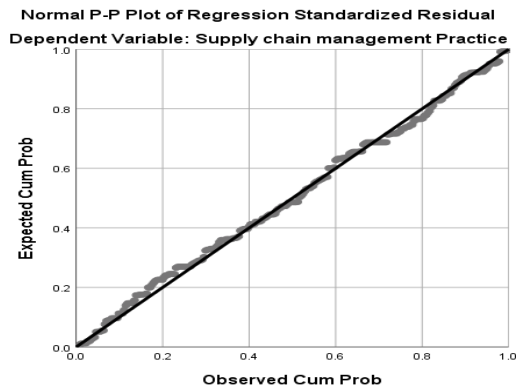




**Figure 3.** Histogram  
Source: SPSS output (2022)

When the curve does not pass through either the left or the right side of the data distribution, as it is described in histogram presentation, normality is present (Gujirati,

2004). The data indicated that it was normally distributed, as shown in the histogram.



**Figure 4.** P-P plot of standardized predicted value  
Source: SPSS output (2022)

A P-P plot (probability–probability plot) is another helpful graph that the researcher can check to see if a distribution is normally distributed. The plots, according to Hair, (Hair, Anderson, Babin, & Black, 2010) differ from residuals plots in that the normal distribution is used to compare the

standardized residuals. The plotted residuals are compared to the normal distribution's diagonal, which is typically a straight line. In the event of a normal distribution, the residual line will nearly resemble the diagonal (Pan, 2013). Therefore, the data was normally distributed, as shown in the picture

below. The residual values are normally distributed. The P-P plot for the model indicated that the residuals' assumption of normality was fulfilled.

**Reliability test**

Cronbach's alpha was utilized as the indicator in a reliability analysis to evaluate the reliability of the Likert scale that was employed in this study. A reliability coefficient of 0.7 was deemed to be sufficient. The reliability coefficient from Table 5 under was reported in this case, showing that the Likert scale had a sufficient level of internal consistency.

Reliability Statistics	
Cronbach's Alpha	Number of Items
.752	7

**Figure 5.** Reliability test  
 Source: SPSS output (2022)

Just by looking at the items, the researcher

**Table 6.** Model summary

Model Summary <sup>b</sup>				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.953 <sup>a</sup>	.909	.907	.148

a. Predictors: (Constant), Transportation management, Quality of information sharing, Distribution management, Facility management, Customer relationship management, Inventory management  
 b. Dependent Variable: Supply chain management Practice

Source: Data output (2022)

The aforementioned regression model shows how much variance in the kaizen implementation measure can be accounted for by the underlying independent variables. R: This value, which ranges from 0 to 1, represents the value of the various correlation coefficients between the predictors and the outcome. A bigger value denotes a stronger correlation, and a value of 1 denotes an equation that accurately predicts the observed value.

R square (R<sup>2</sup>) indicates the proportion of variation that can be explained in the

would conclude that the test is a reliable indicator of the concept being assessed. The majority of the items included in the instrument were matched to the concept, according to the researcher's evaluation of how well each measuring item matched the idea's provided conceptual domain. As a result, it demonstrates appropriate instruments for this investigation to reach an acceptable conclusion.

**4.3 Multiple regressions**

Since a multiple regression equation determines the best-fitting line based on the method of least squares, multiple regressions was also employed to determine the degree to which the explanatory factors explain the variance in the explained variable (Gujirati, 2004). In order to assess how well the five independent variables predict the dependent variables, we treated them as independent variables.

dependent variable by the linear combination of independent variables. In other words, adjusted R<sup>2</sup> is a measure of how much of the variability in the outcome is accounted for by predictors. The value of R square also ranges from 0 to 1 (Sekaran, 2003). The linear combination of supply chain management variables They explain 90.9% of the variance in supply chain management at the study area, along with transportation management, quality information sharing, distribution management, facility management, customer relationship

management, and inventory management, and the remaining 9.1% is explained by

extraneous variables that were not included in this regression model.

**Table 7.** ANOVA Table

Model		ANOVA <sup>a</sup>				
		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	52.711	6	8.785	403.100	.000 <sup>b</sup>
	Residual	5.274	242	.022		
	Total	57.986	248			

a. Dependent Variable: supply chain management practice  
 b. Predictors: (Constant), Transportation management, Quality of information sharing, Distribution management, Facility management, Customer relationship management, Inventory management  
 Source: SPSS output (2022)

The overall statistical significance and acceptability of the model are displayed in ANOVA table 6 (Sekaran, 2003). The variance explained by the model, as shown in table 4.8 above, is not random, according to the p-value of 0.05 or 0.0001. Therefore, the ANOVA table above illustrates the model's acceptance. The model's fit to the data is assessed using the F-ratio. The

dependent variable's 403.1 percent significance level in the ANOVA F-test ratio meant that (p 0.01). (G. Maddala, 1992) states that the estimated value of F has to be bigger than 5. The value of -F- (403.1) is higher than the cited number, according to the researcher's summary in the table 6 above.

**Table 8.** Regression analysis result of influencing factors and Supply chain management Practice

Coefficients <sup>a</sup>						
Model		Unstandardized Coefficients		St. Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	.132	.094		1.405	.161
	Customer relationship management	.194	.031	.243	6.332	.000
	Quality of information sharing	.336	.035	.319	9.509	.000
	Inventory management	.447	.041	.461	10.953	.000
	Facility management	.066	.020	.077	3.257	.001
	Distribution management	-.046	.012	-.090	-3.695	.000
	Transportation management	-.012	.010	-.023	-1.161	.247

a. Dependent Variable: Supply chain management Practice  
 Source: SPSS output (2022)

The standardized regression coefficient Beta ( $\beta$ ) can be used in multiple regressions to compare the relative strength of each independent variable's influence on the

dependent variable, and the standardized regression coefficient Beta ( $\beta$ ) can be used to interpret the impact of each predictor variable on the dependent variable (Sekaran,

2003). The constant beta value ( $\beta$ ) and the p-value of the variables are shown in table 7 above to assess the significance of the hypothesis. The significance level (p-value) standardized coefficients of customer relationship management, quality information sharing, inventory management, facility management, distribution management, and transportation management variables are: 0.000, 0.000, 0.000, 0.001, and 0.000, and standardized coefficients of 0.243, 0.319, 0.461, 0.077, and -0.090, respectively. Except transportation management, all Independent variables have p-values that are less than 0.05. This indicates that either all the factors are effective predictors of the dependent variable or that there is a substantial relationship between the independent variables and the dependent variable (Supply chain management Practice).

## 5. Discussion of Results

This study sought to investigate the variables that influence Supply chain management Practice in the Mizan-Tepi University Teaching Hospital. Supply chain management variables include customer relationship management, quality information sharing, inventory management, financial management, distribution management, and transportation management. As mentioned in the discussion section above, all of the regression coefficients (Beta coefficients) between the predictor variables and the application of supply chain management have positive values and are significant at  $p = 0.05$ , with the exception of transportation management. As a result, distribution management had a negative relationship with the dependent variable (Supply chain management Practice).

Customer relationship management is the most significant factor of Supply chain management Practice because it has the ( $\beta =$

0.243,  $p < 0.000$ ). The Beta coefficient result of 0.243 signifies that for every 1 unit change in the independent variable (customer relationship management), the dependent variable (Supply chain management Practice) will change by 0.243. It is apparent from this result that customer relationship management is a decisive factor that affects Supply chain management Practice. The result of this study is consistent with the study conducted by (Nwachukwu & Hieu, 2021) and (Das & Hassan, 2021) Hassan. Their conclusion shows the significance of customer relationship management and Supply chain management Practice to improve product quality and customer satisfaction in Malaysian manufacturing enterprises. The study by, titled (Khan, Professor, & Ahmad, 2014) "The Power of Customer Relationship Management in Enhancing Product Quality and Customer Satisfaction," was done. He comes to the conclusion that online shopping greatly benefits from the integration of supply chain management and customer relationship management. Its impact on other areas, like aviation and offline retail, hasn't yet been felt. Therefore, from the finding, it can be said that customer relationship management at Mizan-Tepi University teaching hospital could get attention from the body concerned to achieve its strategic objective

The impact of shared quality information on Supply chain Practices significant ( $= 0.319$ ,  $p < 0.000$ ). The Beta coefficient result of 0.319 signifies that if 1 unit change in the quality of information sharing occurs, the supply chain management will change by 0.319. This implies that quality information sharing leads to good supply chain performance. These companies and industries can use knowledge of quality information sharing to develop and improve information sharing cultures and use sound inventory management techniques in supply chain practices for the improvement of

organizational performance. This study found that beyond the theoretical implications, the study gives the teaching hospital under consideration the opportunity to recognize the important impacts that information sharing and inventory management practices have on the Supply chain Practice of the teaching hospital. This is also supported by other empirical evidence like (Omar, Lo, Tan, & Siron, 2010, Omar et al., 2010, Gebisa & Ram, 2021)<sup>1\*</sup>, and Prof. Gebisa & Ram, 2021 concludes that "The study's results convincingly show how crucial it is for organizations to develop efficient information sharing amongst supply chain partners in order to improve performance."

Inventory management is another predictor that has a positive and significant influence on Supply chain management Practice ( $\beta = 0.461$ ,  $p < 0.01$ ). The Beta coefficient result of 0.461 signifies that for every 1 unit change in inventory management, the Supply chain management Practice will change by 0.461. According to (Nzioka & Were, 2017) study, the results showed that inventory control assisted the Ministry in delivering services at a high level of efficiency. Besides, (Musau, Namusonge, Makokha, & Ngeno, 2017)'s study found that inventory management has the potential to have a positive impact on the performance of textile companies. As a result, firms have invested in current material flow systems and established clear procedures to manage the orderly and transparent flow of materials that can be tracked through a supply chain.

This study shows that facility management is positive and significantly influences Supply chain Practice ( $\beta = 0.077$ ,  $p < 0.001$ ). The Beta coefficient result of 0.077 signifies that for every 1 unit change in the facility management, the Supply chain Practice will change by 0.077. The finding is supported by researchers like you. This variable was added to this model by the researcher. Therefore, no prior research supported this

research. But this variable should get attention because of its positive effect on Supply chain management Practice.

Supply chain management is positively influenced by distribution management ( $\beta = -0.09$ ,  $p < 0.000$ ). The Beta coefficient result of 0.09 signifies that for every 1 unit change in the distribution management, the Supply chain management Practice will decrease by 0.09. The finding shows Supply chain Practice is affected by facility management. Study conducted furthermore, because transportation is more difficult to monitor, it is rarely considered when determining the sustainability of supply chains, neither for Chinese nor for international businesses. This finding is supported by (Rask & Gustafsson, n.d.).

## 5.1 Summary of Major findings

The result of the correlation analysis has shown that the five independent variables: customer relationship management, quality information sharing, inventory management, facility management, distribution management, and transportation management factors were positively correlated with the dependent variable Supply chain management Practice with a 95% confidence interval and at a 0.01 p-value 2 tailed by a Pearson correlation coefficient "r"-value of 0.835, 0.867, 0.907, 0.564, 0.6342, and 0.033 respectively. Even though all variables were correlated with the dependent variable, there was a difference in the strength of the relationships. As a result, inventory management, quality information sharing, and customer relationship management were found to have stronger relationships with kaizen Supply chain management Practice at Mizan-Tepi University teaching hospital than the other variables.  $r = 0.907$ ,  $0.867$ , and  $r = 0.835$  at  $p < 0.01$  respectively. The remaining factors have moderate to weak relationships with the dependent variable. Finally, the results of the

regression analysis revealed that, with the exception of transpiration management, all independent variables were statistically significant at p value 0.05. The score of the coefficient correlation determination (R<sup>2</sup>) is 0.907, which indicates that 90.7% of the variability of the overall Supply chain management Practice of Mizan-Tepi University teaching hospital was explained by the five independent variables. The other variables that were not considered in this study contribute about 9.3% of the variability of Supply chain management Practice. In this study, the Beta weight score indicated that the effects of inventory management and quality information sharing variables are greater than other independent variables.

## 5.2 Conclusion

Following discussions of the study's findings and conclusions, the researchers came to the final conclusion that, in this specific study, customer relationship management, quality information sharing, inventory management, facility management, distribution management, and transportation management are the most crucial factors influencing the performance of the Supply chain management Practice in Mizan-Tepi University Teaching Hospital. To boost Supply chain management Practice and to decrease waste, which also improves customer happiness and the performance of the company, these elements should be carefully taken into account. The respondents in this study were chosen at random using the Yamane formula and both primary and secondary data were used to gather the study's information. In addition, questionnaires and interviews were used to address every goal of this study. The data was also examined using both descriptive and inferential statistics. A mean and standard deviation were applied from descriptive statistics, and Pearson correlation

and multiple linear regressions were applied from inferential statistics. Before analysis, every piece of data was checked and verified. The relationship between independent and dependent variables can thus be inferred from both descriptive and inferential statistics.

## 5.3 Managerial insight

Since customer relationship management is significantly correlated with supply chain performance. Mizan-Tepi University teaching hospitals should improve their customer relationships to a higher level by evaluating their customer satisfaction on a timely basis and giving on-the-job training to increase the ability and commitment of the hospital professionals, instructors and other healthy officers.

The hospital should use modern technology, implement a maximum minimum inventory control system, and provide staff training and supportive materials to aid in forecasting and acquiring essential and vital materials for teaching programs and medicine, as well as other medical laboratory equipment by which the patients will be treated. Additionally, since the university student's attachment is at this institution, the materials must be delivered on time by using scientific inventory management techniques. It was advised that the management at the department employ suitable inventory control measures to ensure high-quality goods are available in the outlets. This was done to make sure the hospital kept the necessary inventory.

It is extremely important to invest time and energy into creating favorable relationships with the supply chain partners in order to proceed toward information quality and information sharing promotion. Because of this, the Mizan-Tepi Teaching Hospital needs to focus on acquiring trustworthy data to aid senior management in making the optimal supply chain management choices.

The government must also stay updated on how the institution conducts its normal operations, particularly in regards to the delivery of supplies, medications, lab equipment, and supplies for the cafeteria and dorms. The zone and transportation authorities are also in charge of planning every supportive vehicle since the required supplies shouldn't be carried anywhere outside the hospital and the teaching hospital. This is because the purpose is to satisfy the community's wish.

#### 5.4 Limitation of the study

The findings of the research are not without

limitations. This means this study did not cover all of the factors that influence supply chain management practice, so more research is needed to identify any other factors that influence supply chain management practice. Such factors could include geographical challenges, poor infrastructure, politics, and even a legal mandate. The list is intended to be illustrative rather than exhaustive. The other limitation is that this research has been done at only one teaching hospital, which is Mizan-Tepi University Teaching Hospital. Thus, any other researcher should include as many hospitals as possible.

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## PROPOSAL OF A DYNAMIC MODEL FOR PLANNING AND MANAGING STRATEGIC OIL RESERVES

***Abstract:** Sustainable supply of essential energy resources is a priority for the economy of every country. With the increasing interdependence of economies at a global level, it is of great importance to recognize the existence of risks in key supply chains: food, products, and energy resources. One of the crucial supply chains for the daily functioning of the economy is the supply chain of crude oil and oil derivatives. This paper analyzes the concept of strategic oil reserves (SOR) as a tool for mitigating a series of disruptions in the sustainable supply of crude oil and oil derivatives. The aim of the conducted research is to find an optimal approach to modeling the national oil supply chain and the structure of strategic oil reserves. The created simulation model enables the analysis of the state of oil reserves at the national level, and provides opportunities for analyzing different management policies in conditions of interruptions in the supply of crude oil or oil derivatives. The goal of the model is to analyze the resilience of the national supply chain under the influence of various external and internal stressors. **Keywords:** System dynamics, Risk analysis, Strategic oil reserves, Energy policy, Supply chain simulation*

### 1. Introduction

National energy security, manifested through reliable access to energy for the population, economy, and public sector, represents a priority for every state. In the early 1970s, one of the first integrations of risk management and national energy security strategy emerged through the formation of the concept of strategic energy reserves (Leffler, Melvyn, 1985). The concept of strategic energy reserves involves the procurement and preservation of various energy fractions, which have a defined usage cycle according to the security and economic circumstances in which a state finds itself. These reserves serve as a buffer to mitigate the effects of unwanted events, in case of uncontrolled volatility of energy prices or uncertainty from producers or suppliers of a particular energy source. The most

frequently analyzed energy reserves by regulatory bodies and economic agents are strategic oil reserves (SOR). The formation of strategic oil reserves became an essential state policy at the global level in the 1970s (Davis, Ruth, 1981).

Due to the energy crisis caused by the Arab oil embargo, which lasted from 1973 to 1974, the United States Congress approved the formation of strategic oil reserves (SOR) and a series of regulatory bodies aimed at preserving national energy security (Andrews, Pirog, 2012). With the establishment of the SOR in 1975, the United States launched a strategic state project on its territory to ensure the country's energy resilience. The adopted US Energy Policy and Conservation Act strictly defines the conditions under which strategic oil reserves can be used (Hubbard, Weiner, 1985). The United States also commits to

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using its strategic oil reserves according to the need of establishing energy stability for the member states of the International Energy Agency (IEA). In accordance with the defined IEA regulations, all member states are required to establish a strategic oil reserve system that ensures the availability of 90 days of net oil imports (Van de Graaf, Lesage, 2009). All forms of SOR (strategic oil reserves) are considered a risk mitigation strategy, or insurance policy for national energy security. In addition to the direct importance of establishing an energy reserve system for a country, SOR and other energy reserves can have a significant impact on maintaining economic stability and cooperation among different states in a region. There are several ways in which a country's strategic oil reserves and other energy reserves can be formed. The main factor in determining the structure of the energy reserve system is the level of capital investments that a state is willing to allocate for ensuring energy security. The research paper proposes a simulation model for analyzing energy resilience on a country level and provides planning capabilities for forming or improving existing SOR. The study examines the concept of strategic energy reserves as a tool for mitigating various risks in the energy sector. The aim of the designed model is to enable the simulation of the effects of different socio-economic crises and natural disasters and the ability of the energy system to respond reliably to market needs.

## **2. Energy System Resilience and Risk Assessment**

From 1950 to the second decade of the 21st century, more than 30 energy crises related to the availability of crude oil and oil derivatives have been recorded. The duration of these disruptions varies from two consecutive quarters to multi-year periods

(Chen, et al., 2020). In addition to the occasional uncertainty in oil price and availability, it is important to highlight the significance of energy stability in the natural gas supply. Global natural gas supply for industrial and household needs is experiencing significant annual growth due to its cost-effectiveness and low impact on the global warming process (Yousaf, Lin, 2022). However, energy risks related to the supply of this energy source came to the forefront with the onset of the Russo-Ukrainian War in 2022 (Mbah, Wasum, 2022). European Union countries have established a legal system for dealing with crisis situations caused by energy crises (Mastropietro, 2022). Unwanted events in global energy markets, besides legal infrastructure, require an adequate approach to risk management in achieving national energy security. Recognizing trends that affect national energy security, as well as a sustainable energy supply in regional complexes, is of crucial importance for establishing an energy risk methodology (Stanojević, 2022).

Methods for energy risk must indicate strategies: measurement, mitigation (alleviation), and further prevention of unwanted stressors, which come from volatile events in global energy markets. Tools and methods for energy security planning must be able to encompass the entire energy system of a country and, with an adequate level of reliability, display the dynamic behavior of the system under different conditions. Understanding the limitations of each risk analysis tool for the analysis of complex systems such as the oil supply chain is crucial in the planning process, i.e., the planning process itself must be adjusted according to the limitations in accurately predicting how the dynamic system will respond to an unwanted event. Global oil supply chains are greatly influenced by political decisions, which

require frequent political risk analysis in the decision-making process (Gebelein, Pearson, Silbergh, 1978). Tools for determining political risk, due to their often dependence on expert opinion input, which represents an unreliable tool for risk analysis (Shiller, 2002), can jeopardize the integrity of the rest of the model.

Most tools for measuring and mitigating risk within the energy market are adapted for the needs of financial institutions in creating value through financial transactions related to energy prices (Eydeland, Alexander, Wolyniec, 2002). Although these tools can be used for specific aspects of national energy security, there is a need to develop methodologies specialized for national energy security challenges. The energy system of each country can be classified as a complex system, and therefore, analyzing risk using conventional methods such as VaR (value at risk) is inadequate (Sadeghi, Mehdi, Shavvalpour, 2006) and carries a range of drawbacks and potential hazards (Geman D, Geman H, Taleb, 2015). The high degree of unreliability of often-used econometric tools should be considered when analyzing complex nonlinear systems (Taleb, 2009). There are several risk management studies that point to the shortcomings of highly complex statistical models in their practical application compared to simpler models based on good heuristics (Makridakis, Taleb, 2009).

### **2.1. Concepts of resilience and anti-fragility of systems**

One of the drawbacks of traditional risk analysis methods for complex systems can be seen in their failure to recognize the phenomena of resilience and anti-fragility of systems. Resilience defines the ability of a system to recover its capacities to its original state after an unwanted event or stressor (Afgan, Veziroglu, 2012). The concept of

anti-fragility is significantly more complex than resilience and is based on an established approach to modeling and mapping dynamic behavior in complex systems (Taleb, Douady, 2013). Anti-fragility defines the ability of a system to reach a superior state to the initial one after an unwanted event or stressor (Aven, 2015). Anti-fragile systems, like biological organisms, are in a continuous phase of adaptation, i.e., learning from previous mistakes and stressors. One of the common criticisms of strategies for achieving resilience in companies or supply chains is the lack of preparation of the system for the next risk, which may have greater intensity and complexity than already realized events. Biological systems, after exposure to an unwanted event, tend to enter a state of overcompensation (Tomov, 2019), i.e., they create reserve capacities to overcome an unwanted event of greater intensity in the future.

The subject of research is to examine the optimal approach for modeling and simulation of the oil supply chain, formation of the structure of strategic oil reserves, and analysis of system resilience. In addition to the conventional approach to creating the ability of the system to be resilient, the possibilities and strategies for achieving a certain level of anti-fragility of the national oil supply chain must be analyzed. The concept of strategic oil reserves is viewed as a dynamic system that requires continuous adaptation to better enable a country's energy security. The reason for proposing that the national oil supply system must be more than resilient stems from the belief that unwanted events in the future for the analyzed system will not have the same dynamics as already realized risks (Taleb, 2012).

### **3. Modeling the Oil Supply Chain**

Global oil supply chains (OSC) consist of 3 operationally dependent segments: upstream

production, midstream logistics and transportation sector, and the downstream processing and marketing sector (Hadi, Nickel, Ashayeri, 2014). All three mentioned segments involve different forms of oil or oil derivative storage, requiring reliable logistical coordination between agents located in different sectors of the supply chain. Operators in different segments of the supply chain, i.e., extraction, processing, transportation, and distribution sectors, differ significantly in the infrastructure and operations they carry out, as well as in the risks they are exposed to.

Upstream production encompasses all primary extraction and storage systems for oil and gas, with economic entities in this segment facing the highest degree of risk and uncertainty in finding and efficiently extracting the energy source. The process of evaluating potential investments represents a complex and uncertain endeavor, however, the risk-reward ratio in this sector is extremely high compared to other segments of the oil supply chain (Surbhi, 2012). Other OSC segments carry significantly lower risks and are based on the process of transportation, storage, processing, and marketing operations of oil and oil derivatives. Regardless of their position in the OSC, state and private economic entities are interdependent, and the efficient functioning of the entire system depends on avoiding disruptions in any part of the chain.

Complex systems like the oil supply chain, in terms of mathematical modeling by their structure, are nonlinear, and composed of a series of feedback loops and delay functions. One approach to analyzing a complex system like the oil supply chain is the use of simulation technologies. Modeling and simulating systems of different levels of abstraction can be carried out through the use of 3 simulation approaches: system dynamics, discrete-event simulations, and

agent-based simulations (Borshchev, et al., 2014). These approaches offer opportunities in simulating low abstraction segments in the energy system, such as physical oil pipeline networks and energy storages (Bauer, et al., 2019), up to the possibilities of numerical analysis of high abstraction elements like energy policy and supply-demand systems (Daneshzand, et al., 2018). It is important to note that complex phenomena in supply chains, such as the bullwhip effect, were initially conceptualized after the emergence of simulation methodologies, such as system dynamics (Hadžimetović, Vujošević, 2017). The creation and development of simulation methodologies provided a range of possibilities for simulating and optimizing systems such as: health systems (Stainsby, Taboada, Luque, 2009), supply chains (Angerhofer, Angelides, 2000), infrastructure projects (Han, Love, Peña-Mora, 2013), municipal systems (Winz, Brierley, Trowsdale, 2009), etc. Simulation methodologies offer the possibility to conceptualize any complex system graphically and numerically, with the aim of implementing optimization or the desired form of analysis.

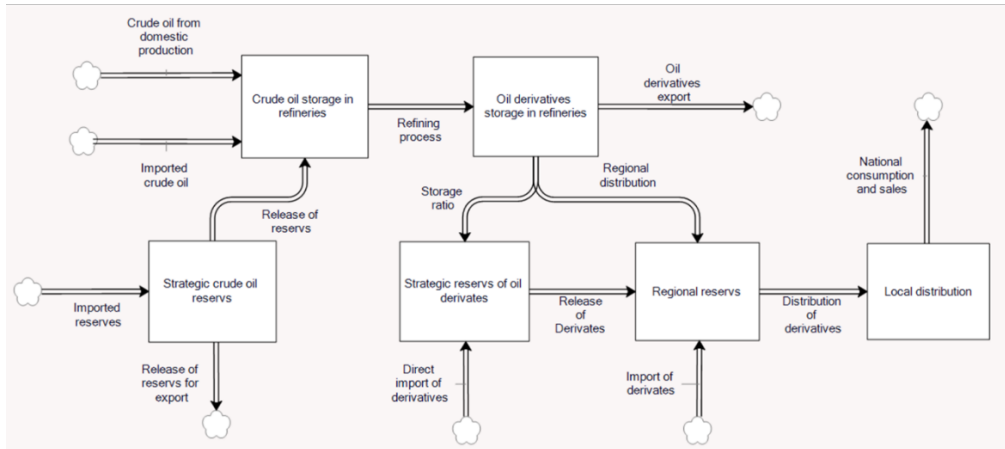
### 3.1 Model Proposal for Analyzing SOR

The strategic oil reserve management model should encompass the operations of an entire country's energy supply chain, i.e., the Strategic National Reserve (SNR) model represents only part of the model structure simulating the broader system. In the case that a country's energy system includes oil and gas production, the model can have several benefits in covering that segment of the supply chain as well. The designed model consists of multiple levels of abstraction of the oil and oil derivatives supply chain. Figure 1 shows a macro-model of strategic oil reserve operations and the overall supply chain. The macro-model encompasses the consideration of strategic



reserves of crude oil and oil derivatives, with great importance placed on adequately defining the structure of SNR flows within

the oil supply chain.



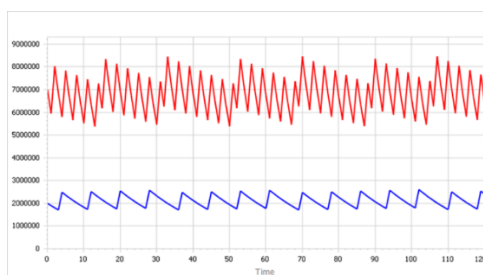
**Figure 1.** Macro-model of SOR supply chain

The flow of oil and oil derivatives in the macro model functions from the left side of oil production and imports towards the right side of exports and sales. In the macro-model, the Strategic National Reserves (SNR) is defined with two levels: Strategic Crude Oil Reserves (SCOR) and Strategic Oil Derivative Reserves (SODR). The value of the SCOR level is regulated by changes in the Crude Oil inflow from imports for SCOR and outflows for stock release and export stock release. The stock release outflow allows crude oil from the SCOR to be released into the national system, i.e., refilling crude oil stocks in refineries.

The designed oil supply chain model contains populations of different agents. The model is designed to contain a population of state entities for: oil storage, processing, transportation, and sales. Therefore, the model differentiates between state-owned oil and oil derivative stocks within the system and privately-owned stocks. Figure 2 shows the values of crude oil stocks in state-owned (red) and privately-owned (blue) refineries. It is important to emphasize that the model

The model uses experimental data on refinery capacities in the European energy sector for 2022 (Klepikov, Pavlovich, Klepikova, 2022).

In Figure 2, a strategy is simulated requiring state and private refineries not to let their crude oil stocks fall below a certain amount, with values expressed in barrels of crude oil.



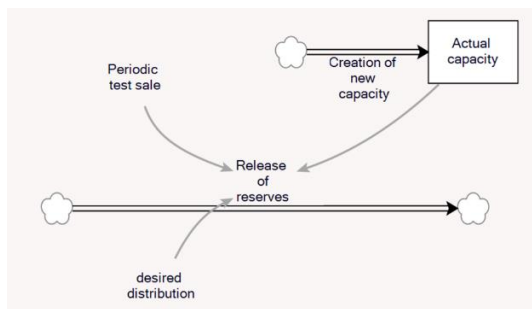
**Figure 2.** Value of crude oil storage levels at refineries.

can calculate different policies towards

strategic oil reserves, from using and expanding state capacities to creating SNR within the private sector. There are several structures for organizing strategic oil reserves, from a system of state ownership over reserves to integration with the private sector (Colgan, 2009). The macro model in Figure 1 shows the outflow, i.e., stock release for export, indicating the sale of crude oil stocks or exchanges with other countries. The model itself can simulate different policies toward releasing crude oil reserves into the system and policies toward oil derivative reserves. The policy of releasing oil derivative reserves into the system in case of disruption should be specifically analyzed both at the local micro-level and the macro-level of the state.

The macro-model in Figure 1 is defined with multiple sub-models that calculate the values for inflows and outflows in the macro-model. The outflow of stock release shown in Figure 1, which determines the quantities of crude oil to be released into the system in the event of a disruption, obtains values from the sub-model shown in Figure 3. The variable Periodic Test Sale aims to initiate smaller sales/releases of crude oil reserves. The Periodic Test Sale of Strategic National Reserve (SNR) is used as a tool to analyze the efficiency of system operations, i.e., identifying all irregularities, blockages, and bottlenecks during SNR operation. It is essential to identify all problems in distributing crude oil from the Strategic Crude Oil Storage (SCOS) in smaller releases. The importance of implementing test sales is potentially highest in the case that a state has designed its strategic energy reserves in partnership with private sector companies, making the system potentially more complex to manage. Another form of smaller crude oil release from SCOS is the implementation of Crude Oil Exchange. The variable Crude Oil Exchange simulates the process of distributing smaller amounts of

crude oil reserves to private entities that are in short-term blockages in servicing the market. This process aims to mitigate short-term problems in the distribution of oil and oil derivatives in the market. Crude Oil Exchange can be viewed as a form of "short-term credit" that the state enters into with a private distributor, so that the exchange is exclusively conducted with oil, and the distributor is expected to return crude oil to the SNR and pay the prescribed premium.



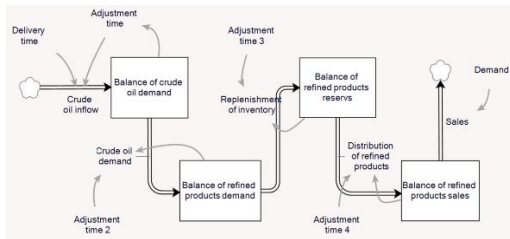
**Figure 3.** Sub-model for calculating the value of stock release outflow.

The release of oil stocks from SCOS is primarily done to remedy major disruptions in the supply chain, representing the primary goal of this system. The model is designed for entering different types of disruptions, where the calculation of the extent of interruptions and available distribution capacities from SCOS determines the numerical value for the outflow variable Release of oil stocks.

An essential segment of the model is the sub-model for calculating the supply and demand ratio, primarily in analyzing the "bullwhip" effect in the supply chain. The sub-model has a similar structure to existing simulation models for analyzing the "bullwhip" effect in oil supply (Zhang JH, Zhang QQ, 2013). The sub-model consists of 4 levels: Crude oil demand balance, Refined product demand balance, Refined product inventory balance, and Refined product sales balance. The sub-model analyzes the

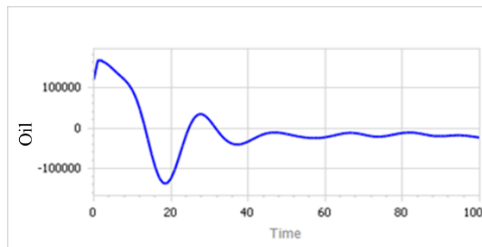
demand for oil derivatives from the market and the system's ability to meet market requirements. Each level in the sub-model calculates the supply and demand balance, and thus, the new value can be negative. Balances do not represent the physical stocks of oil in the system, where in that case, any of the 4 levels could not have a value below 0.

The flow of information in the model proceeds from right to left, i.e., the market creates a pull effect. Each of the levels represents a segment of the supply chain: import of crude oil, storage, processing, and further storage and distribution.

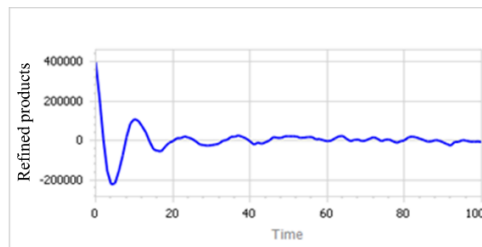


**Figure 4.** Sub-model for calculating the supply and demand ratio.

During the analysis of the bullwhip effect in the supply chain, it is of great importance to determine the precise delay time between the chain segments. Processing time or delay time between entities in the distribution chain plays a crucial role in the function of the entire chain. For the purposes of this work, experimental values from studies that have investigated this phenomenon using system dynamics were used (Zhang JH, Zhang QQ, 2013). Figure 5 shows the values for the crude oil demand balance at the beginning of the sub-model. Market demand is defined by the function  $\text{RandomUniform}(135000, 160000)$ , with the units for the function being barrels/day.



**Figure 5.** Crude oil demand balance



**Figure 6.** Refined product sales balance

Figure 6 shows the refined product sales balance, which exhibits significant instability in the first 20 days of operations. The oscillations shown in the sub-model indicate significant blockages in the supply chain and inadequate inventory holding in the chain. It is important to note that the general economic interest of stakeholders in supply chains is to avoid holding excessive inventory, as this policy leads to a deterioration of the company's cash flow and creates a range of operational risks. As already noted, the sub-model does not display the values of physical oil or refined product stocks, so the stocks themselves cannot be negative. The importance of this segment of the model is to point out potential oscillations in the supply chain to which the SNR system can respond.

## 4. Conclusion

A dynamic model for strategic planning of state energy policy has been designed. Through the use of the model, it is possible to determine the resilience of the national oil supply chain to various disruptions. The dynamic model examines the flow and

storage of state and private reserves of crude oil and oil derivatives. From the model, it can be concluded how long the national economy is able to function under conditions of limited oil supply and different policies regarding strategic oil reserves. The model allows for testing different policies towards strategic oil reserves, as well as the possibility of considering alternatives for reconstructing the entire system, through increasing private sector participation in the SNR system. Future research can be directed

towards expanding the model to analyze reserves of other energy sources, as well as the functioning of distribution capacities in various emergency situations.

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## QUALITY CRITERIA IN UNIVERSITIES

**Abstract:** *The increase in the number of universities in all countries in recent years has necessitated a rethinking of the criteria for evaluating education. It is important to keep in mind that no single indicator can capture all the factors that contribute to the quality of a university and different institutions may prioritize different factors depending on their strengths and objectives. It is important to note that university quality is a multifaceted concept and cannot be assessed based on only one indicator. A comprehensive assessment of a university's quality may require consideration of multiple indicators and contextual factors in order to get a holistic picture of its overall performance. Creative and innovative thinking is at the heart of this. As a result, many different criteria emerge. Quality is undoubtedly the first criterion that comes to mind. There have been great developments in this regard in Turkey. Every institution has started to create strategic plans targeting quality. In this sense, the Higher Education Council in Turkey has taken a new step in higher education with YÖKAK (Higher Education Quality Authority). Now, all universities are subjected to external evaluation, monitoring and accreditation by preparing KIDR (Internal Evaluation Report). It is observed that this is a great quality move for our country. In this sense, YÖKAK is making efforts to realize the desired quality indicators in universities not only on a formal basis but also on the basis of practice. In this sense, YÖKAK has been working on 4 basic issues (Leadership, Governance, Quality-Education, Teaching-Education, Teaching-Research Development-Social Contribution) which are addressed in quality in all universities. A systematic structure has been established to monitor quality. Each university now has a Quality main heading on its web pages, and the studies carried out are explained to the society. Of course, these studies find an increasing place not only on the web page but also in the application areas. In this study, quality criteria in Turkish universities are explained in a basic sense and suggestions are given about what needs to be done.*

**Keywords:** *Image, innovation, business*

### 1. Introduction

Quality is generally defined as "the degree to

which a set of inherent properties (attributes) of an object satisfies a set of requirements".

The quality of an object is therefore

determined by comparing a set of predetermined characteristics against a set of requirements. If these characteristics conform to the requirements, high quality is achieved. A traditional definition of quality includes literacy, numeracy and life skills and is directly linked to critical components such as content, methodologies, curricula, examination systems, policy, planning and management.

Academic quality is a way of describing how well the learning opportunities offered to students help them reap the rewards. It is about making sure that appropriate and effective teaching, support, assessment and learning opportunities are provided for them. A common policy debate in countries around the world is whether education is public or private. Students recognize that the benefits are individual. Quality education helps in finding a job, raising social status, etc. Policy makers assume that the benefit is sociopolitical. Quality education has to be in place to increase national productivity and social equality or social cohesion and political solidarity. Depending on one's perspective, quality education should be measured by its cost-effectiveness relative to employment; and from another perspective, it should be measured by overall intellectual output. Although quality has become the center of attention, neither its meaning nor its use is consistent. Indeed, there is no agreed technical side to the concept of quality in higher education. Its meaning and use often involve a heavy contextual overlay of some political or educational position" (Lindsay, 1992). Although quality has come into the limelight, neither its meaning nor its implications are always clear. Indeed, there is no agreed technical specification of the concept of quality in higher education. Its meaning and use often involves the overlay of some political or educational issues (Lindsay, 1992). Quality in higher education encompasses all its functions, activities, teaching and academic programs, research

and scholarship, staff, students, buildings, facilities, equipment, services to the community and the academic environment (UNESCO.1998).

The world knows that the economic success of states is directly determined by the quality of their education systems and that the most influential factor of production is human capital, expressed in the knowledge, skills, creative abilities and moral qualities of individuals in society. In the last decade, higher education institutions have come to be considered within the growing importance of knowledge-driven economies that place them at the center of national competitiveness agendas all over the world. Higher education institutions are increasingly viewed by policy makers as "economic engines", enabling the generation of knowledge through research and innovation and the continuous training of the workforce. As a result, higher education policy on quality in higher education is becoming increasingly important on European and national agendas. The widespread recognition that higher education is the main driver of economic competitiveness in an increasingly knowledge-driven global economy has made higher education more important than ever. The imperative for countries is to increase higher levels of employability skills, maintain a globally competitive research base and improve knowledge dissemination for the benefit of society.

When it comes to global trends in higher education, universities are caught in the middle of the public-private debate. This has led to the desire to contribute to human development and career skills; to attract highly qualified students, which also raises the institutional status; and to be seen as key social institutions in their countries. Therefore, the most important indicators in recent times include student selectivity, reputation and research output. These indicators assume that at least a good university will be an elite university, whether



or not it meets various individual and societal expectations of universities.

Increasingly, research impact is seen as the most important quality indicator in higher education. Research impact is typically measured by rewards such as the Nobel Prize, research grant income and article citations (good research papers are more often cited by other researchers). While research impact does not directly affect the quality of education, it serves a university's educational mission in two different ways: First, it informs teaching with the latest and most advanced knowledge; second, it enhances university reputation, thus making research-intensive universities more selective. But research does not have a direct and immediate impact on teaching quality, and in many highly ranked research universities, the faculty members who do the best research are the ones who teach the least. Thus, countries that focus on building their higher education systems and institutions solely through increasing research productivity may still face significant challenges in increasing employment and income for their citizens. Other countries are therefore looking instead at measures that focus on teaching quality, intellectual rigor and workforce skills.

Such measures include employer reputation, student retention, percentage of international faculty and the like. But when it comes to global university rankings, research still trumps education. Such metrics include employer reputation, student retention, percentage of international faculty and the like. But when it comes to global university rankings, research still trumps education. Such metrics include employer reputation, student retention, percentage of international faculty and the like. But when it comes to global university rankings, research still trumps education.

In order to raise the social and intellectual level of students and raise their level of awareness, universities make use of quality measures and even link this measure with the

transition of students into business life, such as the entrepreneurship index.

University quality indicators are quantitative or qualitative measures used to assess the overall quality of a university. These indicators can vary depending on the context and purpose of the assessment. In the case of academic rankings, various organizations such as Times Higher Education, QS World University Rankings and Academic Ranking of World Universities (ARWU) interpret available data in terms of publications, research output, international reputation, faculty qualifications and student-faculty ratio. It is important to note that university quality is a multifaceted concept and cannot be assessed based on only one indicator. Quality in universities should be seen as an area that can be continuously improved.

Universities should aim for excellence in education and training processes. Factors such as up-to-date and innovative curricula, effective teaching techniques, classroom interaction, real-world applications and internship programs should be considered to improve the quality of education. Qualified and experienced academic staff is an important factor determining university quality. Universities should attract academics who are experts in their fields and have up-to-date knowledge, support them and encourage their continuous development. Factors such as research support programs, research infrastructure, scientific publications and projects can help improve university quality. Universities should improve the support services provided to students. Services such as academic advising, career planning, scholarships and financial support, guidance and psychological counseling can help students improve their success. Strengthening physical and technological infrastructure: Up-to-date and adequate physical infrastructure, laboratories, libraries and technological resources can improve quality. It is important to strengthen infrastructure through investments and to adapt to modern

technologies.

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.In addition, universities should implement quality assurance and evaluation mechanisms. Within the continuous quality improvement cycle, performance evaluations, accreditation processes, peer review and other quality assurance methods should be used to assess the performance of the university and identify opportunities for improvement. In short, universities should have a strategy for quality improvement.

## **2. Where to start to create quality in universities**

In order to create quality in universities, a quality management system must first be established. This system ensures that the university is managed in accordance with its quality policy, objectives, strategies and quality standards. This should start with analyzing the strengths, weaknesses, opportunities and threats of the university. This analysis provides a basis for how the university's quality management system will be established and in which areas improvements need to be made, which should already be set out in the quality policy. The quality policy should include a clear statement of the university's quality objectives and commitments. Quality objectives should be set in accordance with the quality policy and should be measurable. The university's activities, processes and procedures should be identified and the quality of these processes should be assessed to ensure that they comply with standards. If existing processes need to be improved and redesigned to ensure better performance, these processes should be studied.

The resources of the university include elements such as human resources, financial resources, physical resources and technological resources. Effective management of these resources is important for the quality management system. Measurable objectives should be set for the quality management system and a set of

indicators should be defined to measure performance. Performance measurements provide information on the effectiveness of the quality management system and help identify opportunities for improvement. The quality management system is based on a philosophy of continuous improvement and development. The university's quality management system should be regularly reviewed and improved in accordance with quality management standards. These steps provide a framework to help a university establish a quality management system. By establishing a quality management system, universities can improve the quality of education and training

Quality education increases students' success. A good education provides students with the necessary knowledge, skills and abilities to increase their academic success. Thanks to quality education, students have a better educational experience and start their careers with a better foundation after graduation. A good education provides students with a wider range of career opportunities. Students who receive a quality education gain a competitive advantage in the business world. Graduating from a good university offers students better job prospects, higher salaries and greater opportunities for career progression. Universities produce leaders, experts and professionals who contribute to society. Graduates with a quality education make a more valuable contribution to society. By supporting social development, universities reinforce a sense of social responsibility. They also play an important role in research and development (R&D) activities and innovation. Quality education and research capabilities help universities foster scientific, technological and social innovations.

R&D activities lead to new knowledge and findings and contribute to the scientific literature.

High-quality R&D activities at universities ensure a respected place in the academic world and help the university to gain more prestige at national and international level. Universities that provide a good education have a higher reputation nationally and internationally. This enables them to attract more students, academics and resources

.As a result, the quality of education at universities has many important impacts on student success, career opportunities, social contribution, R&D and innovation activities, and university reputation. A quality education increases the success and impact of universities and offers students a better future.

### **3. The impact of social contribution on quality in universities**

Universities engage in education, research and service activities to respond to the needs of society. Universities develop quality education programs and research projects by responding to the expectations of society. Thus, they train qualified graduates in line with the needs of society and offer solutions to social problems. contribute to social development through education and research activities. Graduates who are trained with quality education become leaders in different areas of social development and contribute to the economic, social and cultural development of society. Universities increase their social contributions by cooperating with society. Universities collaborate with stakeholders such as the public and private sectors, non-governmental organizations and local governments to develop educational programs, research projects and social services that meet the needs of society. These collaborations enhance the quality of universities and strengthen their social contributions.

### **4. Conclusion**

Quality assurance in higher education also has a responsibility to frame and articulate core values to students, government, employers and the public. This is part of the dimension of social responsibility. This can be done by using quality review to articulate and examine the social responsibility efforts of higher education, calling on colleges, universities and emerging providers to take meaningful steps in areas such as access, equity, diversity and inequality, for example. It can be done by demonstrating that academic freedom and autonomy are part of the foundation on which social responsibility rests. In many ways, 'social responsibility' relates to the role of both quality assurance and higher education in ensuring social justice in a country, region or internationally. Nowadays, universities are confronted with rankings based on certain criteria, but rankings in universities are constantly criticized by some. The main problem with rankings is their homogenizing effect on universities. Instead of allowing universities to adapt to student markets, local economies, cultural preferences, etc., rankings have led universities to follow almost identical paths. Ideally, a country should encourage a mix of institutional types in its higher education landscape: research schools/community colleges and the differences between them. To answer this question in a different way, rankings in general are important as a benchmark if a university wants to improve its ranking. But university rankings emerged because of the desire of students, their families, employers and governments to identify (and in a sense reward) universities that have always been of high quality. Journalists were the first to take note, and several publications quickly realized how popular and profitable university rankings could be. Some countries and a few universities have also developed new ranking programs in an effort to prioritize different

measures. To date, there are several widely cited global ranking schemes, each weighing certain measures slightly differently. From a regional perspective, only one publisher ranks universities in the Middle East, and this publisher focuses only on research impact, but it is troubling that it is done from a very narrow perspective and unfortunately based on an extremely limited publication database. As is well known, most of these rankings were developed without significant input from universities, employers or governments. Typically, when a ranking scheme emerges, intense criticism of the methodology, often by universities, can eventually lead to change. It is tempting for rankers to base their assessment on easily accessible data, so research is often the first criterion. Equally, data from universities themselves or from employers is difficult to obtain and therefore less attractive to rankers.

In terms of research quality, rankings can give us valuable insights into the impact and productivity of the best universities. Indeed, the criteria considered in the rankings have created a self-reinforcing system. If a university ranks well one year, its reputation with peers and employers will be maintained, often because peers and employers see the high ranking. In other words, we are all subconsciously influenced by rankings, whether we agree with their methodology or not. Beyond that, I find that ranking schemes provide very little useful information. From personal experience, the differences between universities on a global level are never accurately portrayed in point differences, even if they are ranked several hundred places apart. I have visited universities ranked in the 100s in certain programs that clearly have terrible teaching quality and very low student satisfaction. Conversely, I have visited universities not even ranked that have extremely strong employer reputations, high student satisfaction, innovative teaching, etc. The advice I would give to someone looking for a good university is to focus with great

care on what they want to get out of it. Universities are never designed to be one-size-fits-all.

focus. Universities were never designed to be one-size-fits-all. In practice, American research universities still follow the paradigms of the liberal arts by mandating breadth before depth, such as basic or general education courses before specialization in majors. A traditional humanities university would tend toward smaller classes, and faculty members would be encouraged to place more emphasis on their teaching than on their research, although research (i.e. publishing in peer-reviewed journals or academic publications) is still necessary to ensure that knowledge within the institution is current and relevant. A research institution in the United States will need a broad-based curriculum before specialization, and many of the principles of a liberal arts education can still be seen in research institutions. The main difference is that faculty members are encouraged to publish much more and therefore spend a little less time teaching. In contrast, very few teaching or research institutions in Europe require a broad curriculum before specialization. As mentioned in the answer to the previous question, universities are not one size fits all. Every student will always want something special and unique from a university education.

Many students want more independence and may therefore choose a large research institution. But others may want a more personalized approach and therefore choose a liberal arts institution. And there are many variations in between. Increasingly, liberal arts universities are adding professional programs or research centers and master's degrees. Likewise, many large research universities have created smaller programs that mimic the liberal arts mission.

The point is that universities are constantly evolving and in many ways quality is in no way related to institutional type. Diversity of

types is a very good thing in itself. The question should be whether the university is achieving what it says it aims to achieve. Unfortunately, if we were to just look at the rankings, we would get the message that diversity of species is not welcome. quality has nothing to do with institutional type. Diversity of types is a very good thing in itself. The question should be whether the

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## TIPS FOR A SUCCESSFUL APPLICATION OF INNOVATION IN A BUSINESS

**Abstract:** For a company, the innovation process can be very costly in terms of time and resources if not planned properly. Therefore, companies must take the right steps for innovation and lay the right foundation for a successful innovation process. Businesses that determine innovation as a strategic goal in their companies and add this purpose to all their employees have always been successful in innovation. It should not be forgotten that innovation in businesses is everyone's responsibility and this purpose is critical to the success of the company. You can consider the following tricks to develop a successful innovation strategy in companies:

1. *Make innovation a part of your culture:* Explain that innovation is not just a department's responsibility, but a process that everyone can contribute to. Create a culture that values innovation.

2. *Motivate your employees:* Value and reward your employees' innovation ideas. Encourage employee engagement by using tools like innovation contests or idea boxes.

3. *Do research:* Keep up with innovations in your industry and do research to understand customer needs. In this way, ideas that you haven't thought of before may come up.

4. *Build strategic partnerships:* Explore technological or collaboration opportunities by forming strategic partnerships with other companies. In this way, you can discover new ways in the innovation process.

5. *Don't be afraid to take risks:* Recognize that some ideas can fail in the innovation process. But that shouldn't stop you from generating new ideas. By taking risks, you can contribute to the growth and development of your company.

6. *Innovative leadership:* Lead your employees to adapt to the innovation culture by adopting an innovative leadership approach. You can also increase your company's innovation capacity by establishing a management structure that encourages innovation.

7. *Invest in new technologies:* Follow new technologies and invest according to your company's needs. Thanks to new technologies, you can make your business processes more efficient and improve the customer experience. In this paper, it is explained which points an enterprise should pay attention to

*while implementing innovation. Examples related to the subject are given.*

**Keywords:** *Image, innovation, business*

## 1. Introduction

Today, companies prefer to follow a certain set of rules for every step they take. This series of rules includes experiences and experiences. This can be considered as the first beginning of a culture of innovation. The implementation of innovation ideas in companies has become an important element of being successful in a competitive market and achieving sustainable growth. Businesses must continuously adopt and implement innovative ideas to adapt to changing customer expectations, discover new market opportunities and increase productivity. These are;

1. **Fostering an Innovative Culture:** It is important for companies to create an innovative culture. Employees should be given the opportunity, appreciated and encouraged to share innovative ideas and make suggestions. Internal communication channels, environments that encourage collaboration and open feedback processes should be established.
2. **R&D and Innovation Investments:** Companies should allocate sufficient resources to R&D and innovation activities to develop innovative ideas. This includes providing the infrastructure needed to develop new products, services or processes.
3. **Evaluating External Ideas:** Companies should evaluate external ideas and implement them internally. Collaborations, joint ventures or collaborations with startups can encourage new ideas to enter the company.
4. **A Culture of Risk Taking:** Implementing innovative ideas may require taking risks. Companies should encourage a culture of risk-taking and give employees the opportunity to make mistakes. Successful innovations often require several

unsuccessful attempts before trying.

5. **Training and Talent Development:** Innovation relies on employees' skills and knowledge. Companies should offer training and development programs to help employees develop innovative thinking and problem-solving skills.

6. **Evaluating Customer Feedback:** Customer feedback can help companies improve their innovative ideas.

Innovative culture means that a company creates a work environment that encourages innovative thinking, supports creative solutions and encourages risk-taking. An innovative culture encourages employees to share ideas, generate new and effective solutions, and continuously improve and progress. Here are some steps for creating an innovative culture:

1. **Leadership and Pioneering:** One of the most important steps in creating an innovative culture is leadership and leadership from senior management. Leaders embrace innovation values, demonstrate exemplary behavior and inspire employees. They also set, support and pursue innovation goals.

2. **Open Communication and Collaboration:** Communication and collaboration is one of the cornerstones of an innovative culture. Open, effective and continuous communication channels should be established between employees. Environments that encourage collaboration should be created and teamwork should be emphasized. Information sharing and collaboration between different departments and teams should be encouraged.

3. **Risk Taking and Mistake Tolerance:** Risk taking and tolerance for mistakes are important in an innovative culture. Employees should be encouraged to try new ideas and should not be penalized for making



mistakes. The understanding that failures are learning opportunities should be promoted and the process of trial and error should be encouraged.

4. Reward and Recognition: Reward and recognition mechanisms should be established to encourage innovative ideas. Successful innovations and contributions should be identified and employees should be rewarded accordingly. This can be in the form of financial or moral incentives, praise or career opportunities.

5. Training and Development: Training and development opportunities should be offered to employees to develop innovation skills. Training can be organized on innovation skills such as creativity, problem solving, design thinking, etc.

Companies that are formed by human-based structures can reach their goals in a short time with an innovative culture and fulfill their installation objectives. Innovative culture is a business culture in which innovative thoughts and behaviors are encouraged among the employees of a company and an environment open to change is created. Innovative culture is important for a company to maintain its competitive advantage, seize new opportunities and continuously improve. The following steps are taken to realize this.

1. Leadership and Vision: The role of leaders in creating an innovative culture is critical. Top management should create a vision that supports innovation and communicate this vision to employees. Leaders should encourage innovative ideas, support a culture of risk-taking and reward innovative thinking.

2. Communication and Collaboration: Create a culture of effective communication and collaboration within the company.

3. Risk Taking and Mistake Tolerance: Risk taking and tolerance for mistakes are important in an innovative culture. Employees should be encouraged to try new ideas and should not be penalized for making mistakes.

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2. Communication and Collaboration: A culture of effective communication and collaboration should be established within the company. Exchange of ideas between employees should be encouraged, teams should be formed for innovative projects and information sharing should be supported. Transparent communication channels should

be established and employees should be encouraged to share their ideas.

3. Policies Supporting Innovation: The company's policies should encourage innovative thinking. For example, policies can be established that allocate time and resources to employees for innovative projects. At the same time, it is important to create an environment that allows for the process of making mistakes and trial and error.

4. Reward and Recognition: Rewarding and recognizing employees is important to encourage the emergence of innovative ideas. Rewards, incentive programs and career opportunities can be offered for successful innovative projects. This increases employees' motivation to innovate.

5. Training and Development: Training and development opportunities should be provided for employees to develop their innovative thinking skills. Training programs that support skills such as creative thinking, problem solving and teamwork can be organized.

6. Risk Taking Culture: An innovative culture should encourage a culture of risk-taking.

## 2. The formation of innovative culture in companies

It should be viewed as a business culture in which innovative thinking and behaviors are encouraged among a company's employees and an environment open to change is created.

An innovative culture is important for a company to maintain its competitive advantage, seize new opportunities and continuously improve.

Leadership should be seen as an important factor in creating an innovative culture. Top management should create a vision that supports innovation and communicate this vision to employees. Leaders should encourage innovative ideas, support a culture of risk-taking and reward innovative thinking.

Exchange of ideas between employees should be encouraged, teams should be formed for innovative projects and information sharing should be supported. Transparent communication channels should be established to encourage employees to share their ideas.

The company's policies should encourage innovative thinking. For example, policies can be established that allocate time and resources to employees for innovative projects. It is also important to create an environment that allows for the process of making mistakes and trial and error. It is important to reward and recognize employees to encourage the emergence of innovative ideas. Rewards, incentive programs and career opportunities can be offered for successful innovative projects. This increases employees' motivation to innovate. Training and development opportunities should be provided for employees to develop their innovative thinking skills. Training programs that support skills such as creative thinking, problem solving and teamwork can be organized.

## 3. R&D and innovation investments in companies

R&D (Research and Development) and innovation investments in companies are important investments made to gain competitive advantage, develop new products and services, increase productivity and ensure future growth. By investing in R&D and innovation, businesses aim to stay ahead of other players in the sector and offer innovative solutions that meet customer needs. Here are some important points of R&D and innovation investments in companies:

1. Developing Innovative Products and Services: R&D and innovation investments focus on the development of new products and services. These investments aim to expand the customer base, increase market

share and increase revenues by offering new and competitive products to consumers.

2. Efficiency and Cost Savings in Business Processes: R&D and innovation investments are used to optimize business processes and increase efficiency. Through new technologies and innovative approaches, business processes are made more effective and efficient, resulting in cost savings.

3. Gaining Competitive Advantage: R&D and innovation investments give companies a competitive advantage. Innovative products and services differentiate companies from their competitors and offer unique solutions to customers. This enables them to stand out in the market and gain competitive advantage.

4. Investing in the Future: Investments in R&D and innovation help companies ensure future growth and sustainability. Discovering and developing new technologies prepares companies to adapt to future trends and meet changing customer needs.

5. Collaborations and Knowledge Sharing: R&D and innovation investments are often built on collaborations and knowledge sharing. By building partnerships with companies, universities, research organizations and other industry stakeholders,

R&D (Research and Development) and innovation investments in companies are made to gain competitive advantage, develop new products and services, increase operational efficiency and support sustainable growth. Through R&D and innovation, businesses can explore new ideas, develop new technologies and adapt to changes in the market. In addition, R&D and innovation investments provide companies with the opportunity to explore new markets and grow in existing markets. They can reach new customer segments with innovative products and services. On the other hand, innovation

investments can increase operational efficiency and reduce costs. Improved business processes and new technologies enable businesses to operate more efficiently. This leads to customer satisfaction: R&D and innovation make it possible to offer better products and services to customers. By better understanding customer needs, it can offer them innovative solutions and increase customer satisfaction. It is important to remember that investments in R&D and innovation support sustainable growth. The development of new environmentally friendly technologies and the adoption of sustainable business practices enable companies to meet future demands. These small but impactful acts of R&D and innovation investment foster collaboration and partnerships. Collaborations with academic institutions, other companies and entrepreneurs enable the discovery of new ideas and the realization of innovative projects.

R&D (Research and Development) and innovation investments in companies are made to gain competitive advantage, develop new products and services, increase operational efficiency and support sustainable growth. Through R&D and innovation, businesses can explore new ideas, develop new technologies and adapt to changes in the market. Ultimately, R&D and innovation give companies a competitive advantage. By developing new products and services, they can lead the market and differentiate themselves from their competitors. Market expansion: R&D and innovation investments provide companies with the opportunity to explore new markets and grow in existing markets. They can reach new customer segments with innovative products and services: Innovation investments can improve operational efficiency and reduce costs. Improved business processes and new technologies enable businesses to operate more efficiently. Customer satisfaction: R&D and innovation make it possible to offer better products and services to customers. By better

understanding customer needs, they can offer them innovative solutions and increase customer satisfaction.

On the other hand, R&D and innovation investments support sustainable growth. The development of new environmentally friendly technologies and the adoption of sustainable business practices enable companies to meet future demands. R&D and innovation investments encourage collaboration and partnerships. Collaborations with academic institutions, other companies and entrepreneurs enable the discovery of new ideas and the realization of innovative projects.

Innovative culture has such a positive impact; companies should create a long-term vision and strategy to allocate resources for investments in R&D and innovation. Companies can use various methods to evaluate ideas from outside and find innovative solutions: innovation networks and partnerships: Companies can establish collaborations and partnerships with universities, research institutions, entrepreneurs and other companies. These partnerships enable the sharing of new ideas, access to the innovation ecosystem and the evaluation of external ideas.

1. Participation in the entrepreneur ecosystem: By participating in the startup ecosystem, companies can engage with startups and explore innovative ideas. Steps such as participating in entrepreneurship competitions, investing in incubators and accelerators, or collaborating with startups can be effective in this process.

2. Innovation calls and open innovation: Companies can encourage the submission of external ideas by organizing innovation calls or participating in open innovation platforms. These platforms provide access to a broad base of participants and allow for the evaluation of rich ideas from different perspectives.

3. Customer feedback and market research: Customer feedback and market research

provide companies with important information to evaluate external ideas. Understanding customer demands and needs, keeping abreast of changes in the market and taking customer feedback into account can help discover innovative ideas

4. Innovation culture and processes: Companies should foster a culture of innovation and establish innovation processes. It is important to create an environment that values innovation, encourage employees to share ideas and systematically evaluate innovative ideas

5. Evaluation and selection processes: Companies should define a process for evaluating external ideas and establish evaluation criteria

Companies should establish an open communication and feedback process when evaluating external ideas. A culture of risk-taking in companies means that businesses adopt an entrepreneurial and innovative approach. A risk-taking culture creates an environment where employees are encouraged and innovation and new ideas are fostered. This culture can help the company maintain its competitive advantage and grow. When businesses are ready to take risks and evaluate innovative ideas, they can explore new market opportunities, gain competitive advantage and improve business processes. However, in order to successfully create and sustain a risk-taking culture, some important factors need to be considered: These are;

1. Leadership and Senior Commitment: The company's senior executives must take a leadership role to encourage and support a risk-taking culture. Leaders should have the ability to manage risks and set an example for employees.

2. Open Communication and Feedback: There should be an open communication environment for employees to suggest new ideas and share concerns about risks. At the same time, managers and senior executives should listen to employees' ideas and provide feedback.

3. A Culture of Success and Failure: It is important to strike a balance between success and failure within the company. Successful risks should be rewarded and failures should be encouraged as learning opportunities. Employees should be provided with a safe environment where they can learn from their experiences rather than being penalized for failure.

4. Training and Support: Training and support should be provided for employees to develop their risk management and innovation skills. This can help foster a culture of risk-taking and help employees better understand risks.

5. Appropriate Processes and Resources: Companies should ensure appropriate processes and resources for assessing, managing and monitoring risks. Appropriate audit and control mechanisms should be in place to minimize the impact of risks.

#### 4. TRAINING AND TALENT DEVELOPMENT

Training and talent development is an important element for companies because it is necessary to keep employees' knowledge and skills up to date, adapt to new trends and help the company achieve its goals.

First, a training needs analysis should be conducted based on the company's needs and objectives. This analysis will help determine in which areas employees need to develop their skills and which training programs are most appropriate. Companies should create individual development plans that focus on employee development. These plans should assess employees' current skill sets and goals and identify necessary training and development opportunities. Companies can meet employees' training needs by getting support from internal resources (e.g. internal trainers, mentors) or external resources (e.g. training organizations, consultants). Internal trainers can share their experience within the company and offer employees the opportunity to develop their skills.

With the advancement of technology, online training and e-learning has become a popular

option for companies. This method provides flexibility to employees and offers training accessible from anywhere. Companies can invest in online training platforms or in-house training platforms, but they should also regularly assess employees' skills and provide feedback. This allows employees to understand which areas need improvement and makes training programs more effective

#### 4. Conclusion

Taking innovative steps in business is important for competitive advantage, growth and sustainability. Today, businesses are accelerating efforts to create an environment to encourage and support a culture of innovation. This includes giving employees opportunities to propose ideas and develop new projects, encouraging risk-taking and rewarding successful innovations. On the other hand, by investing in R&D activities, new products, services and processes can be developed, R&D departments or projects can be created, and employees have taken important steps towards encouraging them to participate in R&D activities.

On the other hand, customer feedback is a valuable resource for businesses to take innovative steps. Understanding customers' needs and expectations can guide the development of new products and services. Businesses have now made it a priority to collaborate with other companies to take innovative steps. As a result, partnerships or strategic alliances, entering new markets, technology transfer and knowledge sharing are considered as important achievements. Today, businesses should closely follow technological developments and use the appropriate ones to improve processes or develop new products. Businesses can take innovative steps by forming innovation-oriented teams. These teams can consist of employees with different skills and can work on developing, testing and implementing new ideas. As a result, businesses should be ready

to take risks when taking innovative steps, emergence of successful innovations.  
create a risk-taking culture, and encourage the

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## THE EFFECT OF A CBT-BASED INTERVENTION PROGRAM ON THE QUALITY OF LIFE OF ELEMENTARY SCHOOL STUDENTS

**Abstract:** *This study examined the effects of an intervention program based on cognitive behavioral principles on improving monitoring, regulatory, and self-management skills, as well as the effects on emotional and social climate in the classroom and on students' quality of life, well-being, and functioning. The intervention was conducted for one year with thirty 4th grade students in an elementary school and involved learning, implementing, and performing CBT principles and practices. The implementation process included monitoring and follow-up through interviews, questionnaires, and participant observation. The results of the study showed positive effects on classroom climate while reducing violence and improving students' well-being, sense of protection and belonging, and self-regulation skills.*

**Keywords:** *behavioral problem, behavioral disorder, classroom climate, quality of life, cognitive behavioral theory, elementary school*

### 1. Introduction

Behavioral problems and disorders are terms that combine problematic or disruptive behavior, defiant, oppositional behavior, and antisocial disorder among them. Disorder refers to the violation of social rules and negative actions toward others such as aggressiveness, lying, and stealing (Fossum et al., 2008). Evidence gathered in studies over the years indicates that a high percentage of elementary school children are at high risk of developing a behavior problems and disorders during their school years (Duchnowski, Kutash, & Friedman, 2002; Rubin & Balow, 1978). According to Loeber, Burke, & Pardini (2009) behavior problems among students in the classroom can arise for a variety of reasons. Some are related to environmental factors, others to factors related to the individual. They can be

influenced by developmental background, various types of learning disabilities, emotional state, difficulty driving, sense of competence, sense of belonging, educational challenges, mismatch of learning with the student's aptitudes, and other external and internal factors (Wells et al., 2019).

Conduct disorder in childhood can be an early sign of the development of conduct disorder in adolescence and adulthood (Liber et al., 2013). It can be associated with negative long-term outcomes, difficulties in child-parent interactions, early school dropout, vandalism, and lying (Loeber, Burke, & Pardini, 2009) and can negatively affect the child's development.

The effects of conduct disorder on the child may be manifested in impaired social status, expression of personal identity, self-image, sense of ability and belonging, shaping of

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interactions with peers and teachers, adjustment to the school environment, and success in developmental tasks of the age level. Behavioral disorders can interfere with adjustment and lead to social and behavioral deficits (Smith et al. 2014), challenges, and delays in various areas of functioning. They can act like a vicious cycle and, in the absence of remedies, lead to developmental withdrawal and a steady increase in negative behaviors. A situation that increases the likelihood of school dropout and at-risk situations (Danielson et al., 2018).

Erickson sees school as a significant and crucial factor in this stage of development, as it is able to identify and diagnose deficits in cognitive and academic skills. It is also a source of discipline, requiring the mobilization of "self-control" that help develop the ability to restrain and postpone rewards, as well as organizing children into a group, changing egocentric patterns, and teaching reciprocity as a value and behavior. In addition, the school setting separates the child from the home during activity periods and challenges the child to engage with new authority figures (ibid.).

Behavior problems in the classroom present numerous and varied challenges to the educational system. Their effects are felt directly and indirectly, manifesting in both academic and emotional-social domains, classroom climate, and students' sense of safety and belonging (Mooney et al., 2005).

Cognitive-behavioral intervention is based on an approach that incorporates cognitive and behavioral components and aims to effect change in student behavior. It utilizes basic cognitive processes that are responsible for successful problem-solving processes (Smith & Daunic, 2006; Smith et al., 2012). Studies have shown that this type of intervention is able to improve self-monitoring mechanisms and thus social problem-solving skills in a variety of situations and structures. Therefore, this type of intervention helps to reduce the risk of developing behavioral

problems (Daunic et al., 2006, 2012; Smith, Graber & Daunic, 2009). Several studies have found that programs of this type can be beneficial and help with both treatment and prevention of conduct problems (Sukhodolsky, Kassinove & Groman, 2004; Waschbusch, Pelham & Masetti, 2005).

Studies of various types of school-based intervention programs have shown a small but positive effect on aggressive behavior and conduct disorders. The positive effects have also been found to be long lasting (Dymnicki, Weissberg & Henry, 2011; Wilson & Lipsey, 2007).

The complexity of addressing behavioral disorders, their negative effects, and the importance of effective and adaptive developmental outcomes underscore the importance of studying and developing tools and responses to this complex issue.

## 2. Behavior Problems in the Classroom

Externalizing behavior problems and disorders manifest in the violation of social rules and negative actions toward others (Fossum et al., 2008).

Violence is an extroverted behavior characterized by the exertion of an unpleasant stimulus, physical or verbal, toward the other (Buss, 1961; Kazdin et al., 1987). The discussion of the phenomenon of violence is divided into two general categories: Conduct disorder, which is a disruption of social, academic, and occupational functioning and, in an adolescent who has not reached the age of 18, is characterized by patterns that have been repeated for at least 12 months and includes behaviors that are a violation of rights or norms and involve threats, fighting, cruelty, the use of weapons, theft, or forced sexual acts. (Moore et al., 2011). Oppositional Defiant Disorder is characterized by negative patterns of behavior that have been repeated for at least



six months and include at least four of the following behaviors: Loss of control, persistent arguing, and lack of cooperation, bullying, accusations, anger and hostility, obsessive preoccupation with the other's behavior (APA, 1994, DSM IV). The first category emphasizes intense engagement in violating rights, norms, and laws (ibid.) and is considered more difficult (Moore et al., 2011). However, untreated oppositional behavior can develop into a conduct disorder (Scotti, Mullen & Hawkins, 1998). It is important to note that a child who struggles with a violent problem usually suffers from disorders associated with the conduct disorder, such as attention and concentration problems, hyperactivity, impulsivity, and social problems. (Moore et al., 2011).

Gendreau & Archer (2005) distinguishes between violence that leads to physical harm and violence that leads to psychological harm. The= division focuses on the secret motives that cause violence, the motivation for violent action, and the degree of harm to the other (Gendreau & Archer, 2005 in Moore et al., 2011). This division led to examining violence at the level of the factors that underlie it. Ronen, Rahav & Moldawsky (2007) identified three distinct profiles of children: the aggressor who engages in violent behavior toward the other on their own initiative, the aggressed who is a victim of violence, and the neutral who is not involved in instances of violence. In the literature based on frustration-anxiety theory (Vitaro & Brendgen, 2005 in Moore et al., 2011), violence is divided into reactive and proactive violence. Reactive violence occurs in response to violence that causes anger and frustration and aims to reduce the level of anger and frustration by hitting the perpetrator. This type of violence has a more positive prognosis than initiated violence (Ibid.).

Initiated violence depends on a relationship that exists between two independent behaviors. Through past experiences, the

individual has learned that a violent response helps him or her achieve various goals, and thus it is activated whenever the child wants to achieve his or her goals (Crick & Dodge, 1996; Hubbard et al., 2001; Vitaro & Brendgen, 2005). Other subdivisions refer to the differences between the behaviors that characterize violence, distinguishing between direct violence and indirect violence, and between verbal violence and physical violence (Bjoerqvist et al., 2001; Yudofsky et al., 1986; Ronen et al., 2007).

### **3. Patterns of Victimization During the Elementary School Years**

Victimization is a common stressor in school-aged children and can affect the child's future development (Giesbrecht et al., 2011). Children who suffer from persistent bullying and an unprotected social-emotional climate (Rudnicka et al., 2020) are at increased risk of developing psychological and behavioral adjustment problems such as loneliness, low self-esteem, anxiety, depression, externalizing problems, and school dropout (Hanish & Guerra, 2002; Kochenderfer-Ladd & Skinner, 2002; Leadbeater & Hoglund, 2009). Violent behavior is detrimental not only to the violent child's environment, but also to the development and functioning of the violent child, who is at risk of social rejection, dropping out of school, and developing criminal patterns (Loeber & Farrington, 2000; McGinnis & Goldstein, 1997; Pope & Bierman, 1999).

A relationship has been found between an early victimization experience during the elementary school years and the continuation of the pattern of bullying victimization in later years (Kochenderfer-Ladd & Wardrop, 2001; Schwartz, Proctor & Chien, 2001). The early years of elementary school are a significant and important time to observe the child's developmental process and understand why certain children are victimized and

others are not, and how the change in victimization patterns is related to their behavior and its context over time (Giesbrecht et al., 2011). In addition, the early years of elementary school are of great importance for social, emotional, cognitive, and personal development. Intervention programs can have a positive impact on reducing peer victimization before it takes root (Ladd, 1996; Olweus, 1994).

Research today seeks to understand the components of personality development, focusing on the emotional and cognitive factors that predispose a child to violent behavior (Tremblay et al., 2005). Several studies have shown that the social biological basis of certain children influences the way they interpret their behavior, the behavior of others, and the extent of their influence on a given situation, exposing them to risk and dangerous situations early in life (Anderson & Bushman, 2002; Dodge & Pettit, 2003). The child's information processing model in these situations influences the interpretation they give to the social situations around them, tends to attribute negative intentions and hostility to them, and influences the development of violent behavior (Crick & Dodge, 1996). Examining the individual versus the effects of the environment in relation to violent behavior assumes that an individual has an innate personality tendency toward violence that may predict violent behavior later in life (Brendgen et al., 2006). Therefore, individuals must acquire tools and skills to help them control their tendency (Moore et al., 2011). A somewhat more moderate approach also asserts that there is an innate tendency toward violence. At the same time, it believes that after age six, environmental influences and cognitive abilities determine the developmental trajectory (Rhee & Waldman, 2002). Another study considers violence as a tendency rather than a personality trait or hidden instinct. According to this study, the social environment, skills, and tools acquired by the

child during his integration into that environment determine whether his violent traits will be reinforced and influence his behavior and social affiliation (Nagin & Tremblay, 2005).

As the child progresses through the developmental stages of acquiring complex cognitive skills, patterns of violence decrease. It is likely that there is a relationship between these two processes (Seguin & Zelazo, 2005).

Cognitive skills are related to mechanisms of self-control, information processing, and emotion control. These mechanisms enable individuals to control and regulate their behavior and moderate the relationship between sensitivity and aggression (Apple, 2007; Weisbrod, 2007). Violence control and behavior regulation become possible for a child when he or she acquires tools and skills that enable him or her to behave socially.

The development of self-control skills enables the child to activate mechanisms of observation, monitoring, and self-reinforcement, to use accepted social models, and to control his or her behavior (Moore et al., 2011).

Birchmeter's (2009) study confirms previous studies showing a negative relationship between bullying and students' quality of life. Negative effects on the well-being of students involved in bullying and students who suffer from bullying at school were found. In addition, students who are not affected by bullying report a higher quality of life and receive more support from their friends and teachers.

The presence of behavior problems in the classroom poses a significant challenge to the educational system, affects the emotional and social climate, academic achievement, and students' sense of safety and belonging in the classroom (Mooney et al., 2005).

## 4. Cognitive - Behavioral Intervention

Cognitive-behavioral intervention relies on an approach that incorporates cognitive and behavioral components to change student behavior through its influence on basic cognitive processes responsible for successful problem-solving processes (Smith & Daunic, 2006; Smith et al., 2012). A cognitive-behavioral intervention addresses the acquisition and establishment of a cognitive change in the thinking and belief system to bring about stable emotional and behavioral change (Beck, 2014). The model represents a combination of cognitive strategies based on reflexive and metacognitive skills, behavioral strategies, emotion-focused strategies, and social strategies to build a cognitive infrastructure that leads to effective behavior (Kendall, 1993).

Studies have shown that this type of intervention is able to improve self-monitoring mechanisms and thus social problem-solving skills in a variety of situations and structures. Therefore, this type of intervention helps reduce the risk of developing behavior problems (Daunic et al., 2006, 2012; Smith, Graber & Daunic, 2009), contributes to positive social functioning, and promotes a visible and/or hidden impact on individual development (Kazdin et al., 1992; Lochman & Wells, 2004). Several studies have found that programs of this type can be beneficial and help in the treatment and prevention of behavioral disorders (Ukhodolsky et al., 2004; Waschbusch et al., 2005). Studies of school-based intervention programs have shown a small but positive impact on aggressive behavior and conduct disorders. The positive effects have also been found to be long lasting (Dymnicki et al., 2011; Wilson & Lipsey, 2007). In a study examining the impact of these programs on student behavior problems, it was found that two types of prevention interventions were implemented in schools over the years:

a classroom intervention program and a targeted individual intervention program. The latter were significant and contributed to the reduction of behavior problems. School-based interventions using the cognitive-behavioral approach have been shown to produce positive results in both the short and long term (Mytton et al., 2006). Interventions that focus on a specific goal have also been found to show more significant results than general school-based intervention programs (Liber et al., 2013).

Cognitive-behavioral intervention methods use strategies aimed at bringing about change in thinking, feelings, and behavior (Kendall, 2012). Their foundation is the individual's belief system, behavioral strategies, and the person's understanding of the beliefs and behaviors that characterize them (Alford & Beck, 1997).

Cognitive behavioral Intervention with children focuses on the acquisition, practice, and assimilation of cognitive strategies that help the child cope effectively with events and solve problems. The child acquires cognitive strategies through experience, observation of experience, and interaction with the environment (Ingram, Miranda & Segal, 1998). The differences between creating an intervention plan for children and implementing it with adults arise mainly from the significant involvement of environmental factors in shaping the way the child interprets and responds to various situations, as well as the fact that children usually come to the intervention at the initiative of their environment, often without being aware of the problem that requires it (details in Moore et al., 2011). One of the main issues in child care is the issue of cognitive processing and the distinction between "cognitive impairment" and "cognitive distortion." Processing impairment is caused by a lack of attention to information and a lack of foresight that affects behavior and its outcomes. Cognitive distortion means a disturbance in the thinking processes

(Kendall, 2015). The terms impairment and distortion both refer to a disturbance in cognition (Kendall, 2000). According to Spivack & Shure (1982), deficits in processing interpersonal situations are etiological in nature. Barkley (Barkley, 1997) refers to impulsivity as a consequence of mediation deficits (Kendall, 2015). According to him, impulsive behavior results from cognitive impairment manifested by an inability to let thought precede action, as opposed to cognitive bias indicating active but distorted processing (*ibid.*).

Studies have shown that by applying cognitive-behavioral principles, self-monitoring processes and problem-solving strategies can be accomplished. These processes lead to the improvement of self-management and self-regulation skills (Daunic et al., 2006; Daunic et al., 2012; Smith, Graber, & Daunic, 2009).

Self-management is a general term that refers to a variety of components used to outline an internal locus of control (Chafouleas et al., 2011). Self-management is expressed in the influence a person has on events and situations around them and their outcomes (Barlow, & Chorpita 1998) and includes actions on reality (Ajares, 2007a). Self-regulation is an active process of self-management (Pintrich, 2000).

The self-regulatory system is at the heart of any daily process. Its components mediate the influence of the external environment on the individual and provide him or her with the basis for goal-directed action. (Bandura, 1991).

The use of self-observation can enable individuals to evaluate the relationship between thoughts, behaviors, physiological sensations, and emotions and their consequences (Moore et al., 2011).

The child's self-regulation skills can influence his or her adjustment to the school environment in which he or she must function independently without dependence or the

presence of his or her primary caregivers (Sawyer et al., 2015).

The experiences the child has in his or her first years of school can have long-term effects on his or her behavior, mental health, relationships with children and teachers, and sense of belonging and attachment to school (Belsky & MacKinnon, 1994; Entwisle & Alexander, 1989; Finn, 1989; Hamre & Pianta, 2001; Ladd & Dinella, 2009; Luster & McAdoo, 1996). Studies indicate a negative relationship between the child's level of self-regulation and behavior problems (Belsky et al., 2007; Eisenberg et al., 2010; Hill et al., 2006; Kochanska & Knaack, 2003; Murray & Kochanska, 2002; Olson et al., 2005; Riggs et al., 2004).

Self-management strategies have been shown to be effective for both the individual and the class as a group for adjustment and success (Glynn & Thomas, 1974).

## **5. Quality of Life**

The concept of quality of life refers to the degree of well-being and happiness of the individual. It is defined by the WHO (1996) as an individual's perspective on his or her life in the context in which he or she lives and in relation to the goals, expectations, values, and standards he or she sets for himself or herself. In childhood, quality of life is defined as subjective perceptions of well-being and happiness (Davis et al., 2008)

Almost all definitions of quality of life refer to physical, social, cognitive, and psychological dimensions (Hutting et al., 2022). Quality of life is influenced by both close indicators, such as family and friends, and more general indicators, such as socioeconomic status and culture (*ibid.*). Physical or emotional-mental disabilities have been found to have the greatest impact on quality of life (Kourkouta et al., 2021).

Lack of support, protection, emotional and behavioral difficulties, and lack of

infrastructure to realize potential are considered factors that significantly affect quality of life (Wallander, 2015). The child is considered an individual with equal rights and a future citizen who has influence in shaping society, and therefore there is concern for his or her quality of life (Ben-Arieh et al., 2014). The quality of life is considered his natural right and is considered an important factor in his development and future prognosis (Ben-Arieh&Frønes, 2011).. According to the World Health Organization, mental health and emotional well-being are factors that affect the quality of life of the student and his ability to achieve his developmental goals in school (Rudnicka et al., 2020).

At school age, the child is at a developmental stage where he or she is confronted with the demands of learning together in society, following rules and routines, and participating in a group. Achievement, a sense of competence, and the ability to control become essential to the self-image the child builds (Tiano, 2010).

School provides developmental opportunities for the child, but it can also present challenges that can interfere with normal development. Classroom climate has an impact on student achievement in the classroom.

In the study of Hachoen& Ronen(2011) school climate is defined as the quality of school life. According to the researchers, students' perception of the quality of school life represents their satisfaction with the school and classroom, their sense of their social place, their emotional attitude towards the educator and teachers, and their emotional and behavioral attitude towards studying, showed a relationship between students' perception of class climate and sense of belonging, educational process development, personal development, integration, and effective behavior in the school environment and routine (Zedekiah, 1988; 1996. Urdan et al., 2004) found that positive interaction between class members increased students' social competence in the lower grades of

elementary school (Hoglund&Leadbeater, 2004). School climate is based on norms, relationships, goals, values, and organizational structure (Cohen &Geier, 2010). In addition, it influences students' social, psychological, and academic outcomes (Glisson, 2007). Interpersonal interactions, as a key component of school climate, influence behavioral norms and a sense of protection. A relationship has been found between positive interactions, avoidance of disruptive behavior, and good academic performance (Crosnoe, 2004; McNeely, Nonnemaker, & Blum, 2002; Powers, Bowen, & Rose, 2005; Whitlock, 2006) when the student perceives the school as a protected place where he or she can develop optimally. Similarly, the social-emotional climate creates insecurity, and the presence of verbal or physical violence poses the risk of interfering with student development and achievement, even if they are not directly affected by violence (Rivers et al., 2009)

## 6. Methodology

### The purpose of the study

The purpose of this study was to examine the extent to which a classroom intervention program based on cognitive behavioral principles affects students' acquisition of self-regulation skills, behavioral problems, social and academic emotional climate in the classroom, and quality of life in the classroom.

### Study Population

The sample consisted of thirty4th grade students in an elementary school in the city of Jerusalem. The vast majority of children in the class have been learning together as a group for about five years, i.e., since pre-compulsory kindergarten. Of these, 8 are girls and 22 are boys, aged 9-10 years, who live in or around Jerusalem. 16 of the children in the class were diagnosed with learning

disabilities or ADHD, and 14 of the children were not diagnosed (Table 1).

Five school employees also participated in the study. 3 women and 2 men, all with academic degrees and working at the school. 4 with more than 10 years of experience in education and one with 2 years of experience. 4 of them were born and raised in Israel. 3 of them are married and 2 are not married (Table 2).

**Table 1.** Children

	N	%	Mean
Gender			
• Girl	8	26.66	
• Boy	22	73.33	
Age			9.4
Origin			
• Abroad	2	6.66	
• Israel	28	93.33	
Place			
• Jerusalem	24	80	
• Outside Jerusalem	6	20	
• Adhd	9	30	
• learning Disability	7	23.3	
• undiagnosed	14	46.7	

**Research tool**

*In-depth interviews:* semi-structured in-depth interviews to capture and observe staff feelings towards the class before and after the intervention program. In addition, open-ended face-to-face interviews were conducted on predetermined general topics to understand students' feelings and needs.

*Participant observation:* participant observation was conducted in the classroom, involving directly and personally in the lives and processes of the students and experiencing the reality in the classroom together with them. Observations focused on events that took place during common class time related to self-management and self-

regulation, as well as in the general atmosphere of the classroom during class time and extracurricular activities.

In addition, class discussions were recorded with students during designated class periods to implement and monitor the program and its outcomes.

**Table 2.** School employee

	N	%	Mean
Gender			
Female	3	60	
Male	2	40	
Age			37.21
Education			
Academic	5	100	
Origin			
Abroad	1	20	
Israel	4	80	
experience in education			
More than 10	4	80	
Less than 10	1	20	
Marital status			
Mrried	3	60	
Not married	2	40	

**Open-ended questionnaires:open-ended**

questionnaires were distributed twice a year before the end of each semester. Students were asked to rank various verbs on an axis according to their personal feelings and to put their choice into words.

Quality of life questionnaire components: the ESQoL questionnaire (Yuen et al., 2022) is a 21-item questionnaire developed and validated for elementary school students in Taiwan. The questionnaire was developed with the aim of bringing to light the differences between age levels and the impact that developmental stage may have on quality of life (Wee, Chua, & Li, 2006). The

components of the questionnaire help assess factors related to students' emotional well-being and relate to functioning in school and other areas of the student's life. This study examined the effects on 12 of the 21 components of the questionnaire that relate directly to the educational framework. The questionnaire was developed in Taiwan, a culture where the academic achievement of their children is very important to parents (Chan et al., 2014, Tzeng, 2007), similar to Israel. The questionnaire proved to be an effective instrument for measuring the quality of life of elementary school students and has high validity and reliability.

### Research process

Initial data collection occurred during the academic year prior to the year in which the study was conducted through information collected in reflection sheets completed by students at the end of the year, classroom observations, and information provided in a final team meeting. The data collected indicated an abusive climate in the classroom. This manifested itself in reports of an impaired sense of safety, ability, and motivation among students and teachers teaching in the classroom. All teachers reported that, in their opinion, the academic level in the current class did not reflect its potential. There were also reports of verbal and physical bullying and social boycott.

A joint analysis of the members of the educational staff along with the behaviors that emerged from classroom observations and routine student complaints led to the hypotheses that: Classroom challenges are affected by difficulty in postponing a response and impulsivity.

Dealing with challenges on a daily basis affects students' quality of life and their ability to use resources for optimal development.

At the outset of the study, open-ended face-to-face interviews were conducted with the students and with five staff members who

provide regular support to the class, including the principal, who was personally involved in the implementation of the program.

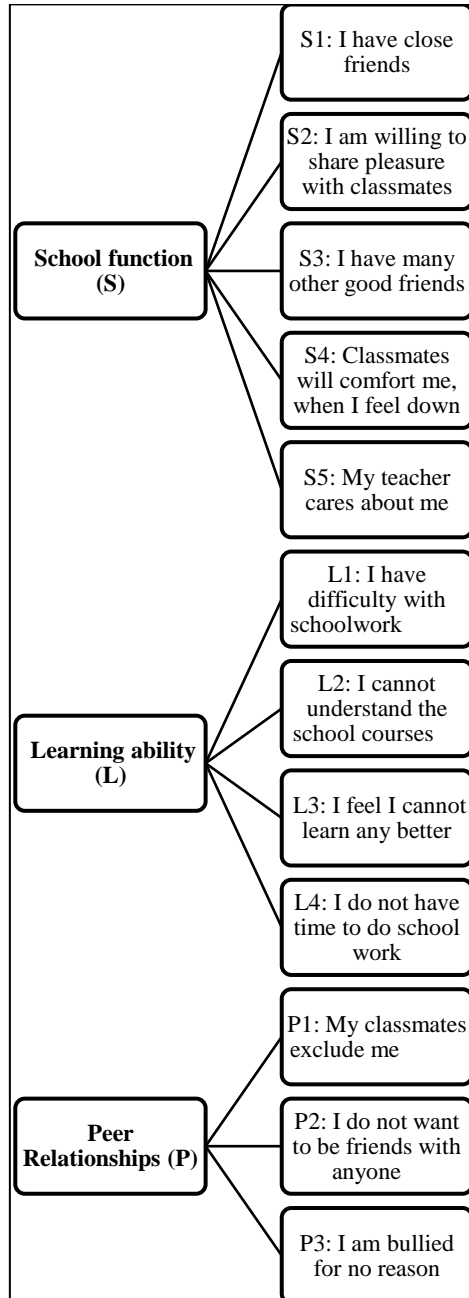


Figure 1. Quality of life 12 components

The course of the investigation included the implementation of a classroom intervention program based on cognitive-behavioral principles with the students, as well as scheduled meetings with staff for the purpose of induction, assimilation, ventilation, and implementation.

During the intervention, regular classroom meetings were held and recorded to practice and monitor assimilation.

Reflective questionnaires were distributed at the end of the program to capture the personal process and general feeling in the classroom. The pages contained a limited number of closed-ended questions on a response scale as well as open-ended explanations. The use of behavior mapping charts helped to observe the behavioral changes that occurred in the class throughout the period. Pre-intervention and end-of-intervention questions were asked about feelings in the school setting to observe changes in students' quality of life related to their functioning and feelings in the classroom.

The components of the intervention program

The intervention included the use of cognitive and behavioral therapy tools. The goal was to teach strategies and tools to strengthen and develop monitoring, management, and self-regulation skills in the first phase.

In the second phase, they were to be applied to defined goals that would support the creation of a positive social and emotional classroom climate and improve the quality of life for students in the classroom.

This, while continuing the processes of establishing and assimilating tools and semantics. The program was established and implemented using a variety of tools:

Tools for assimilation: with the beginning of the school year, the schedules, the system of hours and the accompanying lessons were created in terms of the intervention plan to create a unified and consistent language and a sense of framework and security.

Permanent Lessons: Three permanent weekly lessons were incorporated into the system to learn and use program language, role play, learn tools and strategies, learn through stories, practice social discourse, practice reflection skills, reflect, and create daily report pages.

Monitoring boards: behavior boards were created and posted in the classroom for consistent, orderly, and mandatory monitoring of the behavior process.

Self-management wheel board: based on the cognitive behavioral model derived from the emotional-rational method a self management board was created. The board is divided into quarters to distinguish between an event, a thought, an emotion/feeling, and a reaction.

To allow the model to be applied using routine events and role-plays, each quarter was assigned its own color and a set of cards of the same color was included. The cards included events, thoughts, emotions/feelings, behaviors, and blank cards for self-completion (figure 2).

Reaction stages: A reaction stages axis was placed below the circle for the practice of monitoring behaviors and responses (figure 3).

Board of Sentences and proverbs: the board with the collected Sentences and proverbs was placed under the level of the answers and on it the Sentences and proverbs were hung throughout the year to support and perfect the internal dialog. The Sentences and proverbs helped students solve events and situations. In addition, the board included alternative verbs for practiced situations.

Throughout the process, a goal was set once a month to guide the class according to the goals - based on the needs established in advance.

Each goal was assigned a time range. The first overarching goal was familiarity with the plan and ways to implement it. Familiarity with the auxiliary panels that accompany the behavioral program, experience with pre-



dictated chance events, experience with the panels in everyday situations, experience in role-playing and using the auxiliary panels and the semantics derived from them in everyday behavior in real time. Another overarching goal was proper speech and included using navigation tabs to monitor speech patterns in real time, behaving according to the speech rules used in the classroom, speaking in class when given permission to speak, developing the ability to listen to each other, listen to what adults say, express oneself clearly and in an appropriate tone of voice, respond to what friends say out of respect and politeness, treat a friend's words with respect and politeness even when there is an argument, and use language appropriate to the time and place. Another overarching goal was defined as reflection as a foundation for behavior regulation and included familiarity with the concept of restraint, reflection on situations and situations where students have had to restrain themselves in the past, knowledge of different ways to help avoid an immediate reaction, familiarity with the concepts of self-management, self-regulation, reflection, and self-control, identification of past thoughts and physiological signs of behavior that may lead to an impulsive response, application of behaviors and phrases that help students choose and manage their thinking and behavior in real time, understanding of the emotional impact of success in regulating behavior as opposed to an impulsive response. Another overarching goal was a positive classroom climate and included: learning about the concepts of empathy and intervention, practicing recognizing and expressing the feelings and thoughts of others through role-playing, intervening in a social situation in an appropriate way, acting from the perspective of others, understanding the differences between different individuals' feelings and thoughts about the same situation while having respect for others and their feelings.

Each objective was composed of the phases of the program: Defining a need, identifying automaticity at the level of feelings, thoughts, and actions, suggesting possible responses, choosing a behavior, choosing a word that supports the behavior, and reinforcements.

During the year, specific goals were also defined, based on specific needs - individual and group - that came up in discussions with the group of children.

Reinforcement plan for defined goals: A pool of High goals and personal and group goals are set and rewarded according to progress. Blackboards accompanied the program and allowed for the accumulation of reinforcers of various types and to varying degrees individually or in groups.

Individual processes were conducted with a number of children that were found to have a significant impact on the atmosphere and feeling in the classroom. These processes included phases that were identical to the phases of group work and related to personal goals, goal refreshment, monitoring, and regular updating of all staff involved in the program.

Work with educational staff included recruitment of appropriate staff, ongoing dialog, maintaining consistency in classroom work, and regular meetings within the system. The meetings included acquiring the principles of the program, a discussion of possible courses of action, and airing, sharing, and brainstorming. Times were also set aside for regular and periodic reporting on classroom behavior.

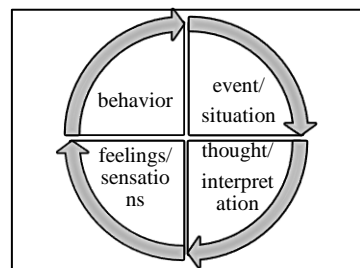


Figure 2. Self management wheel

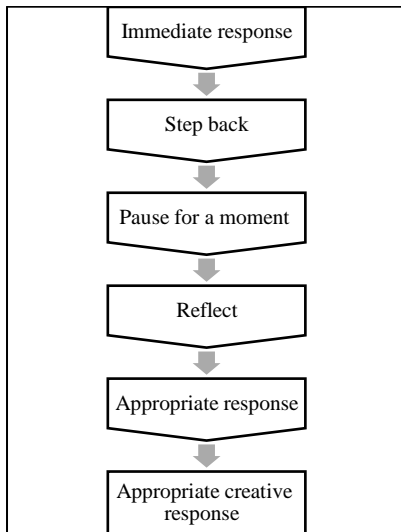


Figure 3. Reaction stages

## 7. Results

The results obtained combine data suggestive of qualitative processes that indicate a change in perceptions and experiences with measurable data that indicate a reduction in maladaptive behaviors, an improvement in adaptive behaviors, and an increase in the quality of life for individuals in the classroom.

*Analysis of social climate results:* The results describe a comparison between the responses on the reflection questionnaires completed by the children at the end of third grade before the intervention program and at the end of fourth grade after the program. The questionnaires completed by the children contained closed and open-ended questions. The closed questions were rated on a scale of 1-5: 1 - never, 3 - sometimes, 5 - always, 2,4 - intermediate situations between always and sometimes or between sometimes and never.

The results describe a comparison between the answers to the reflection sheets filled out by the children at the end of the third grade before the intervention program and at the end of the third grade after it. The questionnaires

included closed and open questions. The closed questions are given a quantitative score on a scale of 1-5: 1 - never 5 - always respectively.

In reference to the saying "I choose my friends and girlfriends"

Table 3. Reflection sheets comparison

	Mean - Before	Mean - After
"I choose my friends by myself"	1.76	4.33
"My friends respect me and my opinions"	2.63	4.43
"I manage to avoid conflicts and arguments with friends and reach a solution in pleasant ways"	1.53	4.36

**Numerical results :** in 70% of the students a numerical increase was observed in legitimacy and in their ability to choose their friends, in 30% the group was ranked at the beginning of the program with the highest score and the result was kept. 60% of the children rated the statement with the maximum number of points at the end of the year compared to 30% at the beginning of the year.

**Literal results:** at the beginning of the year, 70% of the subjects reported a certain difficulty in connecting with a friend with whom they would like to play. At the end of the year, all the children testified about an improvement in their feeling towards their social status in the class. 40% of the children testified about a personal process they went through regarding their personal responsibility in choosing friendships. In reference to the saying "My friends respect me and my opinion"

**Numerical results:** in 80% of the subjects a numerical increase in the feeling of being respected was observed, in the remaining 20% no change was observed, while in 10% of them from the beginning the saying was rated with the highest score and in another

10% it did not apply Improvement in the feeling that they are respected in the classroom. 60% of the subjects scored the statement with the maximum number of points at the end of the year compared to 10% at the beginning of the year. **Literal results:** at the beginning of the year, 80% of the subjects expressed dissatisfaction with the degree of respect they receive among their classmates and 10% stated that they do not know how to refer to a verb. At the end of the year, 80% of the subjects indicated that a change could be felt in the general classroom climate. 10% reported that their feeling in the class is not good.

In reference to the saying "I manage to avoid fights and arguments with friends and reach a solution in pleasant ways".

**Numerical results** 50% of the subjects observed a numerical increase in the feeling that they manage to conduct themselves better in conflict situations. In the remaining 50%, no change in the result was observed. 60% of the subjects rated the statement with the maximum number of points at the end of the year compared to 10% at the beginning of the year. No drop in score was observed in any of the subjects.

**Literal results:** At the beginning of the year, 50% of the subjects testified about the lack and need for conflict management tools. 30% did not see personal responsibility in their involvement in fights. 30% referred to their personal responsibility. 20% stated that they have tools that help them solve problems. 10% referred to their general feeling regarding interactions and communication in the classroom. At the end of the year, all the subjects reported an improvement in dealing with conflicts. 70% of the subjects testified to purchasing tools that help them manage conflicts and solve problems. 30% of the subjects responded positively to the process and the general atmosphere in the class and said that they expanded their social circles. In the next question, the students were asked to say what they would preserve in the class

and what they would improve in it. The question included only a verbal description without a numerical representation. At the beginning of the year, 90% of the subjects thought that there was something to improve in the class in the social aspect. 60% of them experienced the class as an unsafe place and reported bullying behavior towards them or their classmates. 10% reported feeling disrespected. 20% stated that they would like to expand their social circles and the possibilities of playing with friends.

20% reported noise and anger affecting the atmosphere. 10% said they did not know what they would like to improve. 10% said they would like to improve everything in the classroom. At the end of the year, 30% of respondents felt there was nothing left to improve. 10% felt everything should be improved and 60% mentioned specific changes that should be made. Compared to the beginning of the year, only 10% said that the attitude of the children towards each other should be improved.

In terms of things students wanted to keep in the classroom: At the beginning of the year, 70% of subjects wrote that they would keep their best friends. 30% did not find anything on the social level in the class that they would like to keep. At the end of the year, 70% of the children referred to the flow in the class and the general social climate, 40% of the subjects described the improvement of the children's behavior towards each other. 20% of the subjects the presence and effectiveness of the acquired tools for self-management and problem solving. 30% mentioned the good atmosphere and pleasant feeling in the class. 75% of the 30% who did not find what they wanted to preserve at the beginning of the year found things they would preserve.

At the level of the defined goal of social climate and social communication, there was a significant improvement in how children felt about their social status and an increase in their overall good feeling in the classroom. 20% reported noise and rioting affecting the

atmosphere. 10% said they did not know what they would like to improve. 10% said they would like to improve everything in the classroom. At the end of the year, 30% felt there was nothing left to improve. 10% felt everything should be improved and 60% mentioned specific changes that should be made. Compared to the beginning of the year, only 10% said that the attitude of the children towards each other should be improved.

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At the level of the defined goal of social climate and social communication, a significant improvement was observed in the children's feeling of social status and an increase in their overall good feeling in the classroom.

*Results of a circle for self-management, guided discovery, and mantras:*

The results describe a comparison between the content brought up during observations, conversations with children, and class discussions at the end of third grade before the intervention program and at the end of fourth grade after the program.

At the level of the defined goal of habituation and internalization and application of the principles of the program and the reference tables: At the end of the year, most children had acquired the circle of self-management

and the tools for observation, internalized the stages at the cognitive level and the emotional level, and used them to achieve defined behavioral goals, such as: social climate, rules of discourse, social play.

At the defined goal level of rules of discourse, significant improvement was observed in the ability to engage in attentive, appropriate, and respectful classroom discourse. Prior to the intervention, classroom discourse was characterized by outbursts and speaking without permission, rejecting the opinions of others, language that was not respectful and appropriate to the time and place, and verbal violence towards class members and staff. In the observations conducted at the end of the implementation of the intervention program, students in the class waited for permission to speak to express their opinions in class, listened to their classmates and the teacher, expressed themselves clearly, in an appropriate tone of voice and in appropriate and respectful language, and the level of verbal violence decreased significantly.

At the level of the defined goal of a social game, the intervention helped in acquiring tools to manage a social game: observations conducted prior to the intervention found that students were disrespectful of the rules of the game, failed to divide into game groups, gave up the game before they lost, and many conflicts occurred. After the intervention, observations showed that students invited friends to play, managed to play together for a long time, enjoyed playing together, cooperated, followed the rules, lost respectfully, and won without humiliating the other person.

*Reaction stages results:*

according to students' reports, using the Reaction stages as an available, practical and clear tool has helped them avoid impulsive and violent behavior. At the beginning of the year, 51.7% of the children reported being victims of verbal violence, expressed in humiliation, insults, threats, social ostracism

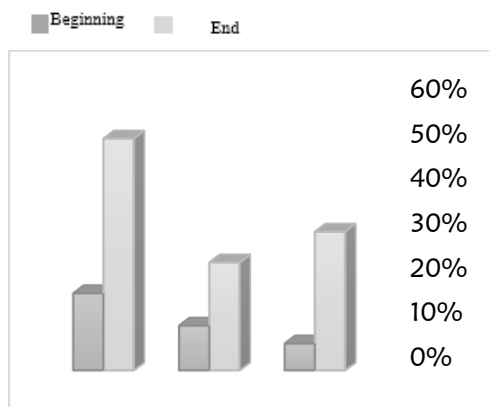
and boycott, compared to 17.24% at the end of the year.

At the beginning of the year, 24.13% of students reported suffering physical violence, compared to 10% at the end of the year.

At the beginning of the year, the percentage of children who required repeated treatment and activation of personal programs due to violent behavior was 30%, compared to 6% at the end of the year.

**Table 5. Violent and victims compression**

	Percent – before	Percent – after
Violent behavior (physical or verbal)	30%	6%
victims of physical violence	24.13%	10%
victims of verbal violence	51.7%	17.24%



**Figure 4. Violent and Victims Compression**

In terms of behavior, the reinforcement program was implemented: Throughout the intervention program, the process of self-monitoring became

more accurate, honest, and realistic through written reflections. Students received more and more positive reinforcements for achieving the set goals. After goals were met and behaviors improved, the demand for positive behaviors was increased to maintain

the reinforcements.

**Table Results Quality of life:**

The impact of the intervention program on students' quality of life and well-being was measured using student reports and 12 items related to three quality of life indicators related to the school environment. The indicators were selected from the QQL questionnaire, which contains 21 items and a total of six quality of life indicators.

**Table 6: School function**  
5 -High QoL

School function (S)	Mean - Before	Mean – After
S1: I have close friends	3.6	4.13
S2: I am willing to share pleasure with classmates	3.6	4.1
S3: I have many other good friends	2.6	3.03
S4: Classmates will comfort me, when I feel down	2.9	3.86
S5: My teacher cares about me	3.6	4.23

*In terms of quality of life:*

Indicators related to functioning in school. Answer 5 means a high level of quality of life (Table 6).

For the index: I have close friends, the average of students' responses before the intervention program was 3.6. After the intervention program, the average of responses increased to 4.13.

In the index: I am willing to share joy with classmates, the average of students' responses before the intervention program was 3.6. After the intervention program, the average of responses increased to 4.1. In the index: I have many other good friends, the average of students' responses before the intervention program was 2.6. After the intervention program, the average of responses increased to 3.03. In the index: classmates comfort me

when I feel down, the average of students' responses before the intervention program was 2.9; after the intervention program, the average of responses increased to 3.86. For the index: my teacher cares about me, the average of students' responses before the intervention program was 3.6; after the intervention program, the average of responses increased to 4.23.

In all indicators of school functioning (s), an increase was observed after the intervention program. For the indices related to learning skills (l) and relationship with peer group (p), the response 1 indicates a high standard of living. (Table 7) In the indicators related to the ability to learn: For the index: I have difficulty with schoolwork, the average of students' responses before the intervention program was 3.06, and after the intervention program, the average of responses decreased to 3. The average response of the index: I cannot understand school subjects was 3.03 before the intervention program and remained unchanged after the program. In the index, I feel I cannot learn better, the average of students' responses before the intervention program was 3.1. After the intervention program, the average of responses decreased to 3.06. In the index I do not have time for school, the average of students' responses before the intervention program was 2.5. After the intervention program, the average of responses decreased to 2.3.

For the indices related to the relationship with the peer group. For the index: my classmates exclude me, the average of students' responses before the intervention program was 3.16. After the intervention program, the average of responses decreased to 2. In the index: I do not want to be friends with anyone, the average of students' responses before the intervention program was 3.1. After the intervention program, the average of responses decreased to 2.73. In the index: I get bullied for no reason, the average of students' responses before the intervention program was 2.53. After the intervention program, the

average of responses increased to 2.

**Table 7.** Learning ability (L) & Peer Relationships (P)  
 1 – High QoL

<b>Learning ability (L) &amp; Peer Relationships (P)</b>	<b>Mean – before</b>	<b>Mean – after</b>
L1: I have difficulty with schoolwork	3.03	3
L2: I cannot understand the school courses	3.03	3.03
L3: I feel I cannot learn any better	3.1	3.06
L4: I do not have time to do school work	2.5	2.3
<b>Peer Relationships (P)</b>		
P1: My classmates exclude me	3.16	2
P2: I do not want to be friends with anyone	3.1	2.53
P3: I am bullied for no reason	2.73	2

## 8. Discussion

School climate is influenced by a sense of support and responsiveness to individual needs, as well as fair and clear rules, order, discipline, organization, and care for the physical environment. Disorder, disciplinary problems, and a sense of alienation and lack of protection significantly affect the climate and do not allow the school to achieve its goals for development, teaching, and learning (Benvanishti et al., 2008). The intervention program primarily required the organization of the classroom, that is, the creation of the weekly and daily schedule and the creation of regularities and routines in the classroom. The organized and orderly structure of the environment is an important and central element in building a framework that facilitates productive learning academically and socially (Allen, 2010). Studies have shown a clear relationship between classroom organization, the establishment of clear and consistent rules and expectations, and an

infrastructure that allows for student participation in decision-making, and a decrease in violence and bullying (Safran& Oswald, 2003). It can be concluded that maintaining an organized and orderly work environment has helped to improve classroom climate, which is reflected in the improvement of how students feel in the classroom by making more connections to learning and having a sense of safety.

The uniqueness of action research was demonstrated by activating a cognitive-behavioral intervention program in a school setting with a large group of 30 students. Studies point to the power of the group and its influence on the effectiveness of any cognitive-behavioral intervention program (Wiborg, et al., 2015; Skjemov, et al., 2015). In addition, intervention programs that work at the level of groups of children have been shown to be particularly effective intervention tools for reducing behavior problems and improving prosocial behavior (Yavuzer&Karatas, 2013; Bowman-Perrott, et al., 2015).

Giesbrecht, Leadeater& Macdonald (2011) attribute great importance to the influence of the early elementary school years and the sense of security during those years on children's social, emotional, cognitive, and personality development. Many studies have found that in a situation where there is no protection, both the victim and the bully are at increased risk of developing social, emotional, and behavioral problems (Hanish& Guerra, 2002; Kochenderfer-Ladd & Skinner, 2002; Kochenderfer-Ladd & Wardrop, 2001; Leadbeater&Hoglund, 2009; Loeber& Farrington, 2000; McGinnis & Goldstein, 1997; Pope & Bierman, 1999). At the beginning of the year, prior to the start of the program, there was a significant disconnect between the high cognitive and academic abilities of the group and the students in it and their lack of implementation. This, along with social, emotional, and behavioral skills that were

below their age. According to Apple (2007) and Weisbord (2007), there is a relationship between cognitive skills and self-control, information processing, and control over emotions as mechanisms that allow an individual to control and regulate their behavior and moderate the relationship between emotions and aggression. Behavior regulation and control of violent behavior allow individuals to acquire tools that help them behave socially using accepted social models (Moore et al., 2011). Going through the process and internalizing the language resulted in significant improvement in the level of violence in the subject and feelings of protection. The reflective and metacognitive work impacted automatic responses and the system of beliefs and perceptions. It also helped students discover for themselves, for the first time, skills and potential in several areas, including mastering appropriate social discourse and finding a place in the social group.

The goal of the intervention program was to develop self-management skills in students through cognitive and behavioral tools to improve classroom climate and the quality of life and well-being of students in the class.

The intervention program led to an improvement in the students' regulation and self-monitoring skills. Something that expanded their awareness and personal responsibility (Kaniel, 2013). The results of the intervention plan illustrate the importance of teaching effective problem solving skills in various situations through a self-management circle. According to Smith & Daunic (2004), problem-solving skills can help monitor thoughts, i.e., act according to reality, monitor the results of monitoring, and manage the results of responding accordingly. The use of cognitive behavioral principles has the potential to change the way students think. Changing thinking and learning thinking and observation skills allow for the development and implementation of an independent self-management system and the learning of new

behaviors (Harris & Pressley, 1991).

The results of the study show how through a slow and structured process, through small successes and reinforcements, self-management skills were acquired in the students. Self-management skills are a tool that students can use to deal with different situations and work on different defined goals. Through these skills, students were able to create a calm climate, regain a sense of protection and belonging compared to the stormy climate that characterized the class at the beginning of the year.

Kaniel (2006) defines self-reflection in terms of "metacognition" or "inner eye." It can be assumed that the writing of daily reflections, monitoring, and daily use by students helped to acquire and internalize the tools. According to Kaniel (2006), the need for reflection and metacognition arises in complex situations that require a combination of cognition, emotion, and behavior. The requirement to conduct daily and aggressive reflections helped to internalize and work on reflective observation as a tool to examine thoughts, feelings, and behaviors. Several studies indicate the relationship between negative automatic thoughts and feelings of anger and violent behavior (Yavuzer&Karatas, 2013). The process of internalization and establishment involved regular classes in the system in which automatic thoughts, belief systems, perceptions, and cognitive patterns, feelings, and emotions that arise as a result and their effects on behavior were brought into awareness. Research results show that by changing automatic thoughts, students were able to moderate the emotion of anger and, as a result, moderate behavioral responses according to the level of reactions and broaden the range of possible responses in a given situation. This contributed to a positive classroom climate and an increase in the feeling of safety. The improvement in climate was reflected in student reports, a reduction in the percentage of physical and verbal

violence, and a positive change in quality of life indicators related to school functioning.

## 9. Conclusion

The purpose of the study was to examine the effect of an intervention program based on cognitive-behavioral principles on classroom climate, classroom interactions, the sense of safety of the students in the class and the teachers who teach in the class, the quality of life and well-being of the students in the class, and the extent to which the students relate to social-emotional development and learning.

Prior to the start of the program, the classroom climate was turbulent, unyielding, and disrespectful. Students in the class reported a lack of a sense of belonging and a sense of protection, as well as a constant feeling of noise and disorder. These feelings prevented the implementation of interventions that would enable and promote learning. Students in the class and teachers reported a lack of legitimacy to express themselves in front of the class and a violation of their sense of competence, self-esteem, and ability to express skills in the cognitive domain. Students indicated that they found it difficult to initiate and sustain social activities in the classroom, such as conversations or social games. This reality caused a sense of constant frustration and a lack of appropriate response. Behaviors indicative of cognitive deficits and biases led to misinterpretation of everyday situations and maladaptive and disruptive behavioral responses, as well as a noticeable lack of reflective and metacognitive strategies. Over the years, the struggles described led to the development of negative social roles and images, associations based on a false background and having a negative and offensive effect. These reinforced the behavioral problems and created a closed circle that determined the fate and place of the individual in the class and the class as a group.



The intervention plan developed for the class was based on cognitive behavioral principles. The initial goal of the program was to build and establish a management and self-regulatory system in the students to provide them with tools to monitor their goals versus their actions, monitor the cognitive and emotional factors that influence behavior, and advocate for intentional self-change based on their will and their personal and group goals.

Through a long and consistent process, consistent semantics were established, tools were practiced and their use adapted, group and personal goals were established, all with shared thinking, clear definition, and limited time. All children in the class acquired management and self-regulation skills at different levels. The individual work built the group and the group work supported the individuals.

There was an improvement in class climate, sense of security, quality of life indicators related to the school environment, legitimacy and belonging of the children in the class, and motivation to maintain and act for a positive atmosphere. Social interactions were created on a positive basis, social circles were expanded, and appropriate and respectful discourse skills and rules were established. Consistent facilitation improved feelings of support and belief in the ability to handle conflict and challenges, calmed the classroom atmosphere, and allowed for learning, initiative, and personal expression.

The study was conducted over one year and demonstrated the positive results of an intervention program based on cognitive behavioral principles for management and self-regulation skills, as well as the impact of the program, along with the acquired skills, on student performance in various domains. The approach proved to be appropriate, the process was successful and provided

resolution. In addition, the degree of effectiveness of the group intervention program varied among the children and about 10% of the students in the class needed an individual intervention program at the same time.

The study did not include a control group to examine the effectiveness of another program or the natural developmental processes of puberty without the implementation of a program

The initiative to set up the program, its creation, implementation, monitoring, and analysis and drawing of conclusions were in the hands of the researcher. However, it must be remembered that this is one of the limitations of any action research (Shakdi, 2011).

In the future, it would be worthwhile to examine the impact on the specific group over time to assess long-term reasonableness and to examine the acquisition and implementation of the tools and their independent use. In addition, to provide continuity, self-management skills will need to be adjusted and the possible tools to manage additional situations will need to be expanded as students mature and enter adolescence.

It would also be interesting to adapt and study the functioning of the intervention program and its outcomes at different levels and for groups with different needs, as well as for prevention in groups without behavior problems

In addition, it is important to conduct a comparative study that examines the effectiveness of the specific intervention program compared to other intervention programs.

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## INNOVATION AS A TOOL FOR IMPROVING PUBLIC SERVICES QUALITY

**Abstract:** *The aim of the article is to diagnose citizens' expectations regarding innovations implemented in the public services sector. The authors present the results of survey research conducted among students of Krakow universities. Respondents answered questions about the need for innovation in the public sector and the purposes they should serve. Based on the obtained results, the conclusion was drawn that an increasing number of citizens expect innovative activity in the public services sector. Therefore, the action of demand factors can be observed, although the mechanisms of their influence on the course of innovative processes in this sector are different from those in companies. The empirical research presented in the article was preceded by a theoretical introduction in which the authors describe the essence of innovation in the public sector, the conditions for their implementation, and the importance of citizens' participation in this process.*

**Keywords:** *innovation, public services, citizen participation*

### 1. Introduction

The scope and costs of operating the public sector, as well as the quality of services it provides, have been an important topic of scientific discourse and public debate for many years. Determining the appropriate size of this sector and its role in meeting the needs of citizens will likely remain a controversial issue. However, there is consensus in the literature that as economic and social development progresses, citizens' expectations for the quality of public services continue to rise. Therefore, diagnosing these expectations, identifying trends, and even shaping attitudes in this area is becoming an increasingly challenging task for public authorities, including at the local level (James, 2009; Song, An, Meier, 2021). Public opinion research typically focuses on diagnosing citizens' needs, while their expectations for problem-solving methods are less frequently studied. This creates an information gap in this area, particularly

regarding the diagnosis of residents' expectations for the innovativeness of the public sector. Public management specialists have long listed innovation as a tool for improving the quality of public services (Gallouj, Savona, 2009), but social perceptions of these innovations are rarely studied.

The aim of this article is to partially fill this gap by diagnosing the expectations of Krakow residents regarding innovations implemented in the public sector. The authors present the results of survey research conducted among students at Krakow's universities, which is one of the largest groups of recipients of public services available in the city. The authors of the study aim to justify the thesis that social support for innovations implemented in the urban space is showing a growing trend. The empirical research presented in the article is preceded by a theoretical introduction in which the authors describe the essence of innovation in the public sector, the conditions for their

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implementation, and the importance of citizen participation in this process.

## **2. Theoretical background**

For several decades after the concept of innovation became widespread in the literature on economics and management, it was primarily used in the context of the private sector. The public sector was mentioned in discussions on innovation, but in a specific role - as a component of the innovation process (basic research) and as a creator of conditions conducive to innovation in businesses (innovation policy). Individual public institutions, both government and local, were not seen as active agents in implementing innovative services for customers. However, this approach has been gradually changing. About four decades ago, the problem of innovation began to be discussed in the context of public sector entities. This was largely inspired by criticism of traditional management methods in public administration and the emergence of concepts for its reform (e.g. New Public Management) (Hughes 1994, Ferlie et al. 1996). The growing interest in innovation in the public sector was also influenced by the popularization of the concept of Corporate Social Responsibility (CSR), which emphasizes the social dimension of innovation (McGregor, Fontrodona 2008, Luo, Du 2012). Recently, a systemic approach to implementing innovation in public services has become increasingly popular, developed within the concept of smart cities (Ratten 2017).

The definition of innovation in the public sector does not differ significantly from the typical approaches used in business analysis. Regardless of whether the private or public sector is being considered, innovation is defined as changes that have certain characteristics. Firstly, an innovation is a change that has been implemented in practice (a project or concept is not yet an innovation).

Secondly, innovation requires positive effects. For entrepreneurs, these are primarily economic benefits (cost reduction, sales growth, improved profitability). In the case of public entities, the focus is primarily on social benefits, such as improving the quality of life of stakeholders (e.g. through streamlining administrative services, optimizing public transportation, etc.). Economic benefits (e.g. cost reduction) in the public sector are also desirable, but they do not have to be of primary importance (Mulgan, Albury 2003). The private and public sectors differ in terms of the types of innovations that are most commonly implemented. In the private sector, new products and services are important. Public sector entities introduce new services relatively infrequently, and new products are exceptions. The public sector is fundamentally service-oriented, and the range of tasks it performs is limited or closed (e.g. local government tasks may arise directly from legal regulations). Therefore, innovations in the public sector are focused more on improving the quality of services provided, rather than expanding their range (Walker 2006, Thenint 2010). The specificity of the public sector also means that it rarely develops technological innovations. These usually arise in commercial entities, while the public sector is their recipient.

Although the nature of innovation in the private and public sectors is similar, the set and significance of factors influencing the implementation process can vary significantly. The basic difference concerns the impact of demand determinants on innovative activity. In companies, demand factors affect their economic condition in a quite obvious way, through the market mechanism. Innovations that reduce costs allow for price reduction, and as a result, increase sales and market share; product innovations provide a differentiation advantage resulting in high demand and profit, and this effect is supported by image benefits. In the public sector, the



implementation of innovations meeting stakeholders' expectations does not bring such economic effects. While cost benefits may arise, satisfaction with the quality of public services does not always translate into the number of customers or revenue growth. For example, a satisfied customer of an office will not visit it more often than necessary, nor will they leave more funds than, for example, a legally established administrative fee.

This does not mean that customer expectations regarding the innovation of public services should not be taken into account as a factor stimulating the innovative activity of public entities. These expectations are important, but the way they influence innovation is different than in the private sector. Demand for innovation expressed by citizens indirectly affects the decisions of public sector entities, using political mechanisms. This concerns involvement in the framework of representative democracy (choice of authorities demonstrating an innovative attitude), as well as direct participation (e.g. decisions on the implementation of specific innovative projects made using the procedure of participatory budgeting).

The political pressure exerted on the authorities, especially local ones, is just one of the channels through which citizens influence innovation processes in the public sector. Equally important is non-political participation, which means direct involvement of citizens in the process of developing and implementing innovative solutions (Dameri, Ricciardi, 2015; Berntzen, Johannessen, 2016; Grab, Ilie, 2019). The form of citizen participation may vary. The most obvious form is citizens' participation in the evaluation of introduced solutions. They do this while using them, providing feedback that is useful for making corrections and modifications. Residents can also be involved a bit earlier by acting as testers in the implementation phase of an innovative solution. The most advanced and increasingly

popular formula for such participation is the so-called living labs, in which citizens are engaged in designing and testing innovations even before they are fully implemented (Nguyen, Marques, Benneworth, 2022). Citizens can take on even more creative roles by co-creating innovative ideas, for example, through city-initiated crowdsourcing platforms (Gooch, Wolff, Kortuem, Brown, 2015; Shahrour, Xie, 2021). The extent of citizen participation in innovative projects depends on whether they are convinced of the benefits of the projects being implemented. Therefore, it is important to monitor their opinions and take informational action in this regard.

### 3. Research methods

Information on the expectations of Krakow residents regarding innovation in public services available in the city was obtained through survey research (questionnaire interview). The respondents were students from Krakow universities. Such a selection of respondents resulted from several premises. Firstly, Krakow is an academic city, so students constitute a large percentage of public sector clients. Secondly, their high and diverse activity means that they commonly use the full range of public services in the city. Finally, thirdly, students can be considered a group fully aware of the currently ongoing technological changes, which increasingly affect the public sector.

The survey was conducted in three rounds: in 2019, 2021, and 2023. In the first round, respondents filled out a traditional paper questionnaire, and in the two subsequent rounds, an online questionnaire. To ensure similar conditions, each time the survey was completed during teaching sessions in the presence of lecturers.

In this study, information from the 1st and 3rd rounds of research was used (in the 2nd round, the questionnaire was modified to take into account circumstances related to the

pandemic, so it contained fewer questions about innovation). In the first round, 1750 people completed the questionnaire. The third round is still ongoing, and so far, 501 questionnaires have been collected. This analysis can therefore be treated as preliminary. However, it should be emphasized that for a population of 143,000 students at Krakow universities, the required sample size is 383 people (assuming the following parameters: 95% confidence level, maximum error of 5%, fraction size of 0.5).

#### 4. Results

The survey results indicate that already in 2019, over half of the respondents recognized the need for implementing innovation in the public sector. Over 42% even stated that they should be implemented unconditionally. The percentage of people who claimed that there was no room for innovative solutions in the public sector was negligible (3.1%). It is noteworthy that almost one-third of the respondents had no opinion on this matter (see Table 1). Therefore, it can be concluded that there was no clear division between supporters and opponents of innovation in the public sector, but rather a division into engaged and indifferent individuals. This information can be seen as a signal of the challenges facing the city in terms of education and promotion of innovative solutions. It is worth emphasizing that Krakow is involved in many such projects, and one of the strategic goals of its development is the implementation of the smart city concept.

The results of a later round of research (in 2023) indicate clear changes in the attitudes of the respondents. The direction of these changes is in line with expectations. In terms of their scale, they can be considered radical. The proportion of students supporting innovation in the public sector has increased by almost one-third. As a result, almost 80% of respondents currently expect innovative

activity from the public sector, and almost 2/3 believe that such innovations should be introduced unconditionally. The percentage of students who have no opinion on this subject has dropped by half. Only 1% of respondents described innovation in the public sector as undesirable.

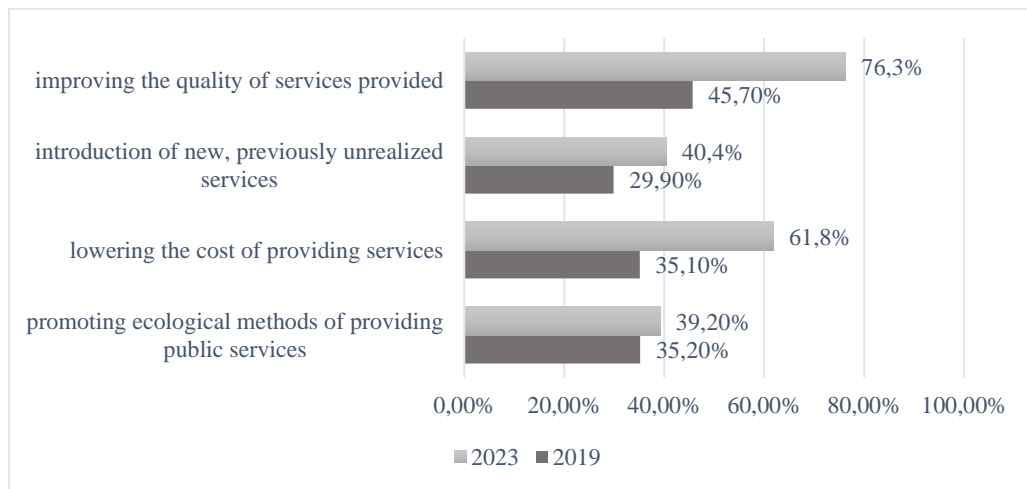
**Table 1.** Expectations of respondents regarding innovation in the public sector

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	2019	2023
Innovation in the public sector: <i>should be absolutely introduced</i>	42.5%	61.3%
<i>are needed, but not necessary in this sector</i>	12.6%	17.9%
<i>are indifferent to the functioning of this sector</i>	10.7%	4.0%
<i>are undesirable in this sector</i>	3.1%	1.0%
<i>I have no opinion</i>	31.2%	15.7%

The analyzed period also saw a change in respondents' preferences regarding the goals that innovation in the public sector should serve. The percentage of respondents who identified two desired effects of these innovations - improving the quality of public services and reducing the cost of providing these services - significantly increased. In 2023, over ¾ of respondents pointed to the improvement of the quality of services (compared to about 46% in 2019). The percentage of respondents indicating cost reduction as the goal of innovation in the public sector increased even more. In 2019, this direction of innovative activity in the public sector was indicated by every third respondent, while in 2023, their share almost doubled. The percentage of respondents expecting the introduction of additional, innovative public services increased from about 30% in 2019 to 40% in 2023. However, the percentage of people claiming that innovation in the public sector should have an ecological character did not change.

significantly over the four years. Young people are usually sensitive to environmental problems, so it may be surprising that a relatively small percentage of respondents indicate ecological effects of innovation as particularly desirable. This is probably due to the fact that Krakow is quite actively implementing and promoting such solutions

(e.g., in public transport). Perhaps respondents emphasized other areas where there is more to be done. The emphasis on the need to reduce costs, especially in the last round of surveys, may result from a general belief in the deteriorating financial condition of local governments in Poland in recent years.



**Figure 1.** Expected effects of innovation in the public sector in the opinion of respondents

## 5. Conclusion

Citizens' opinions and expectations have a significant impact on the course of innovative processes in the public sector. Firstly, residents interested in innovation can exert pressure on public institutions using direct and indirect democratic tools. Secondly, citizens aware of the benefits of implementing modern technologies in the public sector can participate in the process of their development, testing, and implementation in various ways. For these reasons, it is important to diagnose public opinions on innovation in the public sector.

The research presented in this study indicates that the vast majority of surveyed residents of Krakow expect the implementation of innovations in public services provided within the city. They also have specified

expectations regarding the outcomes of such innovations: they should primarily contribute to improving the quality of public services and lowering their costs. Based on this, it can be concluded that in Krakow, there are social conditions that favor the innovative activity of local authorities. This increases the chances of success for implemented projects, especially those aimed at implementing the concept of a smart city.

However, it is worth noting that only students from Krakow universities participated in the study. They were representatives of a very large but specific group of public service users. It can be suspected that support for innovation in other groups of residents, especially in the older generation, may be lower. Conducting broader research, covering the entire cross-section of society, is recommended. They could answer the

question of whether the promotion of innovative solutions in the city is effective and whether there are educational needs in this area.

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## **MATURITY OF THE QUALITY MANAGEMENT SYSTEM AND DEALING WITH CRISIS SITUATIONS**

**Abstract:** *The aim of this article was to analyze how organizations with an implemented ISO 9001 quality system responded to the crisis caused by the Covid-19 pandemic. For the purpose of the study, a set of questions was developed to enable a simplified assessment of the QMS maturity level. Next, it was verified how organizations with different levels of quality culture coped with the reorganization forced by the restrictions associated with the outbreak of the pandemic. As a result, it was confirmed that there is a relationship between QMS maturity and the implementation of actions that can be described as systemic. It was also found that the involvement of top management and the motivating and supporting role of the quality management representative were the factors that had the greatest impact on taking action in a crisis situation.*

**Keywords:** *quality management system, pro-quality culture, restrictions, crisis.*

### **1. Introduction**

Quality management system (QMS) is planned and established by documenting procedures for the processes of organization to fulfill the needs and expectations of internal and end customers. The international standard, ISO 9001, specifies the requirements of quality management system (QMS) to consistently provide products that meet customer and applicable statutory and regulatory requirements (Natarajan, 2017). It provides a framework for organizations to establish, implement, maintain and continually improve their quality management system. By implementing ISO 9001, organizations can improve their processes, reduce errors, increase efficiency, and ultimately enhance customer satisfaction (ISO - ISO 9001 and related standards - Quality management, 2021). However, in contemporary times, it appears that one of the

most significant advantages of implementing a quality management system is the necessity to review organizations from a new, pro-quality perspective.

Effective and efficient quality management, resulting in a high level of product quality, requires the development of a specific organizational culture with a pro-quality character, referred to in literature as a culture of quality (Gołębiowski, 2014). Quality culture encompasses everything that employees possess, think, and do as members of an organization to ensure that the product (or service) meets the needs or expectations of customers that have been established, conventionally accepted, or mandatory (Bugdol, 2018). The notion of quality culture is understood as comprising shared values, beliefs, expectations and commitments toward quality that are supported by structural and managerial elements and processes that enhance quality (Rapp, 2011). Quality culture

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can also be understood as a set of values, policies, behaviors, and decision-making in which there is positive, visible, and shared commitment to quality, with an emphasis on continuous improvement (Wiśniewska & Grudowski, 2022). It also involves the development and implementation of organizational improvement strategies, the use of information for continuous improvement, the correlation between competencies and quality responsibility, collaboration in achieving company goals, and reward systems that take into account work outcomes (Skrzypek et al., 2019). The condition for shaping a culture of quality is a change in the management model from traditional, highly hierarchical and functional to an approach characterized by an active attitude of employees and employee responsibility in the organization's management process (Karaszewski, 1999).

When referring to organizations that have implemented the ISO 9001 system, the concept related to a pro-quality culture of management is the maturity of the quality management system. The maturity of a quality management system refers to its level of development and effectiveness in meeting the organization's quality objectives.

The level of maturity of quality management system is a crucial factor, along with the organizational culture and professional involvement. The QMS maturity signifies how the organization creates and executes the system, evaluates the processes and outcomes, and most importantly, utilizes it as a foundation for ongoing enhancement (Prasnati & Wardhani, 2020). The QMS maturity can be measured quantitatively, in such context it is related to a time dimension, indicating a more advanced state over the years (Sousa & Voss, 2001). However, it is also closely linked to best practices of quality management and can be measured by customer-perceived quality, as well as the effectiveness and efficiency of process management (Nascimento et al., 2016).

Therefore, it can be said that QMS maturity refers to the depth of the organization's experience with quality management system (Novokmet & Rogośić, 2017). A level of maturity is a valuable tool in identifying areas of improvement. This knowledge can be used to fill gaps and ultimately support organizations in reaching strategic and operational objectives (Vanalle et al., 2016).

There are many models for measuring the QMS maturity, most of which are based on self-assessment by the organization. These models are usually related to quality management tools and are linked to models of excellence and quality awards. The three most commonly used models for assessing the level of maturity and functioning of quality management systems are: the SO 9004 standard, the EFQM Model, and the guidelines of the ISO 10014 standard. (Wolniak, 2011). A literature review shows that researchers also create their own maturity assessment models, either by combining existing approaches or developing their own tools. Nascimento et al. (2016) developed a maturity model for quality management systems with 5 levels by combining other recognized maturity models, namely Crosby Maturity Grid, PNQ Quality Award, and JIS Q 9005 standard. Grabowska & Takala (2018) combined QMS maturity with quality costs and proposed a technique for assessing QMS maturity, where QMS maturity is the variable and quality costs are the output measure. Wolniak (2019) developed their own tool to measure the level of QMS maturity, based on the requirements of the ISO 9001 standard modified using the expert method. Xiaofen (2013) proposed a tool based on Crosby's Evaluation Model of Quality Management Maturity, ISO 9004 and criteria for performance excellence of Baldrige National Quality Program. On the other hand, Odważny et al. (2019) developed their own maturity model by building upon the ISO 9004 standard and adding KPI proposals for tracking and measuring



individual activities.

All above models, both basic and modified by researchers to achieve specific research goals, enable the measurement of QMS maturity. Their undeniable advantage is comprehensiveness and the possibility of precisely determining the level of maturity. On the other hand, the research process is usually long and demanding for organizations, which limits the possibilities of its use.

Particularly unexpected and crisis situations make it difficult, and sometimes even impossible, to conduct comprehensive research. Such a situation was the outbreak of the Covid-19 pandemic, which forced drastic changes in organizations. On the one hand, this situation provided extremely instructive observations for researchers, but on the other hand, the possibility of conducting research in organizations struggling with the crisis was significantly limited. Therefore, in the current study, a simplified questionnaire was chosen, containing 10 variables determining the QMS maturity, determined by an expert method. This was aimed at reducing the time that respondents had to dedicate to participating in the study, but above all, to ask during survey a wide range of questions about the phenomena that occurred in organizations during the pandemic.

The aim of this article is to present and analyze data on how organizations with an implemented ISO 9001 quality system responded to the crisis of the Covid-19 pandemic. Providing international best practice, ISO standards are designed to help organizations build their resilience, improve their processes and achieve greater efficiencies. Therefore, organizations with a higher level of QMS maturity should be better able to cope with crisis situations - verifying this relationship was the main idea of this article.

## 2. Materials and methods

The data analyzed in this article is a part of a project aimed at analyzing the behaviors of pro-quality managed organizations in the face of the Covid-19 pandemic crisis (Kafel, 2021). The aim of the project was to diagnose the organizational behaviors of companies with an implemented quality management system compliant with the ISO 9001 standard. Particular emphasis was placed on the functioning of the quality management system in case of a sudden crisis, with special consideration given to the possibility of transitioning to remote work. Organizations that met the following criteria were selected for the study: (1) at least some employees worked remotely in 2020, (2) organizations had implemented and certified a management system compliant with ISO 9001. The database developed for the study contained data from 1200 companies with a certified quality management system. Additionally, PF ISO 9000, the association of organizations with an implemented quality management system supported the survey by providing a link to the CAWI survey to members of the association. So, several certification bodies have agreed to send emails containing a survey link and a letter of recommendation to the companies they are in contact with.

The survey started in January 2021, after a pilot study, it was conducted using the CATI technique. Due to a large number of refusals resulting from respondents' lack of time and low effectiveness of telephone contacts, a mix-mode technique was included in the survey. In some cases, representatives of companies informed interviewers that contact with decision-makers was possible only by email. In such situations, CAWI surveys were sent by email using research agency software. In the final stage of the survey, a single system reminder email was sent to encourage organizations to complete the online survey and telephone interviewers contacted those companies that had

previously expressed a desire to participate in the survey but had delayed completing it. As a result, 205 organizations participated in the survey, which is 17.1% of the target group. Characteristics of the participants are presented (Table 1).

**Table 1.** Characteristics of participants (own elaboration)

Variable (N=205)	Frequency (%)
Number of employees	
up to 9	7,30%
10-49	22,00%
50-249	37,60%
more than 249	33,20%
Annual income (PLN)	
less than 2 mln	15,60%
above 2 to 10 mln	13,70%
above 10 to 50 mln	14,60%
1% more than 50 mln	8,30%
no response	47,80%
Scale of the operations	
local / regional	17,10%
all-Poland	28,80%
international	53,20%

The research form consisted of 5 parts focusing on various aspects related to the quality management in enterprises during the pandemic. The complete questionnaire consisted of 32 closed-ended questions and 11 open-ended questions. The closed-ended questions mainly used a 5-point Likert scale, a dichotomous scale with the option to add comments, and a dropdown list. Additionally, custom scales were created for some sections of the survey.

This article presents a part of the project aimed at investigating the impact of a pro-quality management culture on how organizations respond to crises. This part of the questionnaire contained two sections with

different response scales. The first section focused on the functioning of the quality management system before the outbreak of the pandemic. Respondents evaluated the degree of implementation of listed activities influencing the pro-quality culture on a 5-point Likert scale. The second section focused on the actions taken by the surveyed organizations in response to the pandemic outbreak, using a dichotomous scale. Metric data characterizing the surveyed organizations were also used in the analysis.

Hierarchical clustering using Ward's linkage method and k-means clustering multivariate grouping technique were used to segment consumers. Kruskal-Wallis H test and Mann-Whitney U were used to identify statistically significant differences among the observed groups. Additionally, Spearman's correlation coefficient was used to identify relationships between the level of maturity and actions taken in response to pandemic restrictions. The data analysis was conducted using Statistica (ver. 13.3).

### 3. Results

#### 3.1. Segmentation Based on the Degree of Implementation of Quality Management System

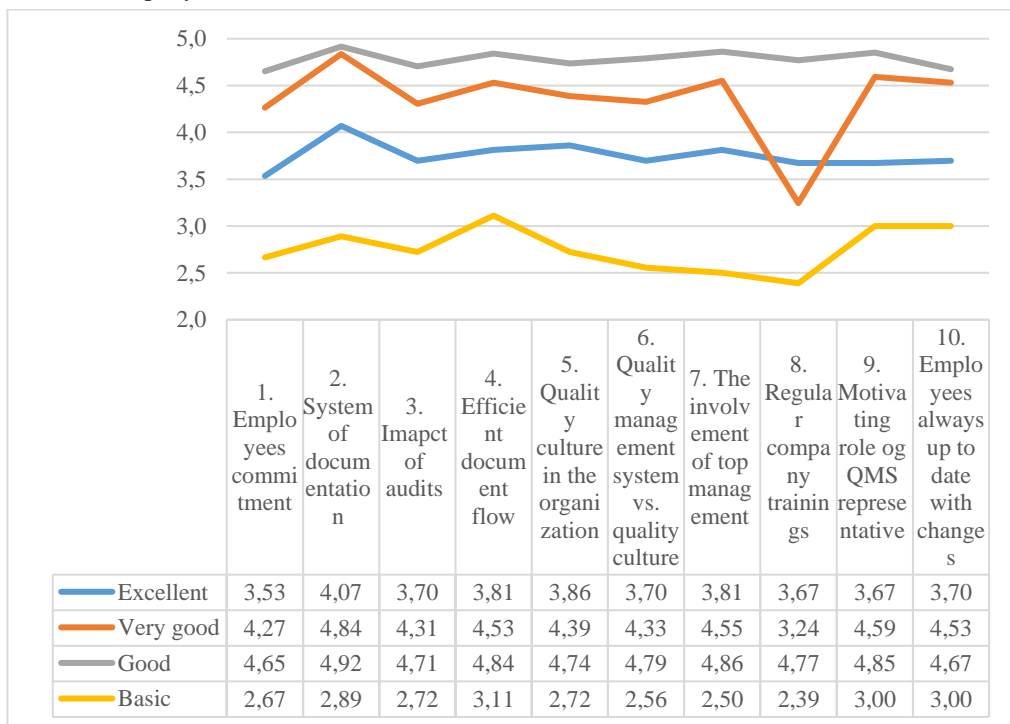
The analysis was based on 10 items that are necessary for the proper functioning of the quality management system. The surveyed organizations performed the self-assessment, measured on a five-point Likert-type scale (where 1=strongly disagree and 5=strongly agree). The statements concerned the functioning of the quality management system before the pandemic and were as follows:

- 1) Employees showed commitment to actions carried out within the quality management system.
- 2) The system documentation was tailored to the company's needs.

- 3) Audits had a significant impact on improving the organization's functioning.
- 4) The document flow within the company was efficient.
- 5) There was an atmosphere in the organization that can be described as a "quality culture".
- 6) The quality management system positively influenced the development of a quality culture.
- 7) The top management was involved in activities related to the quality management system.
- 8) Company trainings were held regularly.
- 9) The QMS representative motivated employees to carry out improvement activities.
- 10) Employees always kept up to date with changes introduced in the company.

As a first step, hierarchical clustering with Ward's linkage method was used to identify the number of clusters adequate to the purpose of the study. To determine the optimal number of clusters, the dendrogram produced by the algorithm was analyzed. The level at which merging two clusters leads to a significant increase in the sum of squared distances were interpreted as the optimal number of clusters. The preliminary substantive analysis showed that the four-cluster solution was the most meaningful and interpretable.

Next, in order to segment the surveyed organizations based on degree of implementation of quality management system, the k-means clustering multivariate grouping technique was used, according to the number of clusters identified through the hierarchical clustering procedure. Figure 1 presents the results.



**Figure 1.** Segmentation of surveyed organization due to QMS maturity (own elaboration)

As a result of the segmentation procedure, organizations were identified in which the maturity (level of implementation) of the quality management system is: (1) excellent, (2) very good, (3) good and 4 (basic).

The “excellent” cluster is the largest, with 97 organizations (46.3%). The average scores for all 10 surveyed items were in the range of 4.7-4.9, which indicates the high maturity of the quality management system.

The second cluster includes 49 organizations (23.9%) and presents a slightly lower level of implementations of some components of the quality management system. The average result for most surveyed items (8 out of 10) is in the range of 4.3-4.6, while the method of conducting ISO system training was definitely rated low (3.2). On the other hand, the adequacy of system documentation was rated on average at 4.8, which means that organizations from a "very good" cluster have a very good basis for achieving a higher degree of quality management system maturity.

The third cluster, labeled as “good” consists of 44 organizations (21.0%) with average score for most surveyed items in the range 3.5-3.9. Only the adequacy of the system documentation to the needs of the organization was rated slightly higher. An average rating of just under 4.0 means that most of the components of the quality management system are implemented and maintained, but at the same time each item still has the potential for improvement.

The fourth cluster is the smallest, containing only 18 organizations (8.8%). Compared to the rest of the respondents, these organizations present the lowest degree of implementation of the quality management system, the average score for most of the surveyed items is 3 or less (2.4-3.1). The degree of maturity of the QMS can be described here as "basic", which means that the organization has implemented the requirements of quality management system, but the system has not yet been fully operational.

### 3.2. Factors Affecting the Maturity of the Quality Management System

The current study investigated the potential impact of five variables on the effectiveness of Quality Management Systems (QMS), namely company size, range of operations, annual income, and number of QMS recertification cycles. The objective was to determine whether these variables resulted in statistically significant differences between groups with varying levels of QMS maturity, which were categorized as excellent, very good, good, and basic.

The Kruskal-Wallis H test was employed to identify statistically significant differences among the observed groups, while the Mann-Whitney U test was used to determine between which groups statistically significant differences in mean values exist. Table 2 presents the results.

**Table 3.** Factors influencing QMS maturity – Kruskal Wallis test (own study )

Factors influencing QMS maturity	Clusters				chi <sup>2</sup>	Sig.
	Excellent	Very good	Good	Basic		
	<b>Kruskall Wallis H</b>					
	median obs.-median exp.					
company size	-0,049	-1,146	0,683	0,512	0,158	0,984
range of operations	-2,780	1,805	0,976	--	3,375	0,337
annual income	-1,202	-2,495	3,936	-0,239	2,268	0,519
number of QMS recertification cycles	13,293	-3,659	-9,634	--	26,947	<b>0,000</b>

The Kruskal-Wallis H test enables the assessment of significant differences in mean values across multiple groups. Based on the findings presented in Table 3, it can be inferred that the mean values were not equal among the various clusters for only one variable, namely the number of QMS recertification cycles. However, statistical analysis indicates that the other three variables did not show significant differentiation among the identified clusters.

In order to identify statistically significant differences between clusters, the Mann-Whitney U test with Bonferroni correction of alpha value was used. The findings indicate that there are no statistically significant differences between the "excellent" and "very good" clusters ( $p = 0.945$ ), as well as between the "good" and "basic" clusters ( $p = 0.727$ ). However, the number of QMS recertification cycles is a significant factor that distinguishes the remaining clusters at a statistically significant level ( $p = 0.000$ ).

### 3.3. Actions Taken by Organizations in Response to Crisis Situation

The analysis was conducted using the case of the crisis represented by the Covid-19 pandemic. Actions that organizations had to implement to ensure continuity of their operations during a crisis were analyzed. Respondents answered 12 questions using a dichotomous scale (yes/no), with the option of adding comments.

In accordance with regulations implemented to prevent the spread of pandemics, organizations had been required to implement three critical measures to prevent the transmission of infectious diseases: distance, disinfection and masks (DDM). The table 3 provides an overview of action implemented by surveyed organization to deal with these restrictions.

All surveyed organizations implemented measures to ensure a sanitary regime (DDM). Notably, the vast majority of them (94.6%)

also developed internal procedures for implementing sanitary recommendations. The majority of organizations approached this problem systematically, with 68.4% of them also establishing crisis teams (only 4 organizations had such teams prior to the outbreak of the pandemic).

Further actions taken by these organizations included the reorganization of internal activities to reduce the risk of virus spread and the transition to remote work. Approximately one quarter of the surveyed companies did not see the need for a change in work organization. The remaining organizations, comprising 74.6% of the survey, implemented changes such as shift work or dividing employees into smaller groups working in separate rooms without contact between workers from different groups. Additionally, they introduced or extended work breaks for ventilation and disinfection of premises, or organized breaks at different times to avoid contacts among employees. Almost all organizations (94.6%) restricted access to meeting places for employees, such as break rooms, employee kitchens, conference rooms, or meeting rooms. The majority (89.9%) also implemented a rotational work schedule or on-call duties for administrative personnel, frequently combined with partial or full transition to remote work.

As part of the transition to remote work, organizations also implemented online activities such as employee training (84.9%), board meetings and other employee group meetings (98.5%), meetings with contractors and stakeholders (98.5%), as well as interviews with job candidates (94.6%). Slightly over half of the respondents (54.6%) decided to conduct internal audits remotely, with an additional 21.5% incorporating newly established remote work areas into the auditing procedures. During the pandemic, remote document circulation was implemented in 69.8% of the surveyed organizations, with 14.6% of organizations

having established remote circulation procedures prior to the pandemic, and 55.1% introducing them as a response to the need for work reorganization caused by the pandemic.

**Table 4.** Factor influencing action taken by organisation in response to crisis (Spearman correlation coefficient) (own elaboration)

Actions	Organizations basic characteristics				QMS Maturity	Factors that constitute QMS Maturity*			
	company size	annual income	range of operations	number of QMS recertification cycles		Positive impact of audits on the functioning of QMS	Efficient document flow	Involvement of top management	Motivating role of QMS representative
Implementation of mandatory sanitary restrictions (DDM)	<b>0,153</b>	0,030	0,033	-0,028	-0,006	0,045	-0,026	-0,010	0,019
Closure of access to social rooms and meeting rooms	0,078	0,151	0,137	-0,094	0,083	0,025	0,029	0,034	0,059
Work schedule reorganization	<b>0,357</b>	<b>0,378</b>	0,202	0,135	-0,030	-0,076	-0,107	-0,097	0,004
Shift work and/administrative staff duty shifts	0,032	0,157	0,115	-0,020	0,021	0,038	0,029	-0,071	0,044
Establishment of a crisis team	<b>0,257</b>	0,180	0,055	0,142	<b>0,543</b>	<b>0,349</b>	-0,039	<b>0,238</b>	<b>0,320</b>
Remote document circulation	-0,078	0,108	0,188	-0,058	<b>0,207</b>	0,050	<b>0,360</b>	-0,008	-0,034
Partial or complete transition to remote audits	<b>0,255</b>	0,130	0,133	-0,027	<b>0,129</b>	0,068	<b>0,128</b>	<b>0,254</b>	<b>0,403</b>
Inclusion of remote work areas in the auditing system	-0,052	-0,034	-0,090	0,080	<b>0,291</b>	<b>0,467</b>	0,129	<b>0,175</b>	0,066
Organization of management meetings and employee meetings remotely	<b>0,284</b>	<b>0,271</b>	0,076	-0,020	-0,033	-0,026	-0,075	-0,063	-0,123
Remote staff training	0,107	<b>0,240</b>	0,090	-0,086	-0,141	0,037	-0,093	-0,051	-0,097
Remote recruitment interviews	0,011	<b>0,234</b>	0,083	-0,094	-0,021	-0,089	-0,080	-0,163	-0,035
Remote contacts with contractors	-0,052	0,122	0,122	-0,069	0,037	-0,122	-0,038	-0,102	-0,032

\*the table includes only those maturity factors that demonstrate a relationship with the implemented measures

\*\*statistically significant correlations at  $p < 0.05$  are in bold

To verify the factors that influenced the actions taken by organizations in response to the pandemic outbreak, the Spearman correlation coefficient was employed. The analysis considered factors that constitute QMS maturity, as well as elements such as organization size, annual revenue, and company scope of operations. The results are presented in Table 4.

For the majority of actions taken by organizations in crisis situations, no correlation with the level of QMS maturity was found. The type of measures taken in response to restrictions was most likely determined by the type of activity conducted by the organizations. Based on the analysis of Spearman correlation coefficients, it can be concluded that there was a statistically significant relationship ( $p > 0.05$ ) between the adaptation of organization to pandemic conditions and variables such as the size of the organization, income level, and scope of activity. The implementation of certain elements of remote work, such as online training, meetings, and recruitment, was also impacted by the income level. Conversely, the decision to form a crisis team and initiate remote audits was influenced by the size of the organization. Additionally, the implementation of an electronic document flow system was positively correlated with the scope of the company's activities.

As predicted, the level of QMS maturity was statistically significantly correlated ( $p > 0.05$ ) with actions that can be defined as "systemic". The higher the level of organizational maturity, the greater the tendency to form crisis teams ( $r=0.543$ ), implement electronic document flow systems ( $r=0.207$ ), transition (partially or completely) to remote audits ( $r=0.255$ ) and include remote work in the auditing system ( $r=0.291$ ).

Among the factors forming the QMS maturity construct, the involvement of top management and QMS representative proved to be significant. A higher level of engagement by these individuals (prior to the

pandemic) was associated with a greater tendency to conduct remote audits ( $r=0.254/ r=0.432$ ; management/ QMS representative) and to forms crisis teams ( $r=0.238/ r=0.320$ ; management/ QMS representative). According to the research findings, there was also a positive correlation ( $r=0.175$ ) between the involvement of top management and the tendency to undertake audits of remote work areas.

The second significant factor of the QMS maturity construct was found to be the functioning of the auditing system. Organizations that valued audits and used them to improve their QMS before the pandemic were more likely to establish crisis teams ( $r=0.349$ ) and include remote work areas in their auditing system ( $r=0.467$ ) during the pandemic. Surprisingly, no statistically significant correlation was identified between the efficient functioning of the auditing system and the tendency to partially or completely switch to remote audits. On the other hand, the implementation of remote audits was supported by efficient document circulation ( $r=0.128$ ). As expected, there is also a strong correlation between the efficient functioning of the documentation system (prior to the pandemic) and the implementation of electronic document circulation in response to the crisis ( $r=0.360$ ).

## 4. Discussion

The implementation of a quality management system is a significant step towards shaping a culture of quality within the organization. The requirement for continuous improvement means that the organization progressively implements and improves actions and strategies that allow for a better tailored QMS to meet internal and external organizational needs. This increases the QMS maturity, which means that system is well-established, documented, and consistently applied throughout the organization. It is also continuously improved based on feedback

from customers and stakeholders. As mentioned in the introduction, there are many QMS maturity assessment models that enable a comprehensive assessment. However, due to the number and detail of the criteria, conducting such an assessment can be complicated and time-consuming for organizations.

Therefore, this study proposes a simplified tool for estimating the level of QMS maturity. The motivation for proposing such a solution was primarily the research goal, which was to verify how organizations with an implemented ISO 9001 quality system responded to the crisis of the Covid-19 pandemic. In this context, determining the level of QMS maturity was only an auxiliary factor, enabling differentiation of study participants. Nevertheless, the obtained results provide some insight into the topic of QMS maturity in Polish organizations with an implemented ISO 9001 system.

A review of the literature reveals that in Poland, analyses are being conducted on the maturity of quality management systems (Skrzypek, 2012; Kafel & Sikora 2013; Książek & Ligarski, 2017, Zapłata, 2018). However, there are not many studies on how organizational characteristics influence the development of a pro-quality culture and organizational maturity in organizations with implemented quality management systems.

Wolniak (2019) conducted a comprehensive analysis of factors influencing the level of maturity of quality management systems in Polish organizations. The research showed a significant correlation between QMS maturity and organization size, with smaller organizations exhibiting higher levels of maturity. However, current research yields different conclusions, no significant statistical relationship was observed between the organization size and the level of QMS maturity. The results regarding the relationship between organization size and QMS maturity are inconsistent in other countries as well. For instance, Xiaofen

(2013) found that there is an exact opposite relationship (i.e., the larger the enterprise, the higher the level of QMS maturity). The ambiguity of the results may stem from the application of different QMS maturity assessment models, as well as differences between the tested samples. However, at this point, it can be stated that it is not possible to unambiguously determine that the size of the organization has a significant impact on achieving the level of QMS maturity. Other factors analyzed in the current study, as income or scope of activity have not been identified in the literature as potentially significant for QMS maturity level. However, the relationship between the number of recertification cycles of the Quality Management System (QMS) and the level of QMS maturity, identified in current research, is confirmed in the literature. For example, Souza & Voss [2001) established that maturity occurs as a function of the number of years in the implementation and certification of QMS.

The conducted research has shown that organizations have implemented restrictions resulting from legal regulations (DDM strategy), and these actions were not dependent on the QMS maturity. However, the maturity of the QMS had a statistically significant relationship with actions such as the establishment of a crisis team and the implementation of remote work elements such as electronic document flow and complete or partial switch to remote audits (including audits of newly created remote positions).

During pandemic the traditional approach to auditing processes on-site has been significantly curtailed, and it was unclear when, and under what conditions, it might resume in full. Internal audits require independent auditors who are usually employees from other processes that audited one (Clastka at al., 2020), and in remote work conditions, meetings between both parties were significantly hindered. In case of



external audits, requirements for auditing management systems are included in the ISO/IEC 19011:2018 and this standard indicate the possibility of using both direct and indirect contact with the auditee (Nowicki & Kafel, 2022). However, before pandemic the remote approach was not a frequently used method in the certification audit of the quality management system, where the traditional approach in the certification process was preferred (Fonseca et al., 2021).

Current research has shown that there was a statistically significant correlation between the level of QMS maturity and the challenge of implementing audits in a new, remote form. The main factors supporting this decision were management involvement and a positive opinion on the effectiveness of audits as QMS improvement tools. Based on a deeper analysis of remote auditing in surveyed organizations, it was also found that the vast majority of organizations that had experience with remote audits considered that remote work did not affect the credibility of the results of external audits (Kafel & Nowicki, 2022). Furthermore, although most audits could not take place in the previously planned time and/or form due to restrictions related to the pandemic, the transition to remote auditing enabled a decisive majority to carry out their audits (Rozmund & Dziadkowiec, 2022).

The partial correlation analysis revealed that in the factors influencing QMS maturity had an uneven impact on crisis management. It is not surprising that the factor with the greatest impact was the involvement of top management, while the motivating and supporting role of the quality management representative also played a significant role. The ISO 9001 standard requires top management to demonstrate leadership and commitment to the quality management system by establishing a quality policy, setting quality objectives, and ensuring the availability of resources. In a quality-oriented

organization, the leader creates conditions for utilizing organizational resources, including the development and abilities of employees. By setting an example, the leader demonstrates identification with the organization's quality goals (Hamrol, 2009). Some researches show that QMS maturity is closely related to leadership. Silva & Matos (2022) found a significant positive correlation between leadership practices and some QMS maturity dimensions in their research on leadership styles in systemic quality management. Wolniak (2019), in his study of QMS maturity in Polish organizations, noted weaknesses in leadership related to "soft" management aspects. In this context, it can be concluded that current research confirms the role of leadership in systemic quality management, and for the studied organizations, it was also a stimulating factor in implementing actions to prevent the loss of continuity of operations.

## 5. Conclusion

For the purposes of the article, a simplified QMS maturity assessment tool was developed, which on the one hand is a limitation of this study, but on the other hand contributes to the approach to the QMS maturity problem. Unlike systemic QMS maturity assessment measures, the proposed tool is not comprehensive, but despite this, it is quite effective in allowing for an approximate assessment levels of QMS maturity. Evidence of this is the fact that the use of statistical tool allowed for the identification of organizations at different levels of maturity, and the differences between levels are fully interpretable in terms of content. It can therefore be stated that in analyses where QMS maturity is an auxiliary variable, as in this study, simplified algorithms can be applied. However, this requires further analysis. At this stage of research, it can be stated that depending on the research objective, different factors can

probably be selected for QMS maturity assessment. Selection can be made, eg. by expert method, as in this study.

The conclusion of the research is that despite the limited set of factors defining the level of QMS maturity, only 4 out of 10 included in the model played a significant role in responding to pandemic-related restrictions. This was surprising, as both the experts selecting variables for the study and the project authors expected many more correlations to be identified. However, it is not surprising that among the factors influencing QMS maturity, leadership has particularly significant importance. In this study, leadership was represented by the involvement of top management and supportive and motivating role of QMS representative.

In summary, the results of this study have shown that organizations with implemented the ISO 9001 system, coped well in the unexpected situation of the Covid-19 pandemic. It can therefore be stated that even just implementing QMS makes organizations more resilient to crises, regardless of QMS maturity level. It has also been shown that there is a statistically significant correlation between the level of QMS maturity and crisis actions that can be described as "systemic".

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This leads to the conclusion that a pro-quality culture has a positive impact on expanding the quality management system to new areas, even in situation of unforeseeable circumstances. Therefore, the thesis that ISO standards are designed to help organizations build their resilience and improve their processes has been confirmed, and that with the development of these systems, organizations are better prepared to deal with crisis situations.

The main achievement of the project is that research was conducted during drastic restrictions. It allowed for insight into the functioning of QMS in atypical conditions. However, the main limitation of this study is the fact that there is relatively little opportunity to verify both the research tool used and the results obtained, due to the fact that the Covid-19 pandemic no longer exists. However, further research is planned, aimed at verifying which of the changes implemented during the pandemic are continued and what impact they have on the functioning of quality management systems.

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## KEY PERFORMANCE INDICATORS (KPIs) IN THE QUALITY MANAGEMENT SYSTEM

**Abstract:** *Key Performance Indicators (KPIs) are often used in business of various sizes and industries to assess operational efficiency and evaluate process effectiveness. A universal model for implementing and utilizing KPIs has been elaborated in the company, and its functionality has been verified in a selected enterprise. In accordance with the developed model, efficiency indicators have been proposed, and among them, key performance indicators (KPIs) have been selected. In addition to commonly used financial indicators, indicators evaluating the performance of the quality management system have been included, along with the need for quality cost optimization.*

**Keywords:** *Key Performance Indicators (KPI), Quality Management System (QMS), functioning model of KPIs*

### 1. Introduction

A quality management system compliant with the requirements of ISO 9001 is a system based on risk and opportunity analysis and continuous improvement processes. The implementation and application of the requirements outlined in the standard should ensure stability and repeatability of identified processes within an organization. The fundamental concept embedded in the standard is the process approach, which involves identifying the processes taking place within the organization and managing the relationships between these processes. Applying the process approach in a quality management system allows for the identification of processes, considering them in terms of value-added, achieving effectiveness in executing the processes, and continually improving them based on data and information assessment (ISO 9001:2015). Within the process approach, the organization should determine the necessary processes for the quality management system, their application within the organization, and

should also:

- identify the required inputs and expected outputs of the processes,
- determine the sequences of these processes and their interactions,
- define and apply criteria and methods (including monitoring, measurements, and related performance indicators) needed to ensure the effective execution and monitoring of these processes,
- identify the resources required for these processes and ensure their availability,
- assign responsibilities and authorities within these processes,
- consider the risks and opportunities,
- evaluate these processes and implement any necessary changes to ensure that they achieve the expected results,
- continuously improve the processes and the quality management system.

Managing processes and the system as a whole can be achieved in an organization by

applying the PDCA cycle: Plan - Do - Check - Act. During the planning stage (Plan), the organization should establish the objectives of the system and its processes, identify the resources needed to deliver results in line with customer requirements and organizational policies, and identify and consider risks and opportunities. The next stage is Do, where the planned actions are implemented, followed by the Check stage, which involves monitoring and, where applicable, measuring processes and the products and services that result from them against policies, objectives, requirements, and planned activities. Based on the obtained and presented results, actions (Act) should be taken for improvement if necessary.

If an organization wants to achieve success, it should be continuously focused on improvement. Improvement in the organization is a process that has its inputs (such as potential areas for improvement), actions (representing its course), and outputs (being an enhanced form of a process, product, or service). This process is crucial for the organization to maintain the current level of performance, respond to changes in internal and external conditions, and create new opportunities. Improving the quality management system is a necessary action in the face of a changing environment, increasing requirements, and customer expectations. It is a continuous process that seeks opportunities to enhance all aspects of organizational functioning in the interest of both the organization and its customers, aiming to improve effectiveness and deliver products that meet expectations. Improvement should be treated as a tool for managing processes and as corrective action to ensure their implementation. The organization should promote the establishment of improvement objectives, develop and implement processes for implementing improvement projects within the organization, establish improvement mechanisms and an evaluation system for

implementing improvement projects, evaluate the achieved results, and standardize tools and methods to solve problems and achieve improvement goals. It should also integrate ideas for improvement with the development of new or modified products, services, and processes. All actions carried out in the organization, comprising the identified processes related to leadership, planning, support, operational activities, performance evaluation, and improvement, should strive for the outcome of customer satisfaction. Operational actions, among others, include planning, determining product requirements, design and development, production, acceptance of products, handling nonconformities in output processes, and overseeing processes, products, and services delivered externally. The requirements for products and services also strongly emphasize the importance of customer contact.

In the process approach to management, it is assumed that every process within the organization creates value for the customer (external - end customer or internal - colleague). Therefore, it is necessary to assess the capability of processes to deliver products or services of a specified quality. Consequently, an analysis of the key attributes of each process should be conducted in the following aspects (Rydzewski-Włodarczyk, Sobieraj, 2015):

- a) process costs, which include all costs incurred in carrying out activities within a given process,
- b) process duration, which refers to the average time required to complete all operations within the process,
- c) process flexibility, which is the ability to completely improve, combine, or divide tasks,
- d) process quality, which is measured by its variability level or the number of errors,

- e) significance for the organization, which represents the benefits generated by the process for the organization,
- f) significance for the customer, which is measured by their satisfaction.

In the improvement of processes, indicators play an important role as they provide information about the results of actions, trends, and opportunities for change. Each organization should individually select indicators and tools through which measurements will be conducted.

The ISO 9001 standard includes requirements related to the evaluation of performance, which is associated with the process of monitoring and measuring processes. The organization should determine what needs to be monitored and measured, the methods to ensure the accuracy of the results, the frequency of monitoring and measuring, as well as how to analyze and evaluate the results of monitoring and measurements. The results of the analysis should be used to assess:

- conformity of products and services,
- level of customer satisfaction,
- effectiveness of actions and the effectiveness of the quality management system,
- whether planning has been effectively implemented,
- effectiveness of actions taken to address risks and opportunities,
- performance of external suppliers,
- needs for improvement of the quality management system.

According to the literature review (Ostapko, 2018; Grycuk, 2010; Zbierowski, 2011), it is evident that there are difficulties in selecting and formulating appropriate indicators, as well as conducting measurements and obtaining relevant information. However, every organization uses various indicators to assess the performance of processes, their effectiveness, achieved results, and resource

consumption.

## 2. Key Performance Indicators (KPI)

Monitoring of the production process, which involves recording and collecting detailed data regarding its course, is a crucial element of enterprise management. The collected data can be used to assess the functioning of processes, identify emerging non-conformities, improve and optimize processes, as well as enhance the efficiency of resource utilization and increase production capabilities. Analyzing processes using raw data of diverse nature from different positions can be challenging. It is much more convenient to utilize synthetic numerical indicators that combine information from various sources. For this purpose, key performance indicators (KPIs) are used, which enable the evaluation of the functioning of the production system in terms of its performance, quality, and maintenance (Barecki et al., 2018; Czerwińska, Pacana, 2020).

Key Performance Indicators (KPIs), according to ISO 22400-1:2014 and ISO 22400-2:2014 standards, are defined as measurable and strategic metrics that reflect critical success factors of an organization. KPIs are essential for understanding and improving production performance from both a production perspective, enabling the elimination of waste, and a strategic goal achievement perspective.

KPIs are indicators that allow organizations to assess the extent to which their strategic objectives and plans are being achieved. They serve as a management control tool that enables the detection of problems even in the early stages, facilitates prompt decision-making, prioritizes actions appropriately, and promotes process improvement within the company. They also enable the identification of areas of inefficiency, monitoring changes

over time, and evaluating employee effectiveness. A set of indicators developed for a specific organization, which fulfills its role and is utilized for management purposes, should meet the following conditions (Rydzewski-Włodarczyk, Sobieraj, 2015; Grycuk, 2010; Grabowska, 2017):

- a) Indicators should address issues that are important to the organization.
- b) Indicators should be tailored to the situation and specific sector in which the organization operates.
- c) The number of indicators should not be excessive, and measurement should focus on monitoring key processes rather than measuring everything.
- d) Each indicator must have a defined benchmark or standard for the specific assessment period, such as results achieved by the organization in previous periods.
- e) Benchmarks should be adjusted in subsequent periods to stimulate continuous improvement.
- f) Only indicators that employees can realistically influence should be selected.
- g) The majority of indicators should focus on processes related to meeting customer needs and measuring customer satisfaction.
- h) The costs of data collection should not exceed the benefits of using indicators.

Therefore, it is important to select and choose indicators appropriately, measuring and analyzing only those that are most important to the company and provide information about the organization's performance. From all the possible calculable indicators, only a few or a dozen should be selected that best reflect the level of achieving strategic goals. The developed KPI indicators should be simple, and the method of calculation should be understandable to employees. The indicators should be clearly and precisely

defined to ensure reliable and comparable results across different periods. Measuring and assessing processes using key performance indicators aim to obtain information about their functioning and the need for improvement actions.

KPI indicators are used to measure economically, technically, and organizationally fundamental parameters characterizing the functioning of a company. They enable not only the determination of the values of applied KPI indicators but also the identification of selected factors influencing their values (Bartecki et al., 2018; Hollender, 2016).

### **3. Model and results**

Key performance indicators are used not only for evaluating processes but can also be used for assessing the functioning of the quality management system and evaluating individual actions carried out within this system. The aim of the study was to determine whether efficiency indicators can be used to improve processes and the quality management system.

A medium-sized manufacturing company operating in Poland, which sells its products not only to the domestic market but also to the European Union, was selected for the study. This organization operates and develops quite dynamically. The investigated company is characterized by a high level of quality in its offered products as well as the executed processes. It typically runs large production batches but also has the capability to fulfill small batches if the need arises.

The organization has implemented and maintains a quality management system in accordance with the requirements of ISO 9001, which operates effectively and has obtained certification for compliance. Due to collaboration with the automotive industry, the investigated company has obtained certification for a quality management system



in the automotive industry in accordance with the requirements of IATF 16949. It has also implemented the requirements of VDA standards and incorporates elements of sustainable development.

Due to the implemented quality management system, the investigated organization, as part of its improvement efforts and in line with the principle of evidence-based decision-making, has decided to introduce process evaluation, including the use of effectiveness indicators. The main objective of focusing on KPIs was to increase production efficiency and eliminate unnecessary activities that do not benefit the company. A team was established within the company to oversee the monitoring, functioning, and improvement of KPI-related activities. The team consisted of representatives from different processes as well as a person from the analysis department. The first step taken by the team to implement key effectiveness indicators was the development of a universal model for their implementation, operation, and improvement. This model is presented in Figure 1. The developed model was verified within the researched company.

According to the developed model, the first step to be taken is to identify the processes or areas for which counting and analyzing KPIs are planned. In organizations that have implemented a QMS, processes are already identified and described.

The investigated organization has identified areas where it deemed it valuable to calculate effectiveness indicators. These areas include production, research and development of new products, orders, human resource management, financial area, customer relations, and maintenance.

The next step was to characterize the processes, determine their inputs and outputs, and identify the key attributes that are specific to each process. Then, as many indicators as possible were collected to describe the identified processes. These indicators were

developed based on available literature, as well as the experience and knowledge of the employees.

The next crucial step is to select, from the prepared indicators, those that are most important, significant, and provide the most relevant information for the process owner during management. The chosen indicators should be linked to the company's objectives and identify the needs of process stakeholders. They should be indicators that can be influenced by employees. By performing their tasks and responsibilities, they can actively respond to process parameters and affect their change.

Having such prepared efficiency indicators, it is necessary to establish and provide target values for these indicators. Target values for Key Performance Indicators (KPIs) represent the level of expectations, the value of the indicator that the organization should strive for when undertaking improvement actions. Determining target values for KPIs constitutes:

- 1) Progress Indicator - serves as a reference point for evaluating the organization's progress towards its goals. Comparing the current values of KPIs with the target values allows determining whether the organization is moving towards its defined objectives and to what extent it has already achieved them.
- 2) Motivation and Performance Management - target values for KPIs are used to motivate employees and teams. Setting realistic goals can inspire employees to greater engagement and effort in pursuing desired outcomes.
- 3) Prioritization and Resource Allocation - target values for KPIs help in establishing priorities and allocating resources within the organization. Identifying areas where KPI values fall below the

expected values enables focusing efforts on improving those areas.

- 4) Monitoring Strategy Effectiveness - Target values for KPIs should be aligned with the organization's strategic objectives. Monitoring the achieved KPI results in relation to the target values allows for evaluating the effectiveness of the strategy and taking corrective actions.

Target values should be established in a measurable, achievable, and contextually appropriate manner for the organization's activities. It is also important for these values to be realistic and monitorable, enabling effective management and continuous improvement of the organization's operations. Determining the value of a given indicator at the initial stage of its implementation, and subsequently verifying its changes within specified timeframes, enables the organization to examine the impact of its actions on the indicator values. The implementation of key performance indicators should be an important component of any system, allowing for the identification, measurement, and monitoring of its functioning. After setting the target values, the organization should measure its processes to calculate the performance indicators and then compare the obtained values with the target values. If the target values are achieved, the organization should analyze what contributed to the success and continue striving for improvement. It should establish new, more ambitious target values for KPIs. Through this approach, the organization can continue to grow and increase its efficiency.

If the target values are not achieved, the organization should also thoroughly analyze what contributed to their non-achievement. In such a situation, areas and processes that require corrective and improvement actions should be identified. Implementing such solutions should improve the functioning of the processes in question and contribute to achieving the target values or getting closer to them in the next period.

In the analyzed company, most of the developed indicators were calculated and analyzed, but not all of them were included in the key performance indicators. The primary indicators verified within the proposed model are:

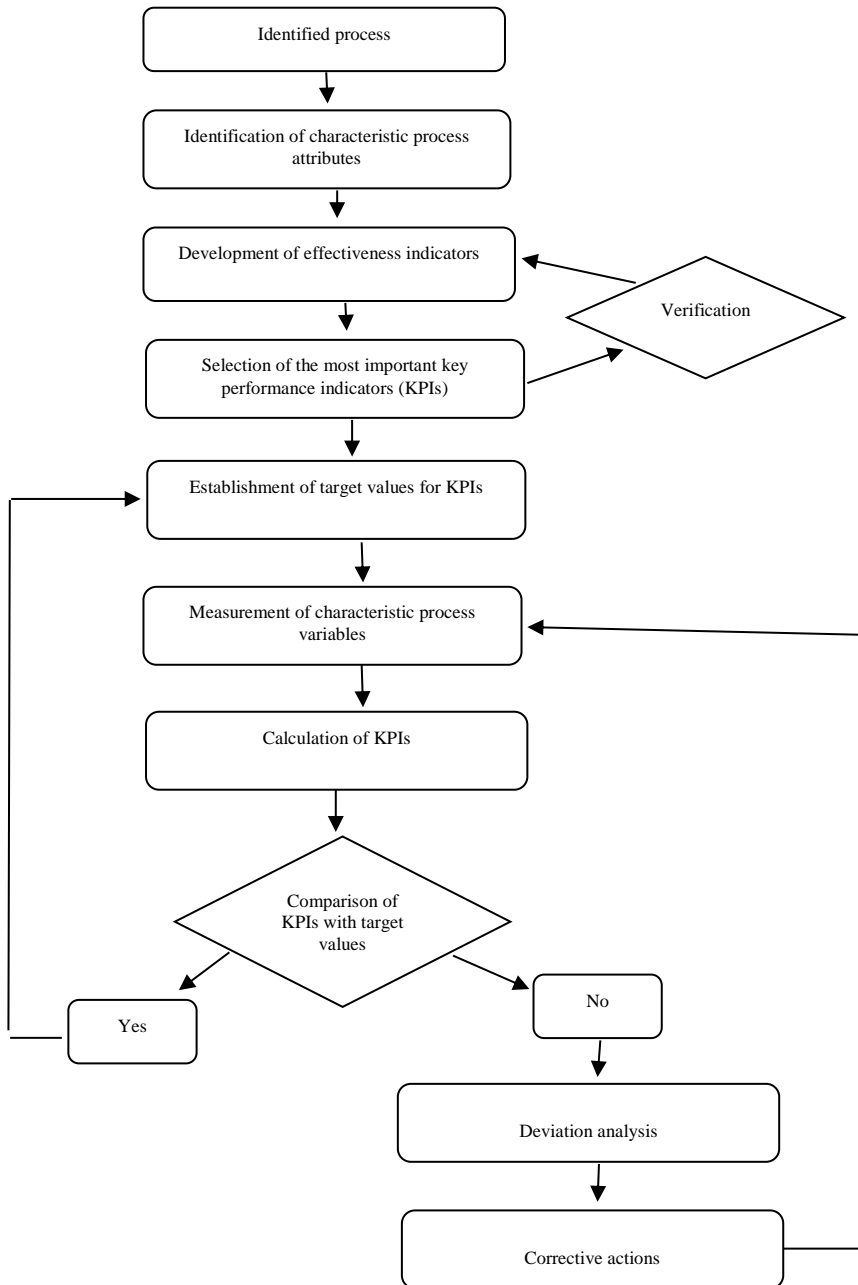
- Return on Equity (ROE);
- Overall Equipment Effectiveness (OEE);
- Inventory turnover;
- Number of complaints;
- Cost of quality indicator;
- Customer satisfaction indicator.

These indicators should provide necessary information about the functioning and effectiveness of individual processes, and they should also be helpful in making managerial decisions at both operational and strategic levels. The indicators have been defined according to the SMART rule, which means they should be: Specific, Motivational, Attainable, relevant, and time-bound (Otręba, Knop, 2019; Kazimierska, Lachowicz, Piotrowska, 2014; Bjerke, Renger, 2017; Mourtzis 2018; Podgórski, 2015; Zhou and He, 2018).

The next step was to establish the target values for KPIs, which are the expected values that the organization should strive for as part of improvement efforts. When setting the target values, the organization followed the SMART methodology. The established target values for KPIs were both realistic and motivating for improvement actions. After determining the target values, the actual values of the KPIs were calculated to evaluate the performance of the analyzed processes. If the actual value of the indicator does not differ from the target value, it indicates that the process exhibits high efficiency, and according to the developed model (Figure 1), the target value of the KPI should be increased to enable further improvement of the process by the organization. Typically, goals are set to be 2-5% more ambitious than in the previous period, which stimulates continuous improvement processes. In case of deviation between the target value and the

actual value, the reason for not achieving the expected value should be examined. The analysis of the process should lead to identifying the cause of such a situation and proposing corrective and improvement

actions. Implementation of these actions should contribute to the improvement of the process functioning and, consequently, to the improvement of KPIs.



**Figure 1.** Implementation, maintenance, and improvement model of KPIs

In the examined company, the target values for KPIs were determined in April, and the actual values were calculated in the following month. The KPIs were recalculated at the end of July. The data regarding target and actual values are presented in Table 2.

Return On Equity (ROE), is an important indicator in ratio analysis that illustrates the profitability of equity. It represents how much

profit has been generated in the company from the contributed equity. The higher the value of this indicator, the more favorable the company's situation. The value of the indicator is determined on an annual scale. In the examined company, this indicator is higher than the set target value, which means that there is no need for improvement actions to be implemented.

**Table 1.** Key Performance Indicators (KPIs) established for selected areas.

<b>Area</b>	<b>Indicator</b>	<b>Information obtained from the calculation of the indicator</b>
<b>Production</b>	Parts per Million (PPM)	Number of defective units per million pieces
	Overall Equipment Effectiveness (OEE)	Efficiency of machine and equipment utilization
	Material consumption in production	Material usage during production
	Production cycle time	Time required to complete one cycle of the process
	Inventory turnover	Flow of goods in the warehouse over a specified period, e.g., a year
	Defect rate	Percentage of defective products in relation to the total number of units produced
<b>Quality Management System</b>	Cost of Quality Indicator	Measures the magnitude of costs incurred for quality (costs related to quality control, prevention of defects, costs of non-conformance) in relation to production costs.
	Effectiveness of Corrective Actions Indicator	Measures the effectiveness of corrective actions taken to eliminate the causes of product or service defects.
	Product Quality Indicator	Measures the level of product conformity with quality requirements, the percentage of products that meet quality standards.
	Customer Complaint Response Time Indicator	The time measured from receiving a complaint to taking corrective actions.
	Customer Satisfaction Indicator	The level of customer satisfaction measured through surveys and/or customer satisfaction studies.
	Audit Effectiveness Indicator	Level of Effective Implementation of Corrective and Improvement Actions Proposed in Post-Audit Activities
<b>Development of New Products</b>	Project Completion Time	The time required to complete a project for the implementation of a new product or changes/improvements to existing products.
	Percentage of Development Costs	The percentage of costs dedicated to activities

		related to product development in relation to the costs of other processes.
	Time to Market	The time required to design, produce, and launch a new product into the market.
<b>Logistics</b>	Inventory Turnover	The ratio of inventory value to sales value.
	Order Picking Accuracy	The correctness of order picking.
	Order Fulfillment Cost	The cost incurred in fulfilling an order.
	Order Fulfillment Cycle Time	The time required to complete one order fulfillment cycle.
	Percentage of Logistics Costs	The percentage of costs dedicated to logistics activities in relation to the costs of other processes.
<b>Human Resource Management</b>	Employee Hiring Cost	The cost associated with hiring an employee.
	Training Cost	The cost associated with conducting training per employee.
	Recruitment Costs	The cost of recruitment activities.
	Employee Satisfaction	The level of employee satisfaction.
<b>Financial Area</b>	Return on Sales (ROS)	The amount of net profit earned per one unit of sales revenue.
	Return on Assets (ROA)	The amount of net profit earned per unit of total assets.
	EBITA Earnings Before Interest, Taxes and Amortization (EBITA)	The profitability of the company before interest, taxes, and depreciation, calculated as a percentage of equity.
	Earnings Before Deducting Interest and Taxes (EBIT)	The profitability of the company before interest and taxes, calculated as a percentage of total assets.
<b>Customer Relations</b>	On Time in Full (OTiF)	The percentage of deliveries that are in accordance with the order,
	On Time Delivery (OTD)	Measuring the timely and complete delivery to customers.
	Customer Acquisition Cost	The cost associated with acquiring a new customer.
	Number of Complaints	The percentage of complaints in relation to the sales volume.
	Customer Satisfaction	The level of customer satisfaction.
<b>Supplier Management</b>	On Time in Full OTiF	Percentage of Deliveries in Accordance with the Order
	On Time Delivery (OTD)	The percentage of deliveries received from suppliers that are delivered on time.
	Number of Rejected Deliveries	The percentage of deliveries that are rejected due to quality issues in relation to the total number of deliveries.
<b>Maintenance</b>	Maintenance Cost	Costs incurred in connection with machine and

<b>Management</b>		equipment maintenance.
	Reporting time for performed maintenance.	The time required to prepare a report after maintenance has been conducted.
	Mean Time To Repair (MTTR)	Average time required to resolve a breakdown.
	Mean Time to Failure (MTTF)	Average uptime of the device/machine before a breakdown occurs.
	Mean Time Between Failures (MTBF)	Mean time between failures

After setting the target values, the organization should measure its processes to calculate the performance indicators and then compare the obtained values with the target values. If the target values are achieved, the organization should analyze what contributed to the success and continue striving for improvement. It should establish new, more ambitious target values for KPIs. Through this approach, the organization can continue to grow and increase its efficiency.

If the target values are not achieved, the organization should also thoroughly analyze what contributed to their non-achievement. In such a situation, areas and processes that require corrective and improvement actions should be identified. Implementing such solutions should improve the functioning of the processes in question and contribute to achieving the target values or getting closer to them in the next period.

In the analyzed company, most of the developed indicators were calculated and analyzed, but not all of them were included in the key performance indicators. The primary indicators verified within the proposed model are:

- Return on Equity (ROE);
- Overall Equipment Effectiveness (OEE);
- Inventory turnover;
- Number of complaints;
- Cost of quality indicator;
- Customer satisfaction indicator.

These indicators should provide necessary information about the functioning and effectiveness of individual processes, and they should also be helpful in making managerial decisions at both operational and strategic levels. The indicators have been defined according to the SMART rule, which means they should be: Specific, Motivational, Attainable, relevant, and time-bound (Otręba, Knop, 2019; Kazimierska, Lachowicz, Piotrowska, 2014; Bjerke, Renger, 2017; Mourtzis 2018; Podgórski, 2015; Zhou and He, 2018).

The next step was to establish the target values for KPIs, which are the expected values that the organization should strive for as part of improvement efforts. When setting the target values, the organization followed the SMART methodology. The established target values for KPIs were both realistic and motivating for improvement actions. After determining the target values, the actual values of the KPIs were calculated to evaluate the performance of the analyzed processes. If the actual value of the indicator does not differ from the target value, it indicates that the process exhibits high efficiency, and according to the developed model (Figure 1), the target value of the KPI should be increased to enable further improvement of the process by the organization. Typically, goals are set to be 2-5% more ambitious than in the previous period, which stimulates

continuous improvement processes. In case of deviation between the target value and the actual value, the reason for not achieving the expected value should be examined. The analysis of the process should lead to identifying the cause of such a situation and proposing corrective and improvement actions. Implementation of these actions should contribute to the improvement of the process functioning and, consequently, to the improvement of KPIs.

In the examined company, the target values for KPIs were determined in April, and the actual values were calculated in the following month. The KPIs were recalculated at the end

**Table 2.** Target and Actual Values of Selected KPIs in the Examined Company

KPI Indicator	Target Value	Actual Value May 30th	Actual Value July 30th
ROE	Min. 0,15 / year	0,16	0,16
OEE	Min. 90% / month	89,87%	89,93%
Inventory Turnover	Min. 0,85 / month	0,84	0,81
Number of Complaints	Max 1 / month	0	0
Quality Cost Index	Max 35%	39%	38%
Customer Satisfaction Index	95%	92%	93%

The Overall Equipment Effectiveness (OEE) indicator reflects the efficiency of machine and equipment utilization in the company. Its main component is the measurement of time, and the calculation result, in simplified terms, represents the portion of plans and expectations that have been achieved at the current level of process organization. The OEE indicator reveals improper resource utilization in processes. By implementing improvement actions, these inefficiencies can be easily eliminated. Therefore, a decision has been made to implement improvement actions. Proposals for these actions were developed based on consultations with the implementation team and included in the actions to be carried out in the near future. The first improvement actions were implemented in the first month. The effects are visible as there was an increase in the indicator in the following month. Due to the proper trend of the indicator's change, it was

of July. The data regarding target and actual values are presented in Table 2.

Return On Equity (ROE), is an important indicator in ratio analysis that illustrates the profitability of equity. It represents how much profit has been generated in the company from the contributed equity. The higher the value of this indicator, the more favorable the company's situation. The value of the indicator is determined on an annual scale. In the examined company, this indicator is higher than the set target value, which means that there is no need for improvement actions to be implemented.

decided to continue applying the same improvement actions.

The inventory turnover ratio indicates how many times the inventory has been turned over in the warehouse during a specified time period, in the analyzed company, it is analyzed on a monthly basis. It allows calculating how long it takes for the financial resources invested in goods to be recovered. In the initial measurement, the actual value of the ratio in the analyzed company was nearly close to the target value. Therefore, it was decided not to implement improvement actions but to observe its performance in the following month. In the subsequent month, the ratio value was even lower and significantly below the target value. This situation was attributed to the holiday period and production downtime. In July, the number of planned orders to be fulfilled decreased, which in turn affected the decrease

in the inventory turnover ratio. Therefore, no improvement actions have been taken for now. Actions will be initiated if such a situation continues in the upcoming months.

The indicator regarding the number of complaints determines how many complaints have been reported to the company. The target value for this indicator was set at 1. However, in the analyzed company, the actual value of this indicator during both measurements remained at 0, indicating that the quality of the products sold is satisfactory for customers.

The cost of quality indicator determines the costs associated with quality control, costs of defects, deficiencies, and non-compliance, as well as the costs of preventive actions in relation to production costs. The actual value of the cost of quality indicator calculated in both periods deviates from the target value. A higher cost of quality indicator indicates that the company incurred higher costs related to quality management than planned. These costs may include quality control, repairs, addressing non-compliance, or preventive actions to avoid non-compliance in the future. Actions taken in the area of cost of quality contribute to the elimination of defects and non-compliance in the production process and the implementation of preventive measures aimed at improving the process. The costs incurred in the analyzed period may only yield results in subsequent periods. This indicator demonstrates the effectiveness of the implemented improvement actions.

The customer satisfaction indicator represents the percentage of surveyed customers who are satisfied with the products purchased from the surveyed company. A lower value of the indicator may indicate that not all customers are satisfied with the quality of the offered products. The lower level of customer satisfaction is not due to product quality issues, as no complaints have been received by the company during this time, as indicated by the complaint indicator being 0 in the current period. Comparing both indicators, it

can be concluded that customer dissatisfaction does not stem from product defects, but rather from a mismatch with customer expectations. It would be worthwhile to conduct surveys among customers to obtain information about the reasons behind such evaluations of the products.

In the examined company, it is necessary to continue monitoring processes and analyzing KPI indicators. The research conducted indicates that there is currently no need to take actions to change the target values. These values are currently properly established, and the company should continue its improvement efforts to enhance processes and consequently improve KPI indicators.

## 4. Conclusions and Discussion

Key performance indicators (KPIs) are important navigational tools used by managers and executives. They allow them to assess and understand whether the company is on track for success. A properly selected set of KPIs enables the determination of the performance of the analyzed processes and highlights areas that require attention.

The implementation of KPIs requires certain assumptions from the company, such as understanding the processes, aligning KPIs with the company's goals, selecting an appropriate set of indicators focused on outcomes, process effectiveness, and providing the necessary information for managers and stakeholders. The indicators should be chosen in a way that allows employees to measure the real impact of their actions and responsibilities (Grycuk, 2010; Torbacki, Torbacka, 2015; Ostapko, 2018; Bhadani et al., 2020; Kaganski et al., 2017).

In the examined company, KPIs have been implemented based on the developed model for introducing, maintaining, and improving KPIs. Literature presents various models for implementing KPIs, but they mainly focus on



the preparation and introduction stages in a company (Lindberg et al., 2015; Grycuk, 2010; Orłowski et al., 2015). The presented model may provide less detailed information on the process of identifying and developing indicators, but it includes actions to be taken depending on the actual results achieved. In case of discrepancies between the target and actual values, it is necessary to identify the area or location within the company or process that contributed to the deviation. Then, the cause of the deviation should be identified, and corrective and improvement actions should be implemented. These actions aim to eliminate the reasons for the discrepancies and prevent similar occurrences in the future.

KPI indicators are used in companies of various sizes and industries. The impact of properly selecting KPI indicators on the decision-making process in small and medium-sized enterprises (SMEs) has been studied by Pîrlog and Balint (Pîrlog, Balint, 2016). According to the authors, KPI indicators serve as early warning signals for a company. Properly approaching this information, making appropriate decisions, and implementing corrective actions can lead to overall improvement in the company's performance. In Business Intelligence (BI) systems, the Key Performance Indicators (KPIs) are considered measurement tools that assess and demonstrate how effectively a company achieves its business goals. A long list of KPIs that lacks clear connections to the overall company objectives may indicate a larger problem: a lack of strategic alignment. Properly selected KPI indicators lead to:

- a) great business insights;
- b) clear and relevant information;
- c) easy access to historical data;
- d) faster and better decisions;
- e) overview of overall company performance.

Therefore, it is important to select key relevant indicators for which data can be obtained. They should be applied in

circumstances that provide the organization with necessary information to determine factors contributing to inefficiencies in key supply chains and performance improvement strategies/policies.

Chae (Chae, 2009) also emphasizes the importance of proper selection of indicators. According to him, the correct selection of KPIs is not easy. He believes that "less is more" when it comes to developing performance indicators. Companies should focus only on a small list of KPIs that are crucial for managing operations, customer service, and financial profitability. Potential KPIs should be developed, measured, reported, and managed in order for the company, department, or project to be perceived as successful. Monitoring KPIs reveals the gap between planning and execution and helps identify and address potential issues and problems. These indicators make it easier to achieve the proposed goal set at the beginning.

KPI indicators are also used in companies to assess the performance of quality management systems, where meeting customer requirements is an important element. This is a crucial factor for companies in terms of survival in the market and generating profits in the medium and long term. Building trust with customers and achieving a high level of customer satisfaction are important attributes. The quality of products is examined during the production process as well as during customer usage. Implemented quality management systems help monitor quality. Additionally, audits are conducted within the system to identify process non-conformities. Non-conformities often lead to defects and discrepancies, which, if unnoticed within the company, appear in the market and are purchased by customers. In such cases, customers have the right to file complaints and express their dissatisfaction during customer satisfaction surveys. Therefore, KPI indicators are also necessary in quality

management systems to assess the effectiveness of improvement actions, the number of complaints, and the level of customer satisfaction. Additionally, quality costs and related indicators can be measured to determine the extent to which improvement actions have optimized costs and reduced non-conformance costs, consequently impacting production costs (Balon, 2012; Sulowska, 2012; Sadowski, 2020; Ayach et al., 2019).

Key Performance Indicators (KPIs) are one of the most important management tools in organizations. Their proper implementation and use support the improvement and control of both processes and the effectiveness of actions taken within the organization. Well-

chosen indicators are a key element in the proper utilization of control and management in an organization. When applied in a manufacturing company, key performance indicators (KPIs) need to be integrated into the company's structure and management system. Monitoring the production process through the use of indicators serves as a tool for steering the organization and identifying problems within the company, enabling dynamic response and documenting actions and their effects.

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# **14. International Quality Conference**



**LATE ARRIVALS**

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## **THE EVOLUTION OF BIBLIOMETRIC INDICATORS FOR SCIENTIFIC PAPERS PREPARED BY POLISH AUTHORS IN THE FIELD OF ECONOMICS**

**Abstract:** *In the first part of the presentation, the analysis of publication achievements of academic staff from five main public universities of economics in Poland will be presented. The survey will be conducted for publications occurred in the last five and will cover:*

- *number of publications,*
- *citations,*
- *structure of authors' teams,*
- *journals,*
- *topics presented on papers.*

*Next, some concepts and measures used for quality evaluation of research papers will be discussed.*

*In the following part of the presentation, potential factors shaping the number of publications and citations will be studied:*

- *publication topics,*
- *number of authors,*
- *journal publishing a paper,*
- *internationalization of the author's team,*
- *the evaluation of authors' previous works.*

*Finally, the model of the evaluation of the number of citations will be presented.*

*All calculations will be based on data retrieved from the Scopus database and conducted by authors with the use of programs prepared in R and Python language.*

**Keywords:** *quality of reserach publications, citations and their determinants.*





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## **QUALITY AGAINST CORRUPTION**

***Abstract:***

***Keywords:***



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## **QUALITY MANAGEMENT CONCEPT IN INDUSTRY 4.0: TRENDS AND CHALLENGES**

**Abstract:** Industry 4.0 is a philosophical transformation of the society and Quality 4.0 proposes the adoption of advanced ICT to enhance quality efficiency and competency. The introduction of an Industry 4.0 based quality management and control necessitates integration steps within and outside the manufacturing company. Furthermore, company partners or customers have to be integrated into the development as they are all part of the overall value chain. Two the biggest challenges will be: Understanding and knowledge: both in industry and academy and Designing Quality / Industry 4.0 systems involves complexity, systems from the high dimensionality and complexity. The aim of this manuscript is to explore directions and trends in development of quality management concepts in the scope of Industry 4.0.

**Keywords:** quality 4.0, qms, industry 4.0



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## **PRODUCTION AND CONSUMPTION IN CIRCULAR ECONOMY AND SUSTAINABLE DEVELOPMENT APPROACH OF THE EUROPEAN UNION COUNTRIES**

**Abstract:** *Production and consumption area is monitored independently, both in the context of progress towards a circular economy and sustainable development. In every case, the number and types of the used indicators are different. It justifies a question on comparability of information produced by two composite measures for equivalent research subjects: production and consumption, which is a thematic area of the EU Action Plan for the Circular Economy as well as responsible consumption and production, which is the 12th goal of UN Agenda 2030. To scrutinize this problem in the context of the European Union countries, this research aims at identification of similarity between the production and consumption indicator (applied within the Circular Economy Action Plan) as well as responsible consumption and production indicator (used by the UN Agenda 2030). For this purpose, the linear ordering method was applied to make the ranking of European Union countries according to their advance in production and consumption sphere for two different years. The comparison of outcomes gave evidence to prove the thesis that the application of the two analysed composite indicators on production and consumption area generates significantly different results.*

**Keywords:** *circular economy, goals of UN Agenda 2030, sustainable production and consumption, responsible behaviours*



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## **THE REFERENCES TO THE ISO 9001 QUALITY MANAGEMENT SYSTEM IN JUDGMENTS AND LEGAL DISPUTES OF POLISH AND SPANISH COURTS**

**Abstract:** *The study describes references to the ISO 9001 quality management system in judgments and legal disputes in Polish and Spanish courts. Results indicate that there are significant differences between Polish and Spanish cases within the studied materials. In general, quality management issues are visible not only B2B legal disputes but also in terms of customer complaints and even private family disputes.*

**Keywords:** *ISO 9001, court, judgment, legal disputes*





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## **INNOVATIONS AS A TOOL FOR IMPROVING THE QUALITY OF PUBLIC SERVICES – CITIZENS' EXPECTATIONS ON THE EXAMPLE OF STUDENTS OF KRAKOW'S UNIVERSITIES**

***Abstract:** The aim of the article is to diagnose citizens' expectations regarding innovations implemented in the public service sector. The authors present the results of surveys conducted on a representative group of students of Krakow universities. The specificity of the academic city of Krakow makes students one of the largest groups of recipients of public services available in the city. The respondents expressed opinions, m.in, on the assessment of the quality of public services, progress in implementing the smart city concept in Krakow and areas in which innovations should be implemented. On the basis of the conducted research, the conclusion was formulated that citizens expect greater innovation activity in the public service sector. Therefore, the action of demand factors can be observed, although the mechanisms of their impact on innovative activity in the public sector are different than in the corporate sector. The empirical research presented in the article was preceded by a theoretical introduction, in which the authors describe the essence of innovation in the public sector, the conditions for their implementation and the importance of citizens' participation in this process.*

***Keywords:** innovation, public services*



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## GRAPHICAL REPRESENTATION OF ATTRIBUTES OF QUALITY TOOLS IN AN EDUCATIONAL INFORMATION SYSTEM - RESEARCH RESULTS

**Abstract:** *One of the main goals of sustainable development of societies is access to high-quality education, in accordance with the principle that social well-being is significantly dependent on the level of education. The implementation of this goal is ensured, among others, by the development of digital technologies that are changing the education system. Information technology has emerged to disseminate shared knowledge and is a major driver of change. Examples of these changes include: new solutions supporting the education process, mobile devices, dynamic visualizations, AV and others. The process of change concerns not only pupils and students, but also a group of people who formally finish their education and enter the labor market.*

*In accordance with the idea of continuous learning, employees of enterprises at all levels continue to develop their competences and skills through self-education, participation in training, post-graduate studies, etc. One of the challenges is to change the form of education of employees of enterprises who are encouraged and engaged in quality assurance activities in their area of work should use appropriate quality management instruments. Access to materials in the form of books, guides, materials posted on the Internet is common, however, this form of elaboration of the material is inconvenient from the perspective of action "here and now", i.e. in production and operational conditions.*

*As part of the research project, the authors create an IT system that facilitates the search, selection and effective use of quality tools. The basis for building the system is the attributive presentation of knowledge about quality tools. One of the current challenges while working on the system turned out to be the graphical representation of recording information about tools. The article*

*presents the results of research on the evaluation of designed graphic symbols (defining various attributes of quality tools in the system under construction) among potential users.*

**Keywords:** *quality tools; educational system; innovation; IT*

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## **APPLICATION OF A NEW MODEL FOR AN OPTIMAL COMBINATION OF THE LEAN SIX SIGMA APPROACH AND THE THEORY OF CONSTRAINTS**

**Abstract:** *Today's Manufacturing firms requires a higher level of quality in processes, services, and products to achieve greater market share and economic success. Most businesses today are global, whether it's a car manufacturer, an electronic company or a construction company, they operate from the world. To achieve excellence, various approaches can be employed such as; lean manufacturing, six sigma and theory of constraints (TOC).*

*The present research proposes an enhancement model which aims to determine the most advantageous product in multi-product manufacturing processes. In addition, the proposed model is a combination between lean Six Sigma and TOC to define the critical step and identify the optimal product mix in order to measure and analyze the operational performances for the optimal product mix. Indeed, we apply the VSM tool (from Weighted DPMO and sigma level ) of lean Six sigma approach and financial and quality indicators (CMPS, CPM) of TOC.*

*The proposed model is implemented in an Algerian automotive industry*

**Keywords:** *Lean Manufacturing, Six Sigma, Theory of constraints, extended Value Stream Mapping, Defects per million opportunities*



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## THE INFLUENCE OF COVID-19 PANDEMIC ON FOOD SAFETY AND QUALITY ASSURANCE STANDARDS IN SELECTED COMPANIES IN POLAND

**Abstract:** Food safety is the basic characteristic of food and the most important one because food has the direct impact on our health. Companies operating along the food chain are obliged by food law to implement the mandatory food standards such as HACCP, GHP, GMP. If they want, they can also use many voluntary food standards. The COVID-19 pandemic influenced the whole food chain and consumer behavior by the restrictions, shutdowns and fear of being infected. This paper presents the results of the survey conducted among 71 enterprises operating in the food industry in Poland in 2022. The representatives were asked to assess the influence of the pandemic on food safety standards and their usefulness during the pandemic. They were also asked about the positive and negative aspects of the pandemic from the perspective of the food industry. It was shown that the pandemic strengthened the need and understanding of the hygienic standards, collaborations with suppliers and employee training. On the other hand, caused the more frequent food quality and safety inspections, shortages of the employees and supplies, and economic losses. For some companies the pandemic was a chance for new form of sales and obtaining additional funding to minimize the negative effects.

**Keywords:** food, food standards, COVID-19 pandemic, pandemic effects





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## **PSYCHOLOGICAL FLEXIBILITY AND HIGHER LEVELS OF QUALITY OF LIFE**

**Abstract:** *Psychological flexibility allows individuals to cope more effectively with stress, regulate their emotions, and maintain positive relationships with others. This can lead to a greater sense of meaning and purpose in life, as well as an increased ability to handle difficult situations. Furthermore, individuals who are more psychologically flexible are often able to set and achieve meaningful goals, which can contribute to a greater sense of accomplishment.*

*We suggest here that there is a strong connection between psychological flexibility and quality of life. That is, that individuals who are more psychologically flexible tend to have better mental health, higher levels of resilience, and greater satisfaction with life.*

**Keywords:** Psychological flexibility, positive relationships, cope with stress, sense of accomplishment



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## **CULTURALLY UNIQUE SUSTAINABLE PRODUCT DESIGN IN EGYPT**

**Abstract:** *This paper presents a research study on sustainable product design in Egypt, which considers the cultural context of the country. This study aims to identify and understand ecodesign strategies that are culturally unique to Egypt, using the Okala Ecodesign Strategy Wheel as a framework. The study examines sustainable design practices in Egypt, highlighting the unique opportunities for ecodesign that arise from the country's cultural heritage. The methodology of the study involves a case study analysis of Egyptian companies that have implemented sustainable product design practices. The study will employ document analysis and field observations to gain insights into the ecodesign strategies used by these companies and how they align with cultural values in Egypt. The expected outcomes of the study are to provide a comprehensive understanding of sustainable product design practices in Egypt, identify ecodesign strategies that align with cultural values, and highlight the importance of considering cultural context in sustainable design practices. The study aims to contribute to the development of a more culturally appropriate and sustainable design approach in Egypt, one that celebrates local culture, promotes environmental and social sustainability, and creates economic opportunities. In conclusion, this research study highlights the potential for sustainable product design to contribute to environmental and social sustainability while also celebrating local culture in Egypt. By identifying and understanding ecodesign strategies that are culturally unique to Egypt, this study aims to promote the development of more sustainable and culturally appropriate design practices in the country.*

**Keywords:** Sustainability, Okala Ecodesign, Product design, Cultural context




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## THE USING CONVOLUTION NEURAL NETWORK FOR AUTOMATIC QUALITY CONTROL ON ASSEMBLY SYSTEM

**Abstract:** *The integration of quality management with the technologies of the fourth industrial revolution (Industry 4.0) enables organizations to adequately respond to the conditions in the modern dynamic business environment characterized by digitization, shorter product life cycles and increasing customer expectations regarding product quality, price and delivery time. At traditional assembly workstations, which are characterized by long-term, monotonous, repetitive and tiring activities of assembling parts and components into the final product, product inspection is performed manually by operators and that takes a lot of time and represents a production bottleneck. Also, due to the appearance of mental fatigue, a drop in concentration in some situations, it is almost impossible for workers to notice the appearance of defects and irregularities. Therefore, in modern assembly systems, the implementation of advanced quality control through quality inspection, visually detect the quality of a product and recognition of irregularities has a crucial role. In this way, the compliance of the final products with the requirements and expectations of customers is achieved and one of the basic goals of Industry 4.0 and Quality 4.0 is achieved, which is zero defects manufacturing.*

*The main aim of this study is to research the possibility of involving neural networks for defects detection of assembly parts in the production process. The research includes using images of two classes (with defect and well done part) and training the neural network with convolution layer for automatic classification produced part. The success of 96 % of applied algorithms using this methodology in automatic detection of defects and non-conformity and on this way reducing cost. One key benefit of the proposed method is the relatively small number of input data set images which*



*enables fast implement method in production environment.*

**Keywords:** automatic detection of defects, Industry 4.0, neural networks, Quality 4.0, zero defects manufacturing

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## **VALUE STREAM DESIGN (VSD) AS A TOOL SUPPORTING QUALITY MANAGEMENT AT THE STAGE OF PROTOTYPE PRODUCTION LINES**

**Abstract:** *This paper presents the way of designing and quality engineering in production processes. Based on the Value Stream Design, the specificity of quality control of products manufactured in special processes (chemical and thermal) was designed. Based on the big map picture of the prototype process, the areas of the greatest threats to the process, from the point of view of product quality management, have been identified. The paper discusses the specifics of designing and improving production processes with the usage of Value Stream Design method - based on the production of precise products from magnetic materials.*

**Keywords:** quality, production management, production engineering, VSD, VSM, Value Stream Mapping





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## **AI BASED SMART SHOPPING LIST TO IMPROVE QULAITY OF LIFE**

**Abstract:** Shopping for daily supplies and keeping track of your shopping list may be a time-consuming and tedious process. mySmartCart is a responsive web application designed to transform the traditional handwritten shopping list or NLP input into a digitalized smart list, to enhance and assist the online shopping experience of a user. The application implements line finding algorithm based on Google Tesseract Engine and DeepNet based Speech Recognition algorithm for processing natural language of the user. An autocorrect module based on Jaccard distance is introduced to enhance the accuracy of handwritten text recognition in an image. Upon generating a digital list, web scraping technique is adopted to find relevant product details from various e-commerce websites for every item. The results are then aggregated, filtered based on price, rating and the top deals are provided to the user providing a qualitative smart digital shopping experience.

**Keywords:** Natural Langauage Processing, E-Commerce, DeepNet, Quality Life



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## **VEHICLE-TO-EVERYTHING**

**Abstract:** *Vehicle-to-everything (V2X) is communication between a vehicle and any entity that may affect, or may be affected by, the vehicle. It is a vehicular communication system that incorporates other more specific types of communication as V2I (vehicle-to-infrastructure), V2N (vehicle-to-network), V2V (vehicle-to-vehicle), V2P (vehicle-to-pedestrian), V2D (vehicle-to-device).*

*The main motivations for V2X are road safety, traffic efficiency, energy savings, and mass surveillance. The U.S. NHTSA estimates a minimum of 13% reduction in traffic accidents if a V2V system were implemented, resulting in 439,000 fewer crashes per year.[1] There are two types of V2X communication technology depending on the underlying technology being used: (1) WLAN-based, and (2) cellular-based.*

**Keywords:** Vehicle-to-everything



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## METHODS FOR IMPROVEMENT OF 3D PRINTED PARTS QUALITY

**Abstract:** Additive manufacturing is production technology for manufacturing geometrical complex parts. It is applicable in different fields such as mechanical engineering, civil engineering, medicine, food industry and so on. Manufactured parts from additive manufacturing can be very diverse depending on used technology and applied material. On qualitative features of 3D printed part can be influenced through various segments of additive manufacturing production from 3D modeling (optimizing model for 3D printing), 3D models slicing and production parameters adjustments (from the applied slicing software), 3D printer settings and used printing technology (applied material and used printing technology such as FDM or SLA, etc.) to 3D part post process treatment. Also, features of 3D printed parts that are needed for quality improvement and quality verification are dependent on the part general or specific purpose. This paper describes various methods for improvement of 3D printed parts quality regarding different features such as mechanical properties, surface finish, etc.

**Keywords:** 3D printing, printed part quality, quality improvement



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## **MEDICAL ASSISTANCE SYSTEM USING BRAIN COMPUTER INTERFACE FOR DIFFERENTIATING CONSCIOUS, SEMI- CONSCIOUS AND MINIMALLY CONSCIOUS STATES**

**Abstract:** *Bionics has undergone an entirely new evolution because of BCI. In the course of additional research, it has also been feasible to assist non-communicative and impaired patients by enhancing their residual cognitive performance. To develop a system that will benefit those who are incapable of triggering their bodily muscles and who require continuous supervision in an intensive care unit, particularly patients in a minimally conscious state and those with locked-in syndrome, a brain computing analysis using EEG spectrum with a three-electrode channel BCI headset was performed on six people ranging in age from 18 to 80 years old, three of whom were healthy controls and three of whom were intensive care patients. Using two forms of stimulation on each individual, raw EEG data was obtained. There were 48 epochs in total. Applied machine learning algorithm such as k-nearest neighbour with a multilayer feed-forward network, which gave preference to the classifier that divided the group of individuals into three distinct factions, including conscious (C), semi-conscious (SC), and minimally conscious (MCS) conditions. The trained data set and test data set after validation revealed a contraction of 10% for the semi-conscious, whereas the aware and minimally conscious data set revealed an increase of 40%, resulting in model overfitting. After refitting and cross-validation, the error rate reached a final value of 30% and gave the accuracy rate of 70%. This study led to the development of a transportable robot-based alert system for critical care unit patients who have been unconscious for 24 hours and require immediate diagnosis. It reduces the effort, saves time, and expedites each patient's prognosis*



***Keywords:*** BCI, KNN, ANN, EREP, LIS



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## EVALUATING THE SUSTAINABILITY OF SUGAR VALUE CHAIN: EVIDENCE FROM VIETNAM

**Abstract:** *This paper investigates the sugar value chain in Vietnam and evaluates its sustainability using integrative indicators based on the Triple Bottom Line (TBL) approach. A set of 50 indicators were used in our survey of key stakeholders in the sugar value chain of Vietnam. After 2 months, we received 218 valid responses. Our findings show that there are still many challenges for the Vietnam sugar value chain to grow sustainably. Thus, we proposed some suggestions to enhance the sustainability of the Vietnamese sugar value chain.*

**Keywords:** Sugar value chain, Sustainable development, Triple Bottom Line, Vietnam



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## **SURFACE MORPHOLOGY AND ITS STUDIES OF AL-17SI ALLOYS DURING FRICTION STIR WELDING PROCESSES**

***Abstract:** In this paper, the effects of process parameters on surface morphology during the friction stir welding processes were studied. The joining process was carried out with three different rotational speeds and feed rates. The increase in the rotational speed and feed rate increases and decreases respectively the heat input, which affects the surface morphology. The metal transports during the process were discussed in all the cases. The decrease in adhesion due to the large rotational speed and low feed rate also results in poor metal transport and weld quality. The adhesion can be improved with the increase in the feed rate, where the decrease in the diffusion rate makes the alloy more viscous and adhere to the tool circumference during its rotation. The microstructure formation at the nugget and TMAZ zone, and tensile strength properties during the processes were discussed finally.*

**Keywords:** Friction Stir Welding, microstructure, Tensile



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## **MAPPING OF BLOCKCHAIN TECHNOLOGY WITH INDIAN FINTECH SECTOR FOR SECURING FINANCIAL OPERATIONS**

**Abstract:** *In this paper, the effects of process parameters on surface morphology during the friction stir welding processes were studied. The joining process was carried out with three different rotational speeds and feed rates. The increase in the rotational speed and feed rate increases and decreases respectively the heat input, which affects the surface morphology. The metal transports during the process were discussed in all the cases. The decrease in adhesion due to the large rotational speed and low feed rate also results in poor metal transport and weld quality. The adhesion can be improved with the increase in the feed rate, where the decrease in the diffusion rate makes the alloy more viscous and adhere to the tool circumference during its rotation. The microstructure formation at the nugget and TMAZ zone, and tensile strength properties during the processes were discussed finally.*

**Keywords:** Friction Stir Welding, microstructure, Tensile



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## **IDENTIFICATION OF THE MAJOR TRENDS IN CURRENT MAINTENANCE POLICIES USING LDA METHODOLOGY FOR SEMANTIC ANALYSIS OF THE PUBLISHED RESEARCH RESULTS**

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**Abstract:** *In this paper, a semantic analysis of the published research results, through the literature review, about maintenance strategies in the Industry 4.0 for a sustainable development of companies is presented. By the analysis, major trends in current maintenance policies were verified. The results allow to identify the key enablers that support the application of maintenance strategies in the Industry 4.0 in the companies' strategies and sustainable development. The analysis is based on application of the Latent Dirichlet Allocation (LDA) methodology for extraction of "hidden" topics from the given data base, in the case of this paper the data base represents the texts published on the maintenance strategies in the Industry 4.0. The database analyzed in this paper consists of the articles published from 2016 to 2023, extracted from the SCOPUS data base.*

**Keywords:** *Industry 4.0, Maintenance, Sustainable development, Semantic analysis, Latent Dirichlet Allocation (LDA)*

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