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INTRODUCTION

Department of Management and Technical faculty "Mihajlo Pupin" from Zrenjanin have started the organization of International Symposium Engineering Management and Competitiveness (EMC) in 2011. Since 2013 the organization of the EMC symposium has been supported by the following foreign partners: Szent István University, Faculty of Economics and Social Sciences, Gödöllő, Hungary, Voronezh State University, Faculty of Economics, Voronezh, Russia and University of Montenegro, Maritime Faculty, Kotor, Montenegro. Since 2024 the partners are: Budapest Business University, Faculty of Finance and Accountancy, Budapest, Hungary and Voronezh State University, Faculty of Economics, Voronezh, Russia.

The objectives of the Symposium EMC are: presentation of current knowledge and the exchange of experiences from the field of Engineering management, consideration of development tendencies and trends in Serbia and the world as well, gathering researchers from this field with the aim of expanding regional and international cooperation, raising the level of professional and scientific work at Technical faculty "Mihajlo Pupin" from Zrenjanin, expanding cooperation with economic and educational institutions and encouraging young researchers within this field. Taking into account that this Symposium is international, the importance of this event is obvious for the town of Zrenjanin, Banat region, Vojvodina and Serbia. Organization of EMC by the Technical faculty "Mihajlo Pupin" from Zrenjanin represents this scientific-educational institution as one of the major representatives of economic and social development in Banat.

Within this Proceedings all accepted papers received for XIV International Symposium Engineering Management and Competitiveness (EMC 2024) are presented. This year at the symposium we have 45 papers and 2 abstracts. The authors come from 9 countries: Bosnia and Herzegovina, Estonia, Hungary, Iran, North Macedonia, Russia, Slovenia, USA and Serbia. The papers are divided into seven sessions: Plenary session, Session A: Management and operation management, Session B: Human resource management, Session C: Marketing management, Session D: Economy, Session E: IT Management, Session F: Abstracts.

We wish to thank the Technical faculty "Mihajlo Pupin" from Zrenjanin and the dean Prof. Ph.D Milan Nikolić for their active role concerning the organization of the Symposium. We are also expressing our gratitude to all authors who have contributed with their papers to the organization of our thirteenth Symposium EMC.

The EMC Symposiums become a traditional meeting of researchers in June, every year. We are open and thankful for all useful suggestions which could contribute that the next International Symposium Engineering Management and Competitiveness become better in an organizational and program sense.

President of the Programming Committee
Professor Sanja Stanisavljev, Ph.D.

Zrenjanin, June 2024.

Word of Thanks

We wish to thank
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XIV International Symposium Engineering Management and Competitiveness 2024 (EMC 2024)
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Plenary session

Papers (pp. 3-38):

ELICITING CONSTRUCTION PROJECTS PERFORMANCE INDEX IN IRAN USING DELPHI METHOD

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ABSTRACT

This paper reports an empirical study which applies the Delphi technique to formulate a model to assess the success of Construction Projects in Iran. Four rounds of Delphi were conducted with 22 construction experts in Iran. The Delphi selected eight Key Performance Indicator (KPIs) to evaluate the success of Construction Projects. These KPIs included: (1) client's satisfaction; (2) cost performance; (3) quality performance; (4) time performance; (5) effective communications; (6) safety performance; (7) trust and respect; and (8) innovation and improvement. Construction senior executives and project managers can use the index to measure, monitor, and improve the performance of their individual Construction Projects. It also broadens the existing body of knowledge of both academics and practitioners in the construction industry because the research method could be replicated in other geographical locations to create similar indices for international comparisons, thus assisting in the understanding of managing Construction Projects.

Keywords: Construction management, Construction Projects, Key Performance Indicator (KPI), Delphi Method.

INTRODUCTION

Research into the area of key performance indicators (KPIs) to assess the success of Construction Projects is vital because it can help set a benchmark for measuring the performance of these projects (Arowoiya et al., 2024). However, few, if not any, comprehensive and systematic research studies have been so far conducted (Ghorbany et al., 2024). It is thus difficult for construction senior executives and project managers to objectively evaluate the performance level of their Construction Projects. The research question for this study is whether there exist a series of KPIs which can be used to comprehensively, objectively, reliably, and practically measure the performance of Construction Projects in Iran. This paper reports an empirical study which applies the Delphi method to develop a model in assessing the success of Construction Projects on a conceptual framework encompassing 25 different performance measures for evaluating the performance of Construction Projects. It should be pointed out that a similar research method was applied to develop a partnering performance index for partnering projects in Hong Kong (Yeung et al., 2007). In fact, Construction Projects need different KPIs from Construction Projects in general. The reasons behind were stated by Crane et al. (1999) and Cheung et al. (2003). Crane et al. (1999) introduced three types of measures for partnering projects. Two of them, result measures and relationship measures, are crucial to measure the performance of partnering projects. They defined result measures as "hard" measures based on performance, such as cost, schedule, quality, and safety. Crane et al. (1999) argued that since result measures tell the decision maker little or nothing about the condition of the environment in which the performance is attained, a partnering relationship must make use of relationship measures to achieve a greater degree of foresight and realize the benefits of increased time to react to problems in the relationship. Cheung et al. (2003) also pointed out that hard measures alone do not provide a clear picture of partnering performance, as partnering is about cooperative working relationships between contracting parties. They also suggested that it is necessary to use relationship measures to assess the behavioral aspects of partnering. Crane et al. (1999) defined relationship measures as "soft" measures and they are used to track the activities and effectiveness of the partnering working team. Examples of the relationship measures include: (1) internal communication; (2) external communication; (3) meeting effectiveness; (4) worker morale; (5) internal trust; (6) external trust; (7) internal leadership; (8) external leadership; (9) accomplishment of objectives; (10) utilization of resources; (11) problem solving; (12)

creativity and synergy; (13) timely evaluation and appropriate response; (14) definition and adherence to roles and responsibilities; (15) continuous improvement; and (16) teamwork. On the other hand, both the result and relationship measures can be divided into objective and subjective measures. The first group uses mathematical formulae to calculate the respective values. Examples include time performance, cost performance, safety performance, and productivity. The other group uses subjective opinions and personal judgment of the project stakeholders. Examples include quality, trust, and effective communications.

The paper reports an empirical study that applies the Delphi technique to formulate a model to evaluate the success of Construction Projects on the consolidated conceptual framework for Construction Projects. A formula for calculating the performance index (PI) for Construction Projects can be finally derived. By doing so, the performance of different Construction Projects can be compared and assessed objectively. Four rounds of Delphi were launched with 22 construction experts in Iran. The selected experts were either industrial practitioners equipped with rich hands-on experience in Construction Projects or prominent academics with demonstrated research experience in Construction Projects. The iterations of the Delphi exercise enable the experts to both select the most appropriate KPIs for Construction Projects, and to provide ratings to each KPI. A more reliable result could thus be achieved. A statistically significant consensus on the ratings of each KPI was also derived from the 22 experts. The Delphi technique is first used to select a series of the most important KPIs for Construction Projects, and second to obtain ratings for each identified KPI. As a result, a series of weighted KPIs is developed from the four rounds of Delphi. Finally, the findings of this Delphi will be discussed in this paper and the significance and limitations of the study to the construction industry will be highlighted, followed by the difficulties encountered in conducting the four rounds of Delphi will be provided.

DELPHI METHOD

The concept of "Delphi" was originally developed from the American defense industry (Chan et al., 2001). A study titled "Project Delphi" was conducted by the Rand Corporation for the US Air Force in the early 1950s, which was related to the use of expert opinions (Helmer, 1967). The aim of a Delphi study stated by Linstone and Turoff (2002) was to get the most reliable consensus of opinion of a panel of experts by a series of intensive questionnaires interspersed with controlled opinion feedback. Goldfisher (1992) pointed out that the Delphi method was initially developed for market research and sales forecasting purposes. The Delphi method involves the selection of procedures for suitable experts, development of appropriate questions to be put to them, and analysis of their responses. The process is typically carried out by remote correspondence, such as mailed questionnaires and e-mail, rather than involving face-to-face group discussions. This enables all participants to respond individually and reduces the impact of group dynamics on the resulting consensus. The method is based on the judgment of the selected experts, and does not rely on previous historical data being available. In addition, the method is typically intended to provide a judgment or opinion on the specific subject area, rather than producing a quantifiable measure or result. Because of this, the method can easily work well in new areas that are frequently subject to unpredictable forces, which are not easily quantifiable in most of the cases. The Delphi technique can also be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals as a whole to deal with complicated problems. Linstone and Turoff (2002) pointed out that Delphi is primarily a communication device that is applied when the consensus of experts on an uncertain issue, often intangible, is desired. It is generally conducted by several rounds interspersed with group opinion and information feedback in the form of relevant statistical data. The three major features of the Delphi method are: (1) anonymity; (2) iteration with controlled feedback; and (3) statistical response (Adnan & Morledge, 2003). Generally, the number of rounds varies between two and seven and the number of participants ranges from three to 15 (Adnan & Morledge, 2003). The desired outcome is that, by using an iterative forecasting procedure on reaching the final round, the experts will have achieved unanimity on the issues put before them.

Corotis et al. (1981) mentioned that panel members remain unknown to one another and respond to a series of questionnaires. The iterative nature of the procedure generates new information for panelists in each round, thus enabling them to change their evaluations and project them beyond their own subjective opinions. It can therefore represent the best forecast available from a consensus of experts. In addition, the Delphi approach offers a fringe advantage in situations where it is important to define areas of uncertainty

or disagreement among experts. Furthermore, Delphi can highlight topics of concern and assess uncertainty in a quantitative manner. Though the group view has a higher probability of being correct than an individual, its success mainly depends on the careful selections of the panel and the formulation of questions. Nevertheless, the major difficulty is to maintain a high level of response and to reach and implement a consensus (Chan et al., 2001).

RESEARCH METHOD

The research method adopted for this paper is to use a Delphi method. Chan et al. (2001) stated that the Delphi approach is being increasingly adopted in many complex areas in which a consensus is to be reached, for example, (1) the development of residential areas (Anatharajan and Anataraman 1982); (2) theory and design application (Corotis et al., 1981); (3) and procurement selection (Chan et al., 2001). The Delphi technique is a highly formalized method of communication that is designed to extract the maximum amount of unbiased information from a panel of experts. Therefore, it is suitable to adopt the Delphi method for this study because it is a rather subjective and new area of research.

Format of Delphi Rounds: The key issues in preparing a Delphi study were: (1) the definition of experts and their selection; (2) the number of rounds; and (3) the questionnaire structure in each study round. The Delphi method used in this research consisted of four rounds. In the first round of the Delphi questionnaire, the respondents were asked to identify a minimum of five to a maximum of ten KPIs that they believed to be the most vital KPIs to assess the success of Construction Projects in Iran. In Round 2 of the Delphi survey, they were asked to reconsider their options and see whether they would adjust their original ratings with the provision of consolidated results of Round 1. In the third round of Delphi questionnaire, they were requested to provide ratings on the top eight KPIs based on a five-point Likert scale (the top eight KPIs were selected for further analysis based on a criterion that they were selected by at least 50% of Delphi experts). While analyzing the data, the focus is on the opinion of the group rather than of individuals. Therefore, a concordance analysis measuring the consistency of the experts' responses over successive rounds of the Delphi was used. In Round 4 of the Delphi questionnaire, they were provided with the consolidated results from Round 3. They were asked to reconsider the ratings of each of the eight selected KPIs and see whether they would change them. The consistency of the results of Rounds 3 and 4 were analyzed and compared by the Kendall's concordance analysis statistically.

Selection of Expert Panel: Chan et al. (2001) emphasized that the success of the Delphi method depends principally on the careful selection of the panel members. A group of experts was selected to determine the KPIs of construction projects. As the information solicited requires in-depth knowledge and sound experience about KPIs for Construction Projects a purposeful approach was adopted to select this group of experts. The following three criteria were devised in order to identify eligible participants for the current Delphi study: Practitioners having extensive working experience in Construction Projects; Experts having current, recent or direct involvement in the management of Construction Projects. In order to obtain the most valuable opinions, only practitioners/academics who met all three sampling criteria were selected. A total of 45 industrial practitioners were identified and invited to participate in this study and they represent a wide spectrum of construction professionals in Iran, with 29 from the private sector, 12 from the public sector, and 4 from the academic sector. The composition of this group of experts provides a balanced view for the Delphi study.

FINDINGS

1. Selecting Most Vital KPIs: The first round of Delphi together with an invitation letter was sent to the group of panel members by e-mail in early September of 2023. The invitation letter explained the aim of the research, and the experts were informed that there would be a total of four rounds of Delphi in the proposed survey. In this first round, the 45 experts identified were asked to select a minimum of five to a maximum of ten KPIs that they believed to be the most important KPIs to evaluate the success of construction projects. However, only about one fourth of the experts completed the questionnaires within 1 month. A reminder e-mail was therefore sent to all the experts who had not yet returned the completed questionnaires within the stipulated deadline. Finally, 22 responses were collected and 23 experts withdrew

in late October of 2023. The main reason for their dropping out was the heavy commitment of their current workload. The sample size is justified to be adequate because the respondents for a typical Delphi usually range from 3 to 15 (Adnan & Morledge, 2003). Table 1 shows the indication of relative importance of each KPI by the 22 Delphi experts. Only KPIs which have been selected by 50% of experts or above will be selected for further consideration. Seven KPIs met this criterion in the first round of the study. The seven selected KPIs selected were: time performance; cost performance; quality performance; safety performance; client's satisfaction; harmonious working relationships; trust and respect. In addition, five new KPIs which had not been identified from the literature review were suggested by the panel of experts. They included: (1) value for money; (2) sustainability; (3) community acceptance of the delivery and for outcomes of the project; (4) alignment of project objectives; and (5) issue management. Nevertheless, they were not selected for further study since they did not meet the 50% cutoff criterion.

2. Reevaluating Selected KPIs: Similar to Round 1 of the Delphi, the second round of the Delphi questionnaire together with an invitation letter was sent to the panel members by e-mail in early November of 2023. In this round, the experts were requested to first reconsider whether they would change any of the options that they provided in the questionnaire for Round 1; and second reselect a minimum of five to a maximum of ten KPIs which they viewed to best evaluate the success of Construction Projects. The consolidated result of Round 1 was shown in Round 2. About half of the experts in this round completed the questionnaire within 1 month. A reminder e-mail was then sent to all the experts who had not yet returned the completed questionnaires. Finally, a total of 18 respondents returned their completed questionnaires in early January of 2024. Table 2 provides the relative importance of each KPI by the 18 experts after their second thoughts. It is of interest to note that two more KPIs, innovation and improvement, and effective communications, that meet the 50% cutoff criterion, were added but one KPI identified in Round 1 that did not meet the 50% cutoff criterion, was removed. In addition, the order of the eight resultant KPIs was changed to some extent as follows: (1) time performance and (2) cost performance (equal frequencies for them); (3) client's satisfaction and quality performance (equal frequencies for them); (4) innovation and improvement; (5) safety performance; (6) trust and respect; together with (7) effective communications. The first two rounds of the Delphi study indicate that the most important eight selected KPIs for construction projects emphasize project success, relationship and people, and total quality management. The reasoning behind this is that it is widely accepted that project success is measured by project performance in terms of time, cost, and quality. The research findings are consistent in respect of project success because time performance, cost performance, and quality performance take the first, second, and fourth positions, respectively, at this research stage. In addition, the findings stress on relationship and people. There is no doubt that three of the eight selected KPIs, including: (1) innovation and improvement; (2) trust and respect; and (3) effective communication are vital goals pursued by a number of project stakeholders who procure construction projects. On the other hand, the findings emphasize the client's satisfaction and safety performance. This implies that many industrial practitioners focus on total quality management in procuring construction projects. It should be noted that a large number of other KPIs were selected by less than one third of the Delphi experts, implying that they are perceived to be less important by most project participants when compared with the above-mentioned goals. The results are in line with another part of the same research on KPIs for partnering projects in Hong Kong (Yeung et al., 2007).

3. Ratings Obtained from Experts: In the third round, experts were asked to provide ratings on the eight resultant KPIs based on a five-point Likert scale to evaluate the success of construction projects. In addition, the five-point Likert scale, ranging from 1=least important, 2=slightly important, 3=important, 4=very important, to 5=most important, is used because the dimension for measuring KPIs should be unipolar, referring to different degrees of the same attribute, but not bipolar, referring to the presence of opposite attributes (Schwarz 1996). More than half of the experts in this round completed the questionnaire within 2 weeks. A reminder e-mail was sent to all the experts who had not returned the completed questionnaires. A total of 16 completed survey forms were eventually received in mid-December of 2023. A statistical analysis was performed of the 16 questionnaires received in which the mean ratings for the eight resultant KPIs were computed. A preliminary series of weighted KPIs was developed based on the mean ratings advocated by the 16 experts. Table 3 shows the eight resultant KPIs together with their corresponding weightings. They are: (1) client's satisfaction, with the weighting of 0.143; (2) cost performance, with the weighting of 0.135; (3) quality performance, safety performance, and effective communications, with equal weightings of 0.126; (4) time

performance, with the weighting of 0.124; (5) trust and respect, with the weighting of 0.111; and (6) innovation and improvement, with the weighting of 0.109.

Table 1: Results of Round One Delphi

KPIs for construction Projects in Iran	Total frequency	Percentage (%)	Rank
1. Time performance	**16**	**72.73**	**1**
2. Cost performance	**16**	**72.73**	**1**
3. Quality performance	**14**	**63.64**	**3**
4. Safety performance	**13**	**59.09**	**4**
5. Client's satisfaction	**12**	**54.55**	**5**
6. Harmonious working relationships	**12**	**54.55**	**5**
7. Trust and respect	**11**	**50.00**	**7**
8. Environmental performance	10	45.45	8
9. Innovation and improvement	10	45.45	8
10. Effective communications	10	45.45	8
11. Dispute occurrence and magnitude	8	36.36	11
12. Top management commitment	8	36.36	11
13. Customer's satisfaction	7	31.82	13
14. Profit and financial objectives	6	27.27	14
15. Long-term business relationships	6	27.27	14
16. Professional image establishment	6	27.27	14
17. Employee's attitude	4	18.18	17
18. Scope of rework	3	13.64	18
19. Job satisfaction	3	13.64	18
20. Introduction of partnering workshop	3	13.64	18
21. Productivity	1	4.55	21
22. Claim occurrence and magnitude	1	4.55	21
23. Value for money	1	4.55	21
24. Sustainability	1	4.55	21
25. Community, acceptance of the delivery, and for outcomes of the project	1	4.55	21
26. Alignment of project objectives	1	4.55	21
27. Issue management	1	4.55	21
28. Litigation occurrence and magnitude	0	0.00	28
29. Reduction of paperwork	0	0.00	28
30. Pollution occurrence	0	0.00	28

Table 2: Results of Round Two Delphi

KPIs for construction Projects in Iran	Total frequency	Percentage (%)	Rank
1. Time performance	**16**	**88.89**	**1**
2. Cost performance	**16**	**88.89**	**1**
3. Client's satisfaction	**15**	**83.33**	**3**
4. Quality performance	**15**	**83.33**	**3**
5. Innovation and improvement	**13**	**72.22**	**5**
6. Safety performance	**11**	**61.11**	**6**
7. Trust and respect	**10**	**55.56**	**7**
8. Effective communications	**9**	**50.00**	**8**
9. Harmonious working relationships	8	44.44	9
10. Environmental performance	7	38.89	10
11. Profit and financial objectives	6	33.33	11
12. Dispute occurrence and magnitude	6	33.33	11
13. Top management commitment	5	27.78	13
14. Customer's satisfaction	4	22.22	14
15. Employee's attitude	4	22.22	14
16. Value for money	3	16.67	16
17. Alignment of project objectives	3	16.67	16
18. Long-term business relationships	2	11.11	18
19. Issue management	2	11.11	18
20. Scope of rework	1	5.56	20
21. Job satisfaction	1	5.56	20
22. Introduction of partnering workshop	1	5.56	20
23. Sustainability	1	5.56	20
24. Community, acceptance of the delivery and for outcomes of the project	1	5.56	20
25. Professional image establishment	0	0.00	25
26. Productivity	0	0.00	25
27. Claim occurrence and magnitude	0	0.00	25
28. Litigation occurrence and magnitude	0	0.00	25
29. Reduction of paperwork	0	0.00	25
30. Pollution occurrence	0	0.00	25

Table 3: Results of Round Three Delphi

KPIs for construction projects	Mean rating	Rank	Corresponding weight
Client's satisfaction	4.50	1	0.143
Cost performance	4.25	2	0.135
Quality performance	3.94	3	0.126
Safety performance	3.94	3	0.126
Effective communications	3.94	3	0.126
Time performance	3.88	6	0.124
Trust and respect	3.50	7	0.111
Innovation and improvement	3.44	8	0.109
Number (*n*)		**16**	

4.Reevaluating Weighted KPIs: Regarding Round 4 of the Delphi questionnaire, the experts were provided with feedback of the consolidated result obtained in Round 3. The mean ratings of the 16 experts for each KPI and the respondent's own ratings in Round 3 were provided. The respondents were asked to re-evaluate their ratings in light of the mean scored obtained by the 16 experts. The final round questionnaire was distributed to the 16 experts by e-mail in mid-December of 2023. Similarly to Round 3, more than half of the experts in this round completed the questionnaires within 2 weeks. A reminder e-mail was forwarded to all the experts who had not yet returned their questionnaires. Finally, all the experts completed and submitted their questionnaires in Mid-December of 2023. Most experts had reconsidered their ratings provided in the previous round and had made adjustments to their ratings. Table 4 shows that there is no change in the order of their mean ratings except that time performance is raised from sixth to fourth rank; effective communications are lowered from third to fifth rank (being equal to safety performance); and safety performance is also changed from third to fifth rank. In addition, their corresponding weightings are similar to those of the third round.

Table 4. Comparisons of Rounds Three and Four Delphi

	Round 3				Round 4		
KPIs for Construction rojects	Mean rating	Rank	Corresponding weighting		Mean rating	Rank	Corresponding weighting
Client's satisfaction	4.50	1	0.143		4.81	1	0.151
Cost performance	4.25	2	0.135		4.19	2	0.131
Quality performance	3.94	3	0.126		4.13	3	0.130
Time performance	3.88	6	0.124		4.00	4	0.125
Safety performance	3.94	3	0.126		3.94	5	0.124
Effective communications	3.94	3	0.126		3.94	5	0.124
Trust and respect	3.50	7	0.111		3.50	7	0.110
Innovation and improvement	3.44	8	0.109		3.38	8	0.105
Number (*n*)		**16**				**16**	
Level of significance		**0.054**				**0.000**	

DISCUSSION

The research findings indicate that the eight weighted KPIs for construction projects in Iran emphasize project success, relationship, and people, and total quality management. It is widely accepted that project success is measured by project performance in terms of cost, quality, and time. The research findings are consistent in this regard because cost performance, quality performance, and time performance take the second, third, and fourth positions, respectively, in this research study. In addition, the findings stress relationship and people. There is no doubt that three of the eight weighted KPIs, encompassing: (1) effective communications; (2) trust and respect; and (3) innovation and improvement are essential objectives pursued by a number of project stakeholders who procure construction projects. On the other hand, the findings emphasize client's satisfaction and safety performance. The results are in line with another part of the same research on KPIs for partnering projects in Hong Kong (Yeung et al., 2007), in which six of their KPIs were the same, which included: (1) time performance; (2) cost performance; (3) quality performance; (4) trust and respect; (5) effective communications; and (6) innovation and improvement. It should also be noted that the Delphi technique by its inherent nature serves as a self-validating mechanism because each expert is given a chance to re-evaluate their scores with reference to the consolidated mean scores as assessed by other experts. By using the Delphi method, the maximum amount of unbiased and objective information can be obtained from the panel of experts.

CONCLUSION

Over the past decade, the topic of KPIs in the construction industry has been discussed. However, there are not many comprehensive and systematic studies on construction projects. This study has tried to develop a model for measuring the performance of construction projects in the Iranian construction industry through the Delphi technique. The order of the eight weighted KPIs identified were: (1) client's satisfaction, with the weighting of 0.151; (2) cost performance, with the weighting of 0.131; (3) quality performance, with the weighting of 0.130; (4) time performance, with the weighting of 0.125; (5) effective communications and safety performance, with the equal weightings of 0.124; (7) trust and respect, with the weighting of 0.110; and (8) innovation and improvement, with the weighting of 0.105. This KPIs' framework for construction projects helps develop a unique composite index and set a benchmark for measuring the performance of construction projects. Different construction projects can then be evaluated and compared objectively based on this PI. As a result, construction senior executives and project managers can use this index to measure, monitor, and upgrade the current performance of their construction projects. It also enriches the knowledge of both academics and practitioners in the construction industry about the KPIs for construction projects in pursuit of better project management and performance. Since the model was developed for Iran only, further research should be conducted in other geographical locations.

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OPTIMIZATION OF THE THREE-OBJECTIVE SCHEDULING OF METRO TRAINS MOVEMENT AND STOP USING GENETIC ALGORITHM AND TOPSIS METHOD

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ABSTRACT

The use of metro lines as one of the fastest and cheapest ways of transportation is always expanding. Underground transportation systems are known as one of the most consuming elements of the power grid. In recent years, a lot of research has been done to reduce energy consumption in metro lines. In addition to these services, serving our passengers is of great importance. Reducing the time between two consecutive trips and optimally using the capacity of trains in order to serve more passengers are among the goals that have been given special attention in recent research. For this purpose, in this paper, a three-objective optimization model has been presented to reduce the service time at the same time as increasing the passenger transportation capacity and reducing energy consumption. The proposed model includes non-linear constraints that NSGA2 algorithm is used to solve. Then, in order to select the best possible solution from among the answers obtained from NSGA2, TOPSIS method was used. In the end, the proposed model was implemented on line 5 of Tehran Metro. The findings confirm the effectiveness of the proposed model, revealing a solution that efficiently serves passengers in the shortest time and with minimal energy consumption.

Keywords: Metro Movement Scheduling, NSGA II Algorithm, TOPSIS, Multi-Objective Optimization.

INTRODUCTION

Rail transportation systems are passenger displacement systems, typically located in underground tunnels or on elevated concrete structures above street level. These systems, due to their high capacity and regular presence at stations, have a significant impact on urban traffic. To ensure the effectiveness and efficiency of rail transportation systems, defining a timeframe for service is essential. Generally, the timetable includes scheduled times for trains to arrive at and depart from stations. Due to the physical complexity of rail transportation systems in the future, scheduling has become one of the most challenging and difficult issues in rail planning, attracting researchers' attention for decades. Current studies in the scheduling problem domain focus on meeting transportation needs, increasing reliability, and so on. In addition to this issue, electricity consumption in the rail transportation industry is becoming increasingly prominent. Many people pay close attention to energy efficiency strategies. Energy consumption for train traction, which is related to train operation, accounts for a significant portion of energy consumption in this system. Therefore, reducing traction energy consumption through optimizing train operation is of paramount importance. Many studies focus on energy efficiency in train operation. New research is based on the assumption that there are no speed and slope constraints on the lines.

Given the pivotal role of efficient scheduling in enhancing rail system performance, extensive research has been dedicated to investigating different scheduling approaches. The widespread advancement of computer technology has led to mathematical optimization emerging as the predominant method for achieving practical and effective operation. Since the pioneering work of Amit in 1971, where optimization techniques were first applied to analyze train scheduling, researchers have developed numerous models targeting scheduling optimization. These models address various objectives such as minimizing travel time (as demonstrated by Szpigel in 1973), reducing passenger waiting time (explored by K. Nachtigall in 1997), optimizing transportation load (as studied by Cordonea et al., 2011), minimizing energy

consumption (as explored by Nourbakhsh et al., 2010), and managing delay time and operational costs (as investigated by Li et al., 2013).

Given that effective scheduling should account for the interests of railway companies, passengers, and the imperative to reduce energy consumption, scheduling is commonly perceived as a multi-faceted decision-making challenge. Numerous studies have delved into this scheduling complexity by devising multi-objective optimization models. For instance, Higgins et al. (1996) introduced an integer nonlinear programming model aimed at minimizing both delay and interest costs, typically resolved using the intelligent branch and bound method. Ghoseiri et al. (2004) proposed a multi-objective model focused on minimizing fuel consumption costs and overall travel time. Yang et al. (2009) devised an expected value programming model targeting the minimization of delay time and total downtime, integrating fuzzy variables to account for the uncertain number of passengers boarding or alighting at each station. Similarly, Wang et al. (2013) presented a multi-objective train planning model aimed at minimizing energy consumption while optimizing overall travel time.

While the rail transportation system stands out as one of the most energy-efficient modes of transportation, energy consumption remains a significant cost factor within this system. In recent times, there has been an increased focus among researchers on reducing energy consumption. For instance, Nag et al. (2004) introduced a scheduling model incorporating recycled energy, while Ishikawa (1968) explored an optimal control model, treating traction efficiency as a constant. This paper introduces a method for planning the movement and halting of city trains at stations. The method, outlined in section 3, considers the objective function of time, cost, and energy. The aim is to minimize time and energy while maximizing cost. The proposed solution is presented as a constrained three-objective optimization problem, incorporating both equality and inequality constraints. The decision-making variables in this model consist of five parameters: duration of acceleration for train movement, duration of braking acceleration, acceleration value during movement, braking acceleration value, and stopping time of trains at each station. The paper then discusses the NSGA2 multi-objective optimization algorithm and the concept of Pareto dominance. The TOPSIS method is employed to select the optimal solution. Finally, the study examines the specifics of Line 5 of the Tehran Metro.

NSGA2 ALGORITHM

Evolutionary algorithms offer a solution to multi-objective optimization problems, drawing inspiration from Darwin's theory of evolution, where the fittest individuals survive. In such algorithms, solutions are likened to individuals within a population, and their optimality is assessed based on their ability to tackle the problem at hand. Individuals within the population can mate and produce offspring, leading to a competition between parents and offspring to survive into the next generation. Through this process, the most suitable and compatible solutions persist, driving the population towards increasingly optimal outcomes across generations (Pratap et al., 2002).

In this algorithm, after generating the initial population, each individual in the population is assigned a rank based on the number of individuals it dominates. Based on this rank, the entire population is sorted. Then, according to Equation (1), the crowding distance of individuals within a rank is calculated, where *F(i).M* represents the objective function value for individual *i* and $\int_m^{min}$ و $\int_m^{max}$.. represent the maximum and minimum objective function values for objective *m*. In the next step, individuals are selected as parents based on binary tournament competition. In this competition, individuals with higher ranks have priority, and if there is a tie between individuals with the same rank, the individual with greater crowding distance takes precedence. Subsequently, genetic algorithm crossover and mutation operators are applied to produce offspring, and the population of offspring is added to the original population. Then, from this new population, individuals are selected based on binary tournament competition to form the next generation, and this cycle continues until termination conditions are met.

$$
\begin{aligned}
&F=\{individual|rank\ individual = i\}\\
&l=|F|\\
&\forall i: F[i]_{distance=0}\\
&\forall m: \{\\
&sort(F.m)\\
&F[1]_{distance=F[1]_{distance=\infty}}\\
&\forall i = 2tol\text{-}1:\\
&F[i]_{distance=} F[i]_{distance+\frac{F[i+1].m-F[i-1].m}{f_m^{max}-f_m^{min}}}
\end{aligned}
\tag{1}
$$

THE CONCEPT OF PARETO DOMINANCE

Among all possible solutions, there are some solutions that dominate over other solutions; meaning that the objective function values for these dominating solutions are more acceptable than those of other solutions. However, there are also solutions that, in comparison with other solutions, only have some acceptable values for the objective functions, and the values assigned by other objective functions cannot be considered more acceptable. Therefore, we say solution x dominates solution *y*, X<Y, if and only if the following two conditions are met:

– Solution *x* should not be worse than solution *y* in any objective function.
– Solution *x* is superior to solution *y* in at least one objective function.

Therefore, if we assume that our objective is to minimize all objective functions, the concept of Pareto dominance can be expressed as follows:

$$
x<_0 y \Leftrightarrow f_m(x) \le f_m(y) \forall m = 1.2 \ldots . M \wedge \exists i: f_i(x) < f_i(y) \tag{2}
$$

We call solution x a Pareto optimal solution if and only if there is no other solution x' that dominates x, i.e.,

$$
X \text{ is pareto Optimmal} \Leftrightarrow \nexists\ x': x' < x \tag{3}
$$

TOPSIS METHOD

Hwang and Yoon (1981) introduce the TOPSIS method with the premise that the optimal alternative should be the one closest to the ideal solution. The procedural steps of the TOPSIS method are outlined as follows:

1) The normalized decision matrix is computed as follows.

$$
n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{m} x_{ij}^2}}, \qquad i = 1,\ldots, m, \quad j = 1,\ldots, \tag{4}
$$

2) The calculation for the weighted normalized decision matrix is performed in the following manner.

$$
V = N_D.W_{n\times n} = \begin{vmatrix} V_{1i},\ldots & V_{1j},\ldots. & V_{1n} \\ \vdots & \vdots & \vdots \\ V_{m1},\ldots & V_{mj},\ldots & V_{mn} \end{vmatrix} \tag{5}
$$

Here, w_j represents the weight of the jth attribute or criterion, and $\sum_{j=1}^{n} w_j = 1.$

3) Determine the positive ideal and negative ideal solutions.

$$A^+ = \left\{\left(\max_j \ v_{ij} \mid i \in I\right), \left(\min_j \ v_{ij} \mid i \in J\right) \mid i = 1,2,..., n\right\}$$
$$A^- = \left\{\left(\min_j \ v_{ij} \mid i \in I\right), \left(\max_j \ v_{ij} \mid i \in J\right) \mid i = 1,2,..., m\right\} \quad (6)$$

"I" is linked with benefit criteria, whereas "J" is linked with cost criteria.

4) The separation measures are determined by employing n-dimensional Euclidean distance. The separation measure for each alternative from the ideal solution is depicted as:

$$d_{i^+} = \left\{\sum_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2\right\}^{1/2}, \quad i = 1,2,..., m \quad (7)$$

Likewise, the deviation from the negative ideal solution is provided as

$$d_{i^-} = \left\{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2\right\}^{1/2}, \quad i = 1,2,..., m \quad (8)$$

5) Determine the relative proximity to the ideal solution. The closeness of alternative A_i relative to A^+ is described as:

$$cl_{i^+} = \frac{d_{i^-}}{\left(d_{i^+} + d_{i^-}\right)}, \quad 0 \le cl_{i^+} \le 1, \quad i = 1,2,..., m \quad (9)$$

The ranking orders of the alternatives are established based on the closeness coefficient, and the optimal alternative is chosen from a set of feasible alternatives (Jahanshahloo et al. 2006).

DECISION PARAMETERS AND VARIABLES

The table (2) shows all the parameters of the scheduling problem, among which 5 parameters, $a_i^{n,n+1}$ ، ،TOD_i^n ،$TOB_i^{n,n+1}$ ،$TOA_I^{n,n+1}$ ،$b_i^{n,n+1}$ which had sufficient flexibility in the problem, were selected as decision variables.

Parameterization of The Problem

The variable $\mathrm{TOC}_i^{n,n+1}$ is determined based on the distance between the stations; therefore, it is not considered as an independent decision variable. Additionally, the decision regarding the time interval between the entry of two consecutive trains into station $\mathrm{TOC}_i^{n,n+1}$ depends on the number of active trains on the line and lacks sufficient flexibility for scheduling decisions. Therefore, by setting upper and lower bounds for it, it is used as a constraint in this problem.

$$TOC_i^{n,n+1}=\frac{d_{n,n+1}}{a_i^{n,n+1}*TOA_i^{n,n+1}}-\frac{1}{2}*(TOA_i^{n,n+1}+TOB_i^{n,n+1}) \quad (10)$$

Table 1: Modeling parameters of metro scheduling problem

Description of parameters	Symbol
Number of line stations	N
Number of stations	$n=1,2,\ldots,N$
Distance between stations n to $n+1$	$d_{n,n+1}$
Number of active trains on the line	I
Train number	$i=1,2,\ldots,I$
Weight of each train without passengers	M
Weight of each passenger	m
Acceleration of the train i at the start of the movement in the distance from the station n to $n+1$	$a_i^{n,n+1}$
Acceleration of the train i during braking in the distance from the station n to $n+1$	$b_i^{n,n+1}$
The time that train i accelerates in the distance from station n and $n+1$	$TOA_i^{n,n+1}$
The time period when train i moves at a constant speed at the distance of station n and $n+1$	$TOC_i^{n,n+1}$
The time it takes for train i to brake at the distance from station n and $n+1$	$TOB_i^{n,n+1}$
The duration of train i in the distance of station n and $n+1$	$TOT_i^{n,n+1}$
The duration of stop of train i at station n	TOD_i^n
Time interval between train i and $i+1$ at station n	$TOH^n_{i,i+1}$
The rate of passengers entering station n per unit of time	Or^n
The passenger rate of exiting station n per unit of time	De^n
Number of passengers waiting on platform n to board train i	B^n_i
The number of passengers who got off at station n from train i	L^n_i
Capacity of each train	C_T
Coefficient of sliding friction of train wheels with rails	f_k
Acceleration of gravity	g

Constraints of the problem

Each decision variable must be bounded by upper and lower limits or constrained by relationships. So that their values do not exceed certain bounds in optimization. To ensure that geometric, cost, and human constraints are satisfied, and the values obtained for them in optimization can be implemented in the real world.

1. Upper and lower bounds for the duration of train stops at stations.

$$TOD^n_{min} \le TOD^n_{i,i+1} \le TOD^n_{max} \quad (11)$$

Considering the passengers who want to disembark from the train at a station and the passengers waiting on the platform to board the train, a minimum value is defined for the train stop at that station to allow all passengers the opportunity to disembark and board the train. In any case, considering the satisfaction and comfort of passengers, it is necessary that this value does not exceed a certain limit. Therefore, we have:

$$TOD^n_{min} = a\left(\frac{Or^n+De^n}{2}\right)-b$$
$$TOD^n_{max} = a'*TOD^n_{min} \quad (12)$$

2. Upper and lower bounds for the time interval between the entry of two consecutive trains into the station.

$$TOH_{min} \le TOH^n_{i,i+1} \le TOH_{max} \quad (13)$$

In general, the time interval between the entry of two trains should neither be too short nor too long, so as not to incur excessive operational costs for the metro operator.

$$TOH_{i,i+1}^{n} = \overline{TOH} + \sum_{k=1}^{n}(TOT_{i+1}^{K,K+1} + TOD_{i+1}^{k}) - \sum_{k=1}^{n}(TOT_{i}^{k,k+1} + TOD_{i}^{k}) \quad (14)$$

3. The maximum acceleration and velocity of the train are expressed as:

$$\begin{aligned} & a_i^{n.n+1} \le a_{max} \\ & b_i^{n.n+1} \le b_{max} \\ & a_i^{n.n+1} * TOA_i^{n.n+1} \le V_{max} \end{aligned} \quad (15)$$

4. The correlation between the duration of acceleration and braking and the magnitude of train acceleration can be stated as follows:

$$a_i^{n.n+1} * TOA_i^{n.n+1} = -b_i^{n.n+1} * TOB_i^{n.n+1} \quad (16)$$

5. The upper and lower limits of the duration of acceleration, movement at constant speed and braking of trains are:

$$\begin{aligned} & \%w_1 * TOT_i^{n.n+1} \le TOA_i^{n.n+1} \le \%w_2 * TOT_i^{n.n+1} \\ & 0 \le TOC_i^{n.n+1} \le \%w_2 * TOT_i^{n.n+1} \\ & \%w_1 * TOT_i^{n.n+1} \le TOB_i^{n.n+1} \le \%w_2 * TOT_i^{n.n+1} \end{aligned} \quad (17)$$

Given that a train cannot be accelerating, moving at a constant speed, or braking throughout the entire distance between two stations, we consider the upper and lower bounds of time as a percentage of the total travel time between two stations. This is to ensure that the acceleration and deceleration values do not become unreasonably low. However, since it's not necessary for the train to travel any portion of the route without acceleration, we set the lower bound $TOC_i^{n.n+1}$ to zero.

6. The upper bound of the total distances of acceleration and braking of the train is represented by:

$$\frac{1}{2}a_i^{n.n+1}\left(TOA_i^{n.n+1}\right)^2 + \frac{1}{2}b_i^{n.n+1}\left(TOB_i^{n.n+1}\right)^2 + \left(a_i^{n.n+1} * TOA_i^{n.n+1}\right) * TOB_i^{n.n+1} \le d_{n.n+1} \quad (18)$$

The total distance that each train accelerates at the beginning of its journey and brakes at the end of its journey should not exceed the distance between those two stations.

The assumptions considered for the problem are as follows:

$$\begin{aligned} & TOA_1^{n.n+1} = TOA_2^{n.n+1} = \cdots = TOA_I^{n.n+2} = TOA^{n.n+1} && n=1, 2\ldots, N \\ & TOB_1^{n.n+1} = TOB_1^{n.n+1} = \ldots = TOB_I^{n.n+1} = TOB^{n.n+1} && n=1, 2\ldots, N \\ & TOD_1^{n.n+1} = TOD_2^{n.n+1} = \cdots = TOD_I^{n.n+1} = TOD^{n.n+1} && n=1, 2\ldots, N \\ & a_1^{n.n+1} = a_2^{n.n+1} = \cdots = a_I^{n.n+1} = a^{n.n+1} && n=1, 2 \\ & b_1^{n.n+1} = b_2^{n.n+1} = \cdots = b_I^{n.n+1} = b^{n.n+1} && n=1, 2\ldots, N \\ & TOH_1^{n.n+1} = TOH_2^{n.n+1} = \cdots = TOH_I^{n.n+1} = TOH^{n.n+1} && n=1, 2\ldots, N \\ & TOH^1 = TOH^2 = \cdots = TOH^n = \overline{TOH} && n=1, 2\ldots, N \end{aligned} \quad (19)$$

Optimization functions

Objective functions

For each of the criteria mentioned in scheduling design, an objective function is formulated based on decision variables. In optimization, we seek solutions for which the values of these functions are minimized or maximized.

$$F1= \sum_{n=1}^{N-1}\left[\frac{d_{n.n+1}}{a^{n.n+}*TOA^{n.n+1}} - \frac{1}{2} * (TOA^{n.n+1} + TOB^{n.n+1}) + TOD^{n} \right]$$

$$F2= \sum_{n=1}^{N-1} B^{n} * TOD^{n}$$

$$F3= \sum_{n=1}^{N-1}\left(M + m * \frac{C_T}{2}\right)* \quad (20)$$

$$\left[\frac{1}{2}\left(a^{n.n+1} + f_k * g\right) * a^{n.n+1} * (TOA^{n.n+1})^2\right) + f_k * g * a^{n.n+1} * (TOA^{n.n+1})^2) + f_k * g * a^{n.n+1} *$$

$$TOA^{n.n+1} * TOC^{n.n+1} + (b^{n.n+1} - f_k * g) * TOB^{n.n+1} * (\frac{1}{2} * TOB^{n.n+1} + a^{n.n+1} * TOA^{n.n+1} \right]$$

CASE STUDY

The study focuses on Line 5 of the Tehran Metro. To simplify the complexities associated with determining travel direction, only the movement of trains from Golshahr (Karaj) to Sadeghiyeh (Tehran) is considered. Therefore, in this paper, stations *1, 2, ..., n* refer to the eastern platforms related to travel from Golshahr (Karaj) towards Sadeghiyeh (Tehran). Data related to peak travel hours and the population density of inbound and outbound stations have been collected. Accordingly, the day's travel hours have been categorized into three groups based on low, medium, and high densities. In this study, the time interval from 7:00 to 8:00 a.m. with high travel density has been emphasized.

The data analysis involved consulting three experts to determine the weights of the cost, energy, and time criteria. These weights, used in the TOPSIS method, are outlined in the table below.

Table 2: Calculating the weights of criteria

	Expert 1	Expert	Expert 3	Weights
Cost	0.55	0.53	0.56	0.55
Energy	0.19	0.19	0.17	0.18
Time	0.24	0.27	0.25	0.25

Configuring the parameters of the NSGA-II algorithm and initializing the optimization's initial population: Matlab software has been employed for implementing the optimization algorithm and the TOPSIS method. The NSGA-II algorithm comes with parameters that need to be adjusted depending on the nature of the problem. In this study, the optimization program was executed multiple times, and through trial and error, the impact of influential factors on the algorithm's performance, such as convergence speed and the rate of deletion of lower-ranked solutions, was assessed. Based on the obtained results, the algorithm parameters were adjusted, as outlined in Table (3).

Table 3: The tuning parameters of the optimization algorithm

Parameters	The tuning value(s)
The size of the initial population	200
Mutation rate	0.2
Crossover rate	0.8

The plotted pairwise levels of the objective functions for 250 and 300 algorithm iterations are shown in Figures (1) and (2), respectively. Observing these two figures, it can be seen that increasing the number of iterations from 250 to 300 does not result in significant improvement in the triple objective functions. Therefore, the algorithm iteration count is set to 250.

Analyzing the impact of variables on the objective functions

– ***Investigating the impact of the variable TOD on the objective functions***

The effect of the variable TOD on the objective functions was evaluated by increasing the coefficient *a* in the TOD-related constraint. Increasing *a* implies increasing the minimum stopping time for trains at stations. At each stage, the algorithm was run with *a* doubled, and the values of the objective functions at each stage were compared. The results obtained are presented in Table 4.

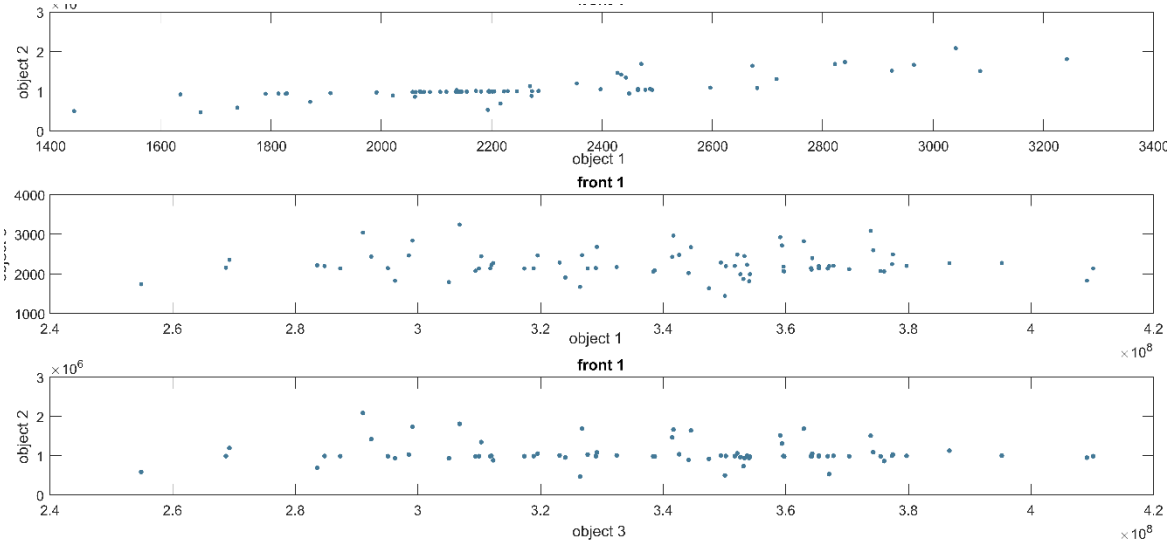

Figure 1: The triple objective functions for 250 algorithm iterations

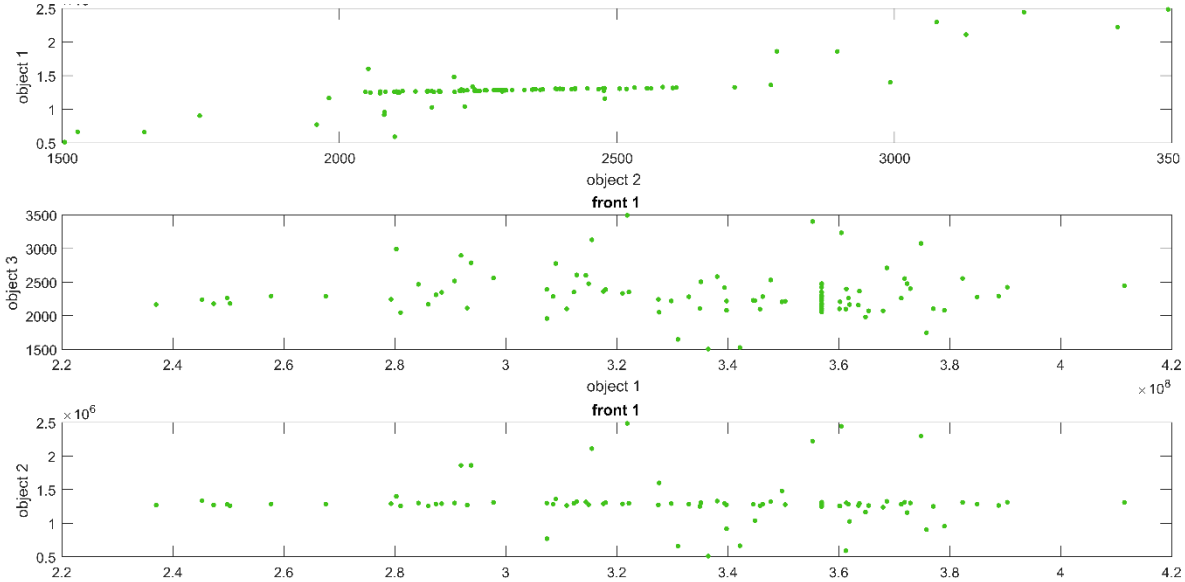

Figure 2: The triple objective functions for 300 algorithm iterations

Table 4: Changes in the objective functions with variations in the parameter a

Variations in parameter *a*	The average stopping time of trains at stations (TOD)	The value of the first objective function (time)	The value of the second objective function (cost)	The value of the third objective function (energy)
a	2.1448	49.05	13644	324029117
2 a	5.8356	80.037	32267	296381450
4 a	11.6363	143.155	57816	292932439

According to Table (4), increasing *a* leads to an increase in the stopping time of trains at stations. The increase in train stops at each station implies an increase in the number of passengers who can board the train. Therefore, the value of the cost objective function has increased. On the other hand, increasing the stopping time of trains at stations results in an increase in the duration between trips. This can be observed from the third column of Table (4), where the value of the first objective function (time) has increased. However, concerning energy, unlike the two previous objectives, no significant change has been observed in the corresponding objective function. This can also be explained by Equations (20). The cost and time objective functions have a direct relationship with the *TOD* variable, and increasing this parameter leads to an increase in their values. On the other hand, the energy objective function is independent of the stopping time of trains at stations. The results of this analysis are depicted in Figure (3).

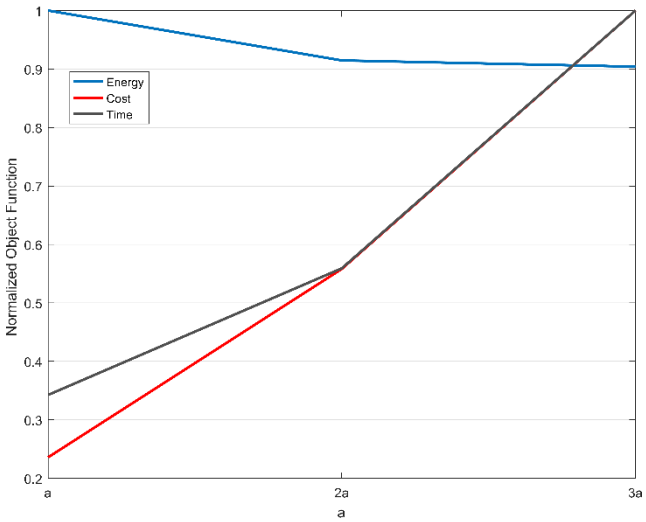

Figure 3: The impact of changes in parameter a on the objective functions

– ***Investigating the effect of the variable TOA on the objective functions***

The allowable range of acceleration time for movement, considering the constraint (17) on the train travel time between two stations (*TOT*), depends on the coefficients *w1* and *w2*. In this section, by simultaneously increasing both coefficients *w1* and *w2*, and consequently increasing the allowable range of the variable *TOA*, the final acceleration of train movement increases. The impact of this increase on the objective functions under analysis is then evaluated. For this purpose, the two coefficients are incrementally increased step by step according to Table (5). With the increase in acceleration time according to the speed relationship in accelerated motion, the final acceleration of the train and consequently its speed increase. With the increase in the speed of trains, their travel speed along the route will also increase. Increased speed also implies a reduction in the service time intervals of trains. The column corresponding to the time objective function in Table (5) supports this notion. As evident, with the increase in the allowable range of train acceleration, the service time has decreased.

On the other hand, with the increase in the acceleration time of trains, the energy consumed to reach the final speed increases. The column corresponding to the energy objective function demonstrates this fact. However, since the number of passengers boarding the train at each station depends only on the *TOD* variable, the cost-related objective function does not see a significant change.

Table 4: Changes in the objective functions and the average speed of trains with variations in TOA

Changes in coefficients $w_1 - w_2$	The average duration of acceleration	The objective function (time)	The objective function (cost)	The objective function (energy)
0.1 – 0.2	0.9099	28.873	197.24	337158989
0.2 – 0.3	1.3699	11.767	196.287	501869298
0.3 – 0.4	1.811	6.915	207.354	701918213

Since in Equation (20), the service time is inversely related to the duration of acceleration, increasing the acceleration time results in a decrease in the provision of services to passengers. On the other hand, the energy consumed is directly related to the square of the acceleration time, meaning that with an increase in the duration of acceleration, the energy consumption also significantly increases.

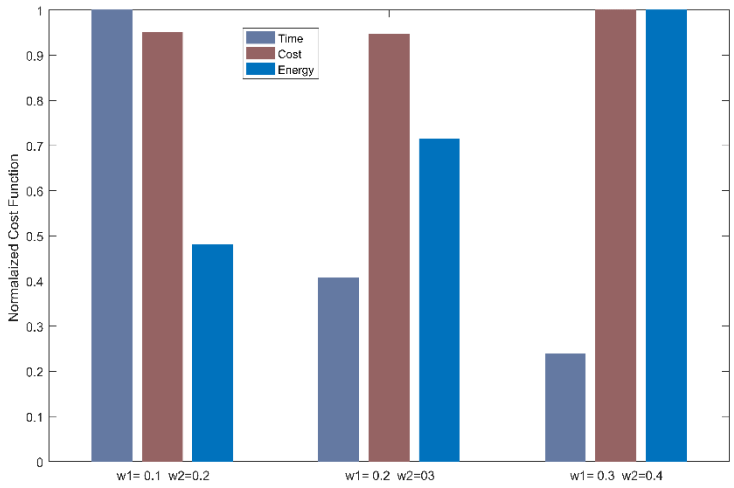

Figure 4: The effect of increasing the acceleration time on the objective functions

Among the results obtained from the analysis of the *TOA* variable, its effect on other variables can be highlighted. The variable with the most significant impact from *TOA* is the braking time (*TOB*). Consequently, with an increase in the acceleration time, the final speed of the trains increases. On the other hand, during braking and complete stopping of the train, in addition to the increase in energy consumption to maintain the train, the braking time also increases to comply with constraint (16). The next parameter influenced by the acceleration time is the acceleration itself. Assuming reaching a specific speed, the train requires less acceleration time to reach this speed with an increase in the acceleration time. This means that the locomotive acceleration decreases with increasing acceleration time. Considering the relationship between the duration of acceleration and braking, and also considering constraint (16), and taking into account that the train comes to a complete stop after braking and its speed becomes zero, the braking acceleration also decreases. Table (5) illustrates the mentioned cases.

Table 5: Changes in objective functions with variations in parameters a

Changes in coefficients $w_1 - w_2$	The average acceleration of trains	The average braking acceleration	The average acceleration time	The average acceleration time
0.1 – 0.2	1.3038	1.3661	0.9099	0.8863
0.2 – 0.3	1.2417	1.2837	1.3699	1.2928
0.3 – 0.4	0.9298	0.8704	1.811	1.779

– ***The result obtained from the TOPSIS method***

Based on the explanations provided in the previous two sections, which thoroughly examined the impact of each parameter on the objective functions and other variables of the problem, in this section, the adjustment of these coefficients using the TOPSIS ranking technique has been employed to select the best solution for train scheduling. The weights of the criteria used in TOPSIS are provided in Table (2). Therefore, by running the NSGA-II algorithm, chromosomes placed in the last front of the first iteration are ranked using TOPSIS. Finally, one chromosome is obtained as the best solution from TOPSIS. The results of running the genetic algorithm and then TOPSIS are presented in Table 6.

CONCLUDING REMARKS

The proposed model utilizing data from Tehran's Metro Line 5 was executed, and the results of solving the three-objective optimization problem using NSGA2 were thoroughly analyzed. One of the significant findings from these analyses is the impact of the stopping time of each train at the station on the objective functions. It was observed that by increasing the allowable time interval for each train's stop at the station, the time between trips increased, while the cost of travel, or the number of passengers serviced, also increased. The energy function remained unaffected by this variable.

One of the variables that was extensively analyzed due to its importance was the acceleration time variable for movement. It was observed that increasing this time interval led to a decrease in service time with the increase in coefficients determining the range of allowable acceleration. Since an increase in acceleration time results in an increase in final speed, this reduction in service time was accompanied by a significant increase in energy consumption. The cost objective function remained independent of this variable and unchanged.

Table 6: Optimal values for the objective functions can be achieved by varying parameters such as a and w_1-w_2

Station Number	***TOA***	***TOB***	***TOD***	***a***	***b***
1	0.847	0.965	4.854	1.582	1.406-
2	1.062	0.984	5	0.757	1.889-
3	1.2	1.114	3.764	1.64	1.410-
4	0.865	1.29	2.286	1.748	1.531-
5	1.088	1.054	1.69	1.24	1.316-
6	0.856	1.233	3.229	0.624	0.883-
7	0.687	0.657	2.494	0.528	0.574-
8	0.519	0.792	3.05	1.94	1.313-
9	0.748	0.896	1.901	1.917	1.124-
10	0.728	0.448	4.996	0.595	0.949-
Objective Function Value	Time =75.945		Cost =21053		Energy= 223176481

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THE FUTURE OF WORK AND INNOVATION: ENTREPRENEURSHIP AT THE CROSSROADS OF SOCIETY 5.0 AND INDUSTRY 5.0

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ABSTRACT

This paper explores the interplay between entrepreneurship and the evolving frameworks of Society 5.0 and Industry 5.0, particularly within Serbia's unique socio-economic context. The authors analyze how these advanced technological paradigms influence the domestic entrepreneurial ecosystem, focusing on the integration of high-tech solutions in everyday business practices and their impact on national competitiveness. The study addresses key factors such as finance, knowledge, government policies, culture, social responsibility, and technology evaluation, highlighting their crucial roles in improving the entrepreneurship landscape. By examining these elements, the paper proposes methods for fostering an environment that encourages innovation, economic growth, and sustainable development. Through a detailed analysis, the authors suggest that embracing the principles of Society 5.0 could significantly improve the entrepreneurial ecosystem in Serbia, making it more competitive and resilient in the face of global challenges. The research underscores the importance of strategic government involvement and the potential for technology-driven solutions to revolutionize entrepreneurship in a manner that aligns with societal and economic advancements.

Keywords: Entrepreneurship, Society 5.0, Industry 5.0, Innovation.

INTRODUCTION

Society 5.0, a concept originating from Japan, represents a vision for the next stage of human evolution where a digital transformation enables a more integrated, smart society. This framework aims to harness advancements in technology, such as artificial intelligence (AI), the Internet of Things (IoT), and big data, to achieve a balance between economic progress and the resolution of social problems. Entrepreneurship plays a pivotal role in this paradigm, offering unique insights and applications (Fukuda, 2020; Shiroishi et al., 2018). For instance, entrepreneurs might develop AI systems that improve healthcare accessibility or IoT applications that enhance disaster response capabilities, aiming to elevate the quality of life and reduce inequality (Solehudin et al., 2023). The entrepreneurial spirit, characterized by innovation and agility, is crucial for driving these sustainable initiatives at a pace that matches the urgency of environmental issues (da Costa Tavares et al., 2021).

In summary, entrepreneurship in the context of Society 5.0 is about more than just economic activity; it is about driving a transformative agenda that aligns technological advancements with human-centric values. Entrepreneurs are envisioned as key agents in building a society that not only thrives economically but also addresses major societal challenges, making life better for all. This shift towards integrative and purpose-driven entrepreneurship is what sets Society 5.0 apart from previous societal models (Bakator et al., 2022). Industry 5.0 marks a significant evolution in the industrial landscape, building upon the automation and efficiency gains of Industry 4.0 by reintroducing human creativity and craftsmanship into the manufacturing process. This approach aims to balance technological advancements with personalized and sustainable production methods, creating a more holistic industrial ecosystem. Entrepreneurs play a crucial role in this new phase, driving innovation and shaping the integration of human touch with cutting-edge technologies (Đorđević et al., 2023).

Entrepreneurs in the context of Industry 5.0 are often seen as visionaries who leverage advanced technologies such as artificial intelligence, robotics, and the Internet of Things to improve production processes while focusing on customizability and sustainability. They innovate by developing solutions that allow for more adaptive and intelligent manufacturing systems which are not only efficient but also capable of producing bespoke products that meet individual customer needs. This shift is crucial in markets where differentiation and personalization are increasingly important (Smuts & Van der Merwe, 2022). Sustainability is another critical aspect of entrepreneurship in Industry 5.0. Entrepreneurs are tasked with finding ways to make industrial processes more sustainable, reducing waste and energy consumption. This involves developing new materials, improving recycling processes, and implementing more efficient production techniques that have a lower environmental impact. By prioritizing these goals, entrepreneurs not only contribute to the economy but also address pressing environmental challenges, reinforcing the role of businesses in fostering a sustainable future.

The main goal of this paper is to develop a theoretical model for improving entrepreneurship. Additionally, suggestions and guidelines for improving entrepreneurship within the framework of Society 5.0 are discussed. The paper consists of five main sections: Introduction, Society 5.0 and Industry 5.0, Entrepreneurship and Industry 5.0 in Society 5.0, Suggestions and guidelines, and Conclusion.

SOCIETY 5.0 AND INDUSTRY 5.

The future of work in the context of entrepreneurship is poised for transformative changes driven by technological advancement, shifting economic landscapes, and evolving societal expectations. Entrepreneurs are expected to navigate these changes, adapting to new modes of working and innovating within their business models to thrive in an increasingly competitive and digital landscape. One significant trend influencing the future of work is the rise of remote and flexible work arrangements. Entrepreneurs are leveraging these trends to access a broader talent pool, reduce overhead costs, and improve work-life balance for their teams. This flexibility also opens the door for a more diverse workforce, which can bring varied perspectives and ideas that are crucial for innovation. Furthermore, as digital collaboration tools become more sophisticated, the ability to manage and grow a business remotely becomes more feasible, allowing startups to operate without geographical constraints (Bryukhovetskaya, 2022).

Sustainability is becoming a central theme in entrepreneurial strategies as well. With increasing awareness of environmental issues and corporate responsibility, entrepreneurs are innovating to create sustainable business practices and solutions. This involves everything from utilizing sustainable materials in products to implementing energy-efficient practices in operations. These efforts not only contribute to environmental conservation but also resonate with consumers and investors who are increasingly prioritizing sustainability (Grabowska et al., 2022). Lastly, the concept of gig economy and freelance work is reshaping entrepreneurship. Many entrepreneurs are now operating on leaner business models, employing freelancers and part-time workers to manage various aspects of their business. This approach allows for greater scalability and flexibility, enabling entrepreneurs to adjust

their workforce based on current needs and demands without the commitment of a full-time staff (Kraus et al., 2023). Society 5.0 represents a vision for a new societal model that integrates advanced technologies into every aspect of life to solve existing social challenges and achieve a higher quality of life. In the context of Society 5.0, innovation in entrepreneurship is crucial for turning these technological potentials into real-world solutions. Entrepreneurs in Society 5.0 are expected to drive the development of innovative products and services that leverage cutting-edge technologies to address significant societal issues. For instance, entrepreneurs might focus on creating AI-driven health care applications that improve access to medical services for underserved populations or develop smart city technologies that optimize energy use and reduce waste, thereby promoting sustainability (Holroyd, 2022). Industry 5.0 seeks not only to optimize production but also to make it more sustainable and adaptable to individual needs, thus creating a more human-centric manufacturing environment (Adel, 2022). In Industry 5.0, entrepreneurs might focus on developing solutions that make manufacturing processes not only more efficient but also more adaptable to the needs of a diverse workforce and consumer base. This includes creating products that are customizable and produced sustainably, aligning with the broader goals of Society 5.0 (Lachvajderová & Kádárová, 2022).

The integration of Industry 5.0 and Society 5.0 through entrepreneurship is essential for realizing a future where technology is used not just for economic gain, but for the greater good. This synergy aims to create a more sustainable, inclusive, and human-centered future, where the benefits of technological advancements are accessible to everyone.

ENTREPRENEURSHIP AND INDUSTRY 5.0 IN SOCIETY 5.0

Based on the analyzed literature a theoretical model for improving entrepreneurship in the context of Society 5.0 is developed. The model is presented on Figure 1.

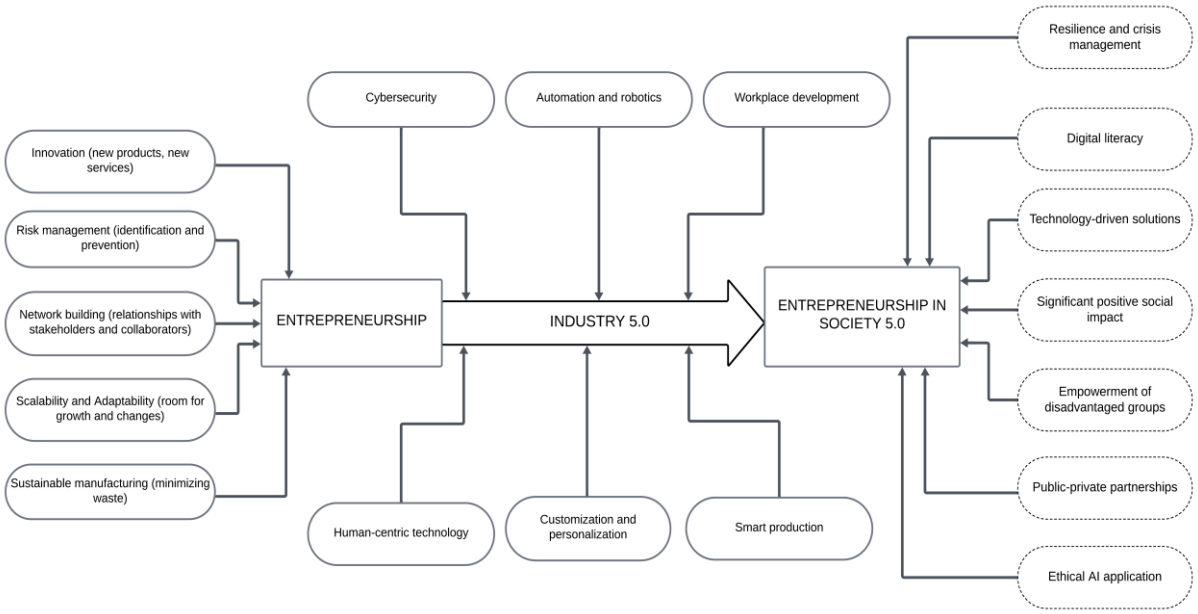

Figure 1: Model for improving the entrepreneurial ecosystem within the framework of Society 5.0

Entrepreneurship is fundamentally linked to its sub-elements through the core processes and characteristics that define entrepreneurial success. Innovation is the heartbeat of entrepreneurship, allowing for the development of new and disruptive products or services. This innovation is closely tied to risk management, where entrepreneurs assess and navigate uncertainties to capitalize on new opportunities effectively. Resource mobilization plays a crucial role in acquiring the necessary assets, such as capital and talent, which are critical for scaling new ideas. Network building supports this by

providing access to a broader ecosystem of advice, funding, and potential customers. Scalability and adaptability are essential as they determine an enterprise's capacity to grow and respond to changing market and technological conditions.

Industry 5.0 emphasizes the symbiosis between humans and machines, aiming to improve productivity and customization while retaining a human touch in manufacturing. This main element involves several crucial processes: Human-centric technology focuses on augmenting human skills with robotic precision, which directly impacts customization and personalization, allowing products to be tailored to individual specifications. The integration of automation and robotics enhances efficiency but requires a strong foundation in cybersecurity to protect against data breaches and system disruptions. Sustainable manufacturing seeks to reduce environmental impact, aligning with global efforts toward sustainability. Smart production leverages IoT and AI to make manufacturing processes more intelligent and responsive, which necessitates continuous workforce development to ensure employees can manage and collaborate effectively with new technologies.

Entrepreneurship within the context of Society 5.0 is driven by the goal of using technology to solve societal challenges, making the role of entrepreneurs critical in shaping future societal landscapes. Technology-driven solutions enable entrepreneurs to address complex social issues with innovative approaches, which often requires forming public-private partnerships to scale these solutions effectively. The focus on social impact ensures that these innovations contribute positively to society, emphasizing the need for inclusivity in offering benefits across diverse social groups. Ethical AI use is crucial in maintaining trust and integrity in new technologies, aligning with the broader goals of responsible entrepreneurship. Additionally, promoting digital literacy and access ensures that more individuals can participate in and benefit from technological advancements, while resilience and crisis management reflect the increasing importance of businesses being able to respond flexibly and robustly to societal disruptions.

These relationships highlight how the sub-elements not only support but are essential to the actualization of their respective main elements. Each set of relationships is crucial for the effective realization of the benefits that Industry 5.0 and Society 5.0 aim to bring to the world, with entrepreneurship acting as both a catalyst and a beneficiary in this multifaceted ecosystem.

Furthermore, entrepreneurship potential development scenarios are presented on Figure 2.

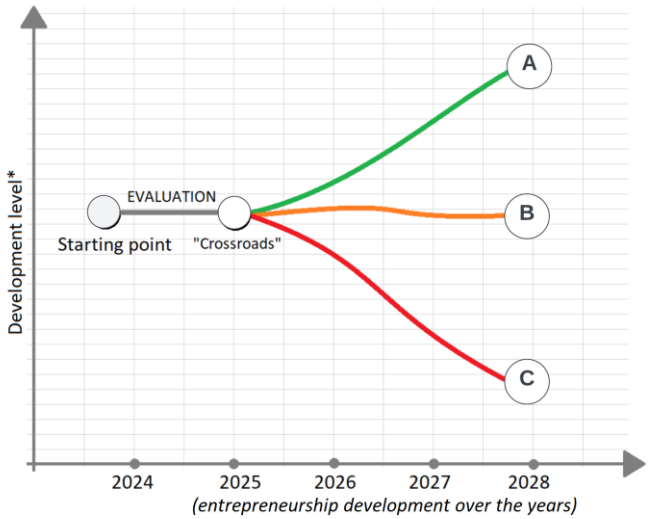

Figure 2: Potential entrepreneurship development scenarios

Scenario A: This scenario represents the most favorable outcome, where entrepreneurship development reaches its highest potential. It assumes the implementation of highly effective strategies

and supportive actions that foster a robust entrepreneurial ecosystem (comprehensive support systems, education and training, government and policies, global networking). Scenario B: In this scenario, entrepreneurship development progresses to a moderate level, reflecting a balance of successes and challenges. It represents a situation where some supportive strategies are implemented, but with limited scope or effectiveness (selective support systems, basic education and training, incremental technological integration). Scenario C: This is the least favorable outcome, where entrepreneurship development remains low or declines. This scenario occurs in the absence of significant supportive actions or effective strategies, or possibly due to adverse external factors (lack of support systems, stagnant technological adoption, restrictive government policies, isolated networking).

SUGGESTION AND GUIDELINES

Based on the analyzed literature and the developed model, the following suggestions and guidelines for improving entrepreneurship are noted:

- Provide grants and subsidies for startups focused on developing smart technologies and sustainable solutions.
- Offer tax incentives for investments in sectors critical to Industry 5.0 and Society 5.0, such as AI, robotics, and green technologies.
- Integrate digital literacy and technology-focused curriculums in educational institutions to prepare a future-ready workforce.
- Support vocational training programs that focus on skills required for Industry 5.0, including data analysis, cybersecurity, and system integration.
- Create clear regulations that encourage the ethical use of AI and other new technologies while
- Develop standards for new technologies to ensure compatibility and security across devices and platforms.
- Facilitate collaborations between startups, established businesses, and academic institutions to drive innovation.
- Engage in public projects that utilize entrepreneurial ventures to solve societal challenges.
- Encourage continuous learning and experimentation among employees to foster innovative ideas.
- Set up internal incubators or innovation labs to develop and test new technologies and business models.
- Design products and services that meet real human needs by engaging with customers and communities to gather insights.
- Invest in user experience research to improve the personalization and functionality of products.
- Adopt sustainable practices in manufacturing and operations to reduce environmental impact.
- Develop products with a longer life cycle and that are recyclable or biodegradable to minimize waste.
- Integrate IoT, AI, and machine learning to improve decision-making processes and operational efficiency.
- Ensure that technological adoption is accompanied by adequate training for staff to maximize utility and productivity.

CONCLUSION

In conclusion, the research presented in this paper provides a comprehensive analysis of the entrepreneurial ecosystem within the context of Society 5.0 in Serbia. It highlights the critical interconnections between advanced technologies and entrepreneurial practices, emphasizing the role of government policies, social responsibility, and technological integration in fostering a competitive and sustainable business environment. The study identifies key factors that can significantly improve the entrepreneurial landscape, suggesting that an effective synergy between these elements is essential for achieving economic growth and sustainable development within the framework of Society 5.0. The authors argue that embracing Society 5.0 not only offers opportunities for enhancing the quality of

entrepreneurial endeavors but also presents challenges that require thoughtful policy interventions and educational reforms.

The paper calls for continued research into the specific mechanisms through which Society 5.0 can influence entrepreneurship, proposing future studies to explore empirical evidence and further develop the theoretical models introduced. Overall, this work serves as a foundational step towards understanding and implementing Society 5.0 principles in a way that maximizes benefits for entrepreneurs and stakeholders within the emerging smart society.

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SOCIAL RESPONSIBILITY OF INDUSTRIAL ENTERPRISES OF THE VORONEZH REGION: TRANSFORMATION OF VIEWS AND PRACTICES IN NEW GEOPOLITICAL AND GEOECONOMIC CONDITIONS

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ABSTRACT

The paper analyzes the changes in the understanding and practices of corporate social responsibility (CSR) of regional industrial enterprises after the adoption of sanctions against Russia in 2022. The study was carried out using a questionnaire-based survey, conducted in 2021 and 2024. The empirical base consisted of questionnaires from 30 industrial enterprises in the Voronezh region. The results of the study show that the level of CSR of these enterprises remains low and is mainly limited to the compliance of mandatory requirements. The paper reveals potential risks of reducing the relevance of CSR for regional enterprises, primarily in the environmental area. However, there are significant incentives and opportunities for the development of CSR practices in terms of social support for employees, their training and occupational safety. In general, as part of adaptation to new geopolitical and geoeconomic conditions, most of regional enterprises not only did not reduce their existing CSR programs, but also managed to increase them in some positions.

Keywords: Corporate social responsibility, Sustainable development, Sanctions, Industrial enterprises.

INTRODUCTION

International sanctions imposed against Russia in February 2022 had a huge impact on the activities of most companies in the country. Restrictions on imports of machinery and equipment, components, and a complete or partial ban on exports to Western countries are just some of the difficulties faced by the Russian economy. In these conditions, there are suggestions that the relevance of issues of sustainable development, corporate social responsibility (CSR) and ESG transformation is decreasing. Studies show that 88% of companies note the negative impact of sanctions on their transition to sustainable development. Only 35.5% of companies consider ESG principles relevant, especially its social and environmental issues (Kuvalin et al, 2022).

A number of circumstances have contributed to the decline in attention of Russian companies to issues of social responsibility and sustainable development . Firstly, the anti-Russian sanctions jeopardized the implementation of ESG principles in companies that were involved in international cooperative relations, actively collaborated with Western partners and followed their socially responsible policies without having their own. Secondly, under the conditions of sanctions, leading rating agencies (S&P Global, Sustainalytics, Bloomberg, Refinitiv, Dow Jones, etc.) stopped including Russian companies in their ESG ratings. This decision closed access to the world's best ESG practices and consulting and reduced the ability to predict its development in accordance with advanced trends in the field of sustainable development. (ESG practices of Russian companies: stability VS variability, 2023). Thirdly, the decline in revenues during the crisis forced companies to reconsider spending on environmental and social goals in order to maintain business profitability. Some enterprises were forced to cut jobs, reduce wages and investment in environmental protection. This increased the risks of environmental degradation and negative social consequences (Kudryashov, 2022).

Despite the ongoing crisis, most companies still do not abandon the implementation of CSR and ESG transformation programs. The idea is expressed that this period can be a breakthrough for the country's transition to a new economic model based on the principles of sustainable development (ESG: Three letters that change the world, 2022).

Most companies are moving from the Western market to the East Asian market, where non-financial reporting also has a significant impact on exchanges. In contrast to the limited participation of Russian companies in international ESG ratings, national ratings have begun to gain popularity. It makes possible to maintain information openness for investors in Russia and friendly countries, including countries of the African continent, Asia and South America. There are growing interest in ESG projects from the stakeholders, especially the government, business partners, consumers, and investors, which can provide an incentive for companies to continue socially responsible practices. (Izmailova, 2022).

Thus, in the absence of strict external incentives in the business environment, the lack of direct positive effects from the implementation of environmental, social and managerial practices by enterprises and, at the same time, increased responsibility for maintaining socio-economic stability, an urgent task is to understand the real involvement of regional enterprises in issues of social responsibility and sustainable development and the changes that have occurred in recent years. Empirical studies of these issues are quite widespread. However, they mainly cover the activities of public companies operating in various industries and do not sufficiently reflect the regional aspects of CSR development. Meanwhile, for such a large and diverse country as Russia, regional peculiarities can significantly affect any aspect of companies' activities, including CSR practices. This article analyzes a wide range of issues related to CSR in relation to a "homogeneous" group of non-public industrial enterprises in the Voronezh region.

RESEARCH METHODOLOGY

The industrial sector traditionally carries a large number of environmental threats, is characterized by difficult working conditions and has a serious impact on the local community. In accordance with this, the object of this study was the sector of industrial enterprises of the Voronezh region engaged in the processing of raw materials (manufacturing industry). In general, the volume of industrial production in 2023 increased by 7.6% in the Voronezh Region by 2022. In manufacturing, output increased by 9.7% compared to 2022 (About the industrial production of the Voronezh region in 2023). Industrial enterprises are among the key employers of the region. The number of workers employed in industry is 142.9 thousand people, or 21.7% of the figure for the Voronezh Region as a whole. In particular, the number of employees in the manufacturing industries is 109.1 thousand people.

In the spring of 2021, the authors conducted the first round of a cohort study of the social responsibility of industrial enterprises in the Voronezh Region (Nikitina & Pertseva, 2021). The study was carried out using a questionnaire method of collecting information, which has shown its effectiveness in CSR and sustainable development studies. In the spring of 2024, a second round of research was conducted on an adjusted questionnaire, which additionally included questions regarding the impact of current economic and socio-political conditions on the implementation of CSR programs. The questionnaire covers the following topics:

- defining the understanding of CSR, the main programs in the field of social responsibility and the benefits of their implementation;
- identification of key stakeholders, the nature and level of interaction with them;
- the use in practice of international and national documents regulating CSR and sustainable development issues and the preparation of non-financial reporting;
- identification of prospects and barriers to CSR development.

In this paper, we will focus on data characterizing the changes in the understanding and practices of CSR at regional industrial enterprises that occurred after the introduction of sanctions restrictions.

The data was collected using the Google Forms online service. The active link to the questionnaire was distributed via e-mail. The mailing list consisted of 100 manufacturing enterprises. A total of 33 companies filled out the questionnaire. In the subsequent analysis, questionnaires containing contradictory answers were excluded (3 questionnaires). Thus, the empirical base of the study consisted of questionnaires from 30 enterprises (large – 53.3%, medium – 36.7%, small – 10%). The form of ownership of most enterprises is private (93.3%). These are mostly non-public enterprises that have been operating for over 10 years. The respondents were general directors / directors – 6.7%, deputy directors / chief specialists – 23.3%, heads of structural divisions – 50%, others (advisor to the General Director, leading specialists) – 20%.

RESULTS AND DISCUSION

In the process of the conducted research, the respondents' opinion was revealed regarding the most significant elements revealing the content of CSR (Table 1).

Table 1: Substantive characteristics of CSR (selection of the three most significant positions)

CSR Characteristics	Percentage of respondents, %	
	2021	2024
Timely and full payment of taxes, social security contributions, salaries to employees	83.3	80.0
Production of high-quality products	46.7	56.7
Compliance with laws and other regulations	70.0	40.0
Staff development programs, labor protection	30.0	26.7
Charitable activities	0.0	23.3
Implementation of environmental protection measures	6.7	13.3
Responsibility to the owners (shareholders, owners of shares)	10.0	13.3
Development of the region of presence	20.0	13.3
Information openness, accuracy of reporting	6.7	10.0
Implementation of anti-corruption measures	0.0	10.0
Sponsorship	0.0	6.7
Business strategy aimed at strengthening competitive positions	13.3	6.7
Ethical relationship with business partners and suppliers	6.7	3.3

It should be noted that the top three most popular answers remained unchanged. However, it is noteworthy that the number of respondents who associate CSR with compliance with laws and other regulations has significantly decreased. At the same time, the production of high-quality products, as the main element of CSR, strengthened its position (an increase from 46.7% to 56.7%) and took the second most popular place. The least significant in the content of CSR (10% or less) in 2024 were: Information openness, accuracy of reporting; Implementation of anti-corruption measures; Sponsorship; Business strategy aimed at strengthening competitive positions; Ethical relationship with business partners and suppliers. In general, the understanding of CSR by representatives of enterprises continues to correspond to the initial, mandatory level and focuses on payments that have legal regulations.

In practice, managers place slightly different accents than in the little-binding declarations. The greatest discrepancies were found in assessing the importance of personnel development on the one hand and the implementation of relevant programs on the other (Table 2).

Programs related to personnel and safety of activities are being implemented steadily and on an ongoing basis. Most areas of external social responsibility remained uncovered. An extremely limited number of enterprises are taking measures to improve the territories of their presence (16.7%), and the healthcare sector is supported (6.7%). It is worth noting the passive attitude of enterprises to

environmental programs: on an ongoing basis, environmental protection measures are common only in 40.0% of enterprises, resource conservation programs are noted in 43.3% of enterprises. In three years, the number of enterprises engaged in cultural and sports events, financing scientific and educational projects has increased. In general, the number of enterprises that do not implement any CSR programs has decreased.

The range of effects expected by enterprises from the implementation of CSR programs is quite wide (Table 3).

In the process of analyzing the results of the survey, a rather pronounced and constant attention of respondents to such possible effects of CSR as improving business reputation and increasing employee loyalty was noted. The decline in the importance of CSR for improving the effectiveness of marketing and sales, increasing investment attractiveness, and strengthening business ties with counterparties means that enterprises do not see the current conditions as an opportunity to influence the market and organize effective interaction with the external environment. The only remaining opportunity is to attract financial resources from government sources (26.7%) and improve their own financial condition (30.0%).

Table 2: CSR programs and the frequency of their implementation

CSR programs	The percentage of enterprises, %					
	Regularly		Sometimes		No programs	
	2021	2024	2021	2024	2021	2024
Staff development	86.7	83.3	13.3	16.7	0.0	0.0
Cultural and sports events	26.7	43.3	53.3	46.7	20.0	10.0
Environmental measures	43.3	40.0	26.7	43.3	30.0	16.7
Financing of educational and scientific projects	13.3	23.3	46.7	50.0	40.0	26.7
Ensuring safe working conditions	93.3	96.7	6.7	3.3	0.0	0.0
Improvement of the urban infrastructure of the territories of presence	16.7	16.7	60.0	63.3	23.3	20.0
Industrial safety	86.7	86.7	13.3	13.3	0.0	0.0
Charity	26.7	20.0	60.0	73.3	13.3	6.7
Resource-saving	56.7	43.3	40.0	46.7	3.3	10.0
Protection of vulnerable groups	20.0	16.7	50.0	60.0	30.0	23.3
Investments in the healthcare sector	10.0	6.7	26.7	43.3	63.3	50.0
Sponsorship	16.7	16.7	53.3	63.3	30.0	20.0

Table 3: Advantages of CSR implementation (several possible answers)

Advantages of CSR	Percentage of respondents, %	
	2021	2024
Improving business reputation, creating a positive image	80.0	76.7
Increase employee loyalty	80.0	70.0
Improving financial performance	40.0	30.0
Strengthening business relations with contractors	30.0	23.3
Improving the quality of management	23.3	23.3
Increasing investment attractiveness	20.0	13.3
Improving the effectiveness of marketing and sales	13.3	3.3
Loyalty from the market regulator, public authorities	10.0	26.7
Reducing non-financial risks	3.3	10.0
Stimulating innovation	3.3	3.3
No advantages	0.0	3.3

The study showed that the understanding of CSR, its practical implementation and expected effects do not fully correspond to the composition of stakeholders whose interests should be taken into account in the course of activities (Table 4).

Traditional stakeholder groups remain the key recipients of CSR programs: the company's staff, its consumers and owners. However, in 2024, the importance of the interests of the state has increased significantly, as indicated by half of the respondents. In the context of the disruption of existing supply chains and logistics links, the interests of suppliers were noted by twice as many respondents as in 2021. It should be noted that the growing importance of the interests of the government and suppliers in the new conditions has reflected an increase in their involvement in CSR programs. Regional industrial enterprises consider non-profit organizations to be the most insignificant stakeholder for themselves, only 2 out of 30 enterprises indicated the involvement of NGOs in their CSR programs. It is characteristic that this position has not changed during the period under review. In general, according to table 4, it is calculated that in 2024, enterprises noted 26.0% more significant stakeholders than in 2021.

Table 4: Key stakeholders of enterprises and their involvement in the formation and implementation of CSR programs (several possible answers)

Stakeholders	The share of enterprises that have identified the relevant key stakeholder, %		The share of enterprises that have identified the relevant stakeholder involved in CSR programs, %	
	2021	2024	2021	2024
Employees	76.7	86.7	76.7	83.3
Consumers	73.3	80.0	23.3	26.7
Owners	60.0	73.3	70.0	96.7
Government	23.3	50.0	20.0	26.7
Management	20.0	20.0	53.3	43.3
Local community	16.7	16.7	13.3	13.3
Suppliers	16.7	30.0	6.7	10.0
Creditors	13.3	23.3	3.3	10.0
NGOs	6.7	6.7	3.3	6.7

A more in-depth study of the composition of NGOs with which enterprises cooperate and the frequency of their interaction showed that enterprises cooperate most actively and on an ongoing basis with educational and scientific organizations (56.7%), most likely the interaction consists in training employees. In the new conditions, there has been an increased interest in cooperation within the framework of associations and associations of entrepreneurs. So far, the noted growth is provided by occasional contacts, but in total 28 out of 30 enterprises in 2024 indicated such cooperation. Enterprises have extremely passive relations with environmental organizations, with which about a third of enterprises do not interact at all. Trade unions focused on protecting the rights and interests of employees were established only at 8 enterprises out of 30. During the period under review, the approach to choosing forms of interaction with stakeholders has not changed. The information strategy, aimed at one-sided communication of information about the company's activities, continues to dominate. Thus, the leading positions, noted by more than half of the respondents, are occupied by: "open days", excursions to enterprises, participation in conferences, forums, publications in the media or a corporate website. The forms of bilateral and multilateral cooperation containing more obvious elements of dialogue are the least widespread (26.7% implement joint programs and participate in expert commissions).

In general, about a quarter of respondents assessed the impact of the international economic sanctions regime on their activities as unambiguously negative or rather negative. For most industrial enterprises, the pros and cons of the imposed restrictions are approximately the same (43%) or have a rather positive (13.3%) or unambiguously positive impact (6.7%). The remaining respondents (10%) indicated that the sanctions had no effect on their activities. Approximately the same trends can be seen in individual CSR indicators (Table 5).

Units of enterprises report job cuts (3 enterprises), employee training costs (2 enterprises) or a reduction in the company's participation in the political life of the country (4 enterprises). For the vast majority, the changes that have occurred at the enterprise in the field of CSR are positive or neutral. Half or more of the enterprises declare an increase in jobs, an improvement in the quality of their

products, and an increase in employee training costs. For the rest of the CSR indicators, the vast majority noted the absence of changes.

Table 5: Changes that occurred at the enterprise in the field of CSR in 2022-2023.

Changes in the field of CSR	Percentage of respondents, %		
	Growth	Remained the same	Reduction
Number of jobs	56.7	33.3	10.0
Working week duration	10.0	86.7	3.3
Professional development programs for employees	33.3	60.0	6.7
The cost of training one employee	50.0	43.3	6.7
Product quality	50.0	50.0	0.0
Industrial safety costs	46.7	53.3	0.0
The volume of social investments	26.7	66.7	6.7
Saving resources	26.7	53.3	20.0
Environmental protection costs	26.7	73.3	0.0
Wage gap between managers and staff	6.7	80.0	13.3
The company's participation in the political life of the country and the region	20.0	66.7	13.3
Tax burden	43.3	56.7	0.0
Difficulties in raising funds to pay taxes	16.7	76.7	6.7

In 2024, 66.7% of respondents predicted optimistic prospects for the development of CSR, whereas in 2021 only a third of respondents (33.3%) believed that CSR would develop successfully. The lack of skepticism among representatives of industrial enterprises certainly inspires hope for further positive changes in the sustainable development of enterprises in difficult geopolitical and geo-economic conditions.

CONCLUSIONS

The research results show that there is no decrease in the relevance and demand for issues of social responsibility and sustainable development for regional industrial enterprises. As part of the adaptation to the new economic conditions, enterprises not only did not lose their existing CSR programs, but also managed to increase them in some positions.

Despite the fact that the CSR level of these enterprises remains low and is often limited to the compliance of mandatory requirements, issues of social support for employees, their training and occupational safety are priority practices for the vast majority of surveyed enterprises. The relatively low level of development, as in 2021, remains in the environmental area. For the studied enterprises, environmental protection and resource conservation issues are not a significant characteristic of CSR, and relevant activities are not carried out regularly without interaction with environmental organizations.

The transformation of the views and practices of regional industrial enterprises in the field of CSR occurred in relation to the role and interests of the government. The government became one of the key stakeholders of the surveyed enterprises, and its loyalty became the desired effect of the implementation of CSR programs. This is largely due to the government support provided to the manufacturing industry in the face of sanctions restrictions. The changing supply chains and international cooperation have also transformed the role of business associations, whose membership was previously perceived formally. In the new conditions, the development of network interactions is considered as a tool to increase economic sustainability.

The further development of social, environmental and management practices of the enterprise is associated with obtaining preferences in the form of tax and credit benefits, government subsidies. In

this regard, the government should take a more active position in promoting the ideas of social responsibility, in particular, updating the measures of regional industrial policy.

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GREENWASHING IN LOGISTICS

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ABSTRACT

As global systems evolve, logistics plays a major role in the movement of goods and the operation of supply chains. However, sustainability is increasingly becoming a priority for companies and society. Integrating this into logistics processes is a major challenge. Sustainability in logistics is important not only from an environmental perspective, but also in its economic and social dimensions. Here we should mention the concept of green logistics. The public exploitation of the benefits of green logistics helps companies to attract customers, although in many cases greenwashing can also be encountered. In this paper, we focus on the role of greenwashing.

Keywords: Greenwashing, Green logistics, Sustainability, Supply chain.

INTRODUCTION

Introducing sustainability into logistics processes presents several challenges. These include the complexity of global supply chains, volatile fuel prices, infrastructure constraints and lack of coordination between business actors. In addition, increasingly stringent sustainability regulations and growing societal expectations are putting further pressure on the logistics sector.

Sustainability is also important in the field of logistics. (see also Figure 1) Sustainability in logistics can be considered in three main areas:

- environmental sustainability: reducing fuel consumption, minimizing emissions, and increasing energy efficiency,
- economic sustainability: reducing costs, using resources more efficiently and optimizing business processes,
- social sustainability: respecting people and communities, promoting the well-being of employees and social responsibility (Csaba and Csaba, 2024) .

GREEN LOGISTICS

Also known as eco logistics, green logistics is a set of sustainable logistics practices and measures in supply chain management and transportation operations. It aims at minimizing the negative impact of logistics operations such as transportation, warehousing, inventory management, and distribution on the environment. It encompasses various strategies and initiatives emphasizing carbon footprint, energy consumption, waste generation, and resource depletion throughout the supply chain processes (Dekker, 2023).

Figure 1: Sustainable logistics parameters (Source: Yontar, 2022)

Green Supply Chain Management

The Green Supply Chain Management (GSCM) practices offer significant benefits for both companies and the environment. On the one hand, striving for supply chain sustainability reduces carbon emissions and other air pollutants by using less energy. Furthermore, greening the supply chain reduces waste and conserves non-renewable resources (Czékus, 2022).

Their nations, organisations and companies aiming to take their commitment to sustainability to the next level are taking emissions regulation one step further. They require companies to not only track, report and strive to minimize emissions for which production is directly responsible in addition to the energy used to produce and operate, but also to reduce their Scope 3 emissions. Scope 3 emissions are those that are not produced by the company itself but by its suppliers, up and down the value chain (Csaba and Csaba, 2024).

Sustainable Supply Chain

Digital transformation and the increasing sophistication of digital supply chain technologies play a significant role in the evolution of supply chain sustainability. Big Data management, advanced analytics, artificial intelligence (AI) and security tools such as blockchain and RFID sensors have brought unprecedented visibility and accountability to modern supply chains. Companies now have a much greater ability - and obligation - to demonstrate corporate social responsibility and share best practices in green supply chains and sustainable logistics (SAP, 2023).

Three components of Sustainable Supply Chains

Twenty years ago, the word sustainability was almost synonymous with eco-friendliness. Today it is a much more holistic term.

Elements of a sustainable supply chain:
- green supply chain
- transparent supply chain
- circular supply chain (SAP, 2023).

GREENWASHING

Greenwashing is washing green or dyeing green. It is a marketing and public relations strategy that makes consumers and the public believe that a company is doing more to protect the environment than it is (Greendex, 2023). (see also Figure 2 and Figure 3)

Figure. 2: How we at Around Zero define 'Greenwashing' (Source: Medium, 2021)

Figure 3: The Six Sins of Greenwashing (Source: Medium, 2021)

New EU rules to tackle greenwashing in freight and passenger transport services. In July 2023, a new draft EU regulation was published to set rules for accounting for greenhouse gas emissions from transport operators, both freight and passenger, that originate or arrive in the European Union.

The regulation is linked to the Green Claims Directive, which is also currently under discussion, and sets out a rigorous methodology for substantiating green claims for transport services (e.g. "emissions from this flight are 15% lower than ..."), so that, if adopted, it will become an important tool in the fight against greenwashing.

Once the Regulation is adopted, there will be two main obligations for operators to measure emissions and thereby substantiate green claims:

1. The greenhouse gas emissions will be calculated according to the methodology set out in EN ISO 14083:2023.
2. The calculation shall give preference to the use of primary data, i.e. values quantified by direct measurement or calculation based on direct measurements for the process or activity in question, and the use of secondary data (e.g. estimates or representative data) will be allowed only in a very limited range (Márkus et al., 2023).

CONCLUSION

Overall, the greening of logistics can only be achieved with the right approach and technologies. As in other areas of the economy, greenwashing can be found in logistics. Hopefully, the new legislation that the EU is preparing will curb this phenomenon in the logistics sector, among others.

Greening must play a bigger role in the future economy. But it can only be effective if we think in terms of closed supply chains.

In this, the IT industry has a critical role to play in promoting sustainability and reducing its carbon footprint.

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Session A: MANAGEMENT AND OPERATION MANAGEMENT

Papers (pp. 41-96):

FINANCIAL MANAGEMENT IN CONSTRUCTION PROJECTS

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ABSTRACT

Construction Project Financial Management involves managing the costs, budgeting, and tracking all financial aspects related to a construction project. Proper financial management can help ensure that projects are completed on time and within budget, while also reducing risks associated with construction finance. Little has been done to relate and theories construction financial management to financial performance of construction projects. Since few studies have been conducted on this topic in developing economies, future studies that focus on this region, reporting's failure of construction projects are encouraged. Discovery and establishing the significant issues on construction financial management could serve as a guide to project managers. The guide could support project managers to develop construction financial management models that mitigate financial risks on construction projects. This will put forward technical ideas about improving the existing to increase the financial success of construction projects. Also, this paper contributes to scanty the literature on construction financial management of construction projects. It will also assist future researches which examine holistically issues relating to construction financial risk management of construction projects.

Keywords: Construction Project Financial Management, Project finance, Construction management, Construction Projects.

INTRODUCTION

Construction financial management is allocating and accounting for financial resources to cut project costs, maximize profits and assure long-term company financial health. In the construction industry, financial analysis involves reviewing income statements, balance sheets, cash flow statements, and other financial reports to understand revenue, expenses, assets, liabilities, and cash flow patterns. Project financial management is the process of controlling the financial aspect of a project, such as its cost, revenue and profit. To do this requires planning, estimating, budgeting, funding, managing project expenses and billing. Construction risk in project finance is a significant project finance risk to which the project is exposed from the commencement of construction through completion, performance testing, and turnover to operations. Considering gaps in literature, this paper aims to present up to date review of critical issues relating to financial management of construction projects. Specific objectives of the paper are: (1) To analyze trends in the annual publications on financial risk management of construction projects (2) To assess research methodologies of construction projects which have been affected by financial from previous studies (3) To identify the key financial management elements, gaps and future directions. The results of this study could provide a guide for project managers in developing holistic financial management models to control financial of construction projects. Moreover, project managers, key partners of construction projects and policymakers will obtain valuable information from this study that will broaden their understanding of financial management. This study will contribute to empirical literature for discussions in academia and future studies. The techniques used to examine the key contributors to studies on financial management of construction projects are also presented. Finally, a brief conclusion with practical implications sums up the paper.

CONSTRUCTION PROJECT FINANCE

Project finance is the long-term financing of construction projects based upon the projected cash flows of the project rather than the balance sheets of its sponsors. Usually, a project financing structure involves a

number of equity investors, known as 'sponsors', and a 'syndicate' of banks or other lending institutions that provide loans to the operation. They are most commonly non-recourse loans, which are secured by the project assets and paid entirely from project cash flow, rather than from the general assets or creditworthiness of the project sponsors, a decision in part supported by financial modeling (Hoffman, 2007). The financing is typically secured by all of the project assets, including the revenue-producing contracts. Project lenders are given a lien on all of these assets and are able to assume control of a project if the project company has difficulties complying with the loan terms. Generally, a special purpose entity is created for each project, thereby shielding other assets owned by a project sponsor from the detrimental effects of a project failure. As a special purpose entity, the project company has no assets other than the project. Capital contribution commitments by the owners of the project company are sometimes necessary to ensure that the project is financially sound or to assure the lenders of the sponsors' commitment. Project finance is often more complicated than alternative financing methods. Traditionally, project financing has been most commonly used in the extractive, transportation, telecommunications, and power industries, as well as for sports and entertainment venues (Cárdenas et al., 2018).

The essence of project financing is that potential lenders base the credit assessment of a project on the projected ‘cash flow’ from the operation of a project, rather than on the physical assets of a project or the credit of sponsors of the project-implementing company (Hoffman, 2007). Hence, in a project-financing scheme, lenders cannot hedge their risks 100 percent but share some risks of the project. In other words, unlike mortgage loans that allow lenders to sell the secured property of a borrower in order to recover their loans in the event that the borrower fails to pay back the loans, lenders in a project-financing scheme cannot recover their loans safely if something should go wrong and the cash flow weakens. Therefore, it is natural that potential lenders of a project employing project-financing techniques would be far more cautious than potential lenders for a project with safe collateral. To summarize, once financial resources are mobilized and a project goes into full operation, the project implementing company usually repays its debts gradually with profits from selling the infrastructure service to the government or the public over a long period. The following will show how these two project models can be implemented in the green infrastructure market of developing countries (Myong Koh, 2018).

Risk identification and allocation is a key component of project finance. A project may be subject to a number of technical, environmental, economic and political risks, particularly in developing countries and emerging markets. Financial institutions and project sponsors may conclude that the risks inherent in project development and operation are unacceptable. Several long-term contracts such as construction, supply, off-take and concession agreements, along with a variety of joint-ownership structures are used to align incentives and deter opportunistic behavior by any party involved in the project (Sorge, 2011). The patterns of implementation are sometimes referred to as "project delivery methods." The financing of these projects must be distributed among multiple parties, so as to distribute the risk associated with the project while simultaneously ensuring profits for each party involved. In designing such risk-allocation mechanisms, it is more difficult to address the risks of developing countries' infrastructure markets as their markets involve higher risks (Myong Koh, 2018). A riskier or more expensive project may require limited recourse financing secured by a surety from sponsors. A complex project finance structure may incorporate corporate finance, securitization, real options, insurance provisions or other types of collateral enhancement to mitigate unallocated risk (Alijani, 2023).

Finance has extended over the following years. These results were later supported by the formal works on the optimal scope of firms from Leland (2007). These finance models positioned project finance as a superior form of financing for high risk investments, but they strongly focused on financial benefits and applied rather restrictive formal modelling. Following the works of Kleimeier and Megginson (2000), Finance researchers extended theoretical perspectives on project finance. Picking up on work from corporate finance, scholars incorporated real options theory into infrastructure finance and identified non-recourse provisions as a sort of real put option for sponsoring firms (Smit, 2003). Later, Esty and Megginson (2003) teamed up to publish a seminal contribution linking legal institutions to the composition of project finance banking syndicates. They integrated arguments from institutional theory and comparative institutional economics into project finance research to explain the formation of partnerships among project finance lenders. At the same time, Esty (2004) documented his empirical experiences with project finance as a clean and undistorted research setting in a conceptual paper, and called for more systematic use of project finance in both Management and Finance research. In the paper, Esty admits that: “large

investments frequently fail to achieve their intended financial and operating objectives." This critical view indicates a soft deviation from the optimism of the project finance boom in the late 1990s. Another indication of the growing acknowledgement of the fallibility of project finance was an increase in publications related to more realistic valuations of projects using methods such as Monte-Carlo simulations (Gatti et al., 2007), and towards more stakeholder-inclusive measures of project value (West, 2015). Despite this increasing skepticism, the structural benefits of project finance were still undisputed and empirically verified in later quantitative studies (Subramanian & Tung, 2016).

Along with the rising popularity of financial contracting theory, the majority of later Finance research extended its focus from capital structure-related benefits to contractual risk management (Byoun et al., 2013; Byoun & Xu, 2014). Research highlighted the pivotal role of contractual agreements between parties in project finance. It also recognized the risk mitigating role of specific project partners, such as international development banks (Hainz & Kleimeier, 2012), and reputable lead arranging banks (Gatti et al., 2013). Overall, financial research provides clear and consistent evidence of the benefits of project finance resulting from agency cost reduction, higher debt capacity, lower cost of debt, financial distress and optimized tax shields. The over-arching agreement is that the separation of a project to a separate entity reduces information asymmetry between lenders, allows for tailored capital structure and provides optimal incentives for all participants.

Overall, Management research has provided detailed insights into the functioning, or indeed the malfunctioning, of megaprojects. As opposed to Finance researchers, Management scholars have predominantly addressed the hidden, ex-post cost of Project Finance. Their work has provided important explanations as to why project fail, or suffer from enormous delays and cost-overruns, despite optimal financial structuring. As such, Management scholarship provides valuable complements to financial research which has focused mostly on the benefits of a-priori structuring and less on the ex-post costs.

CONSTRUCTION PROJECTS FINANCIAL RISK MANAGEMENT

Construction risk can be described as the possibility of an incident that will harm the project's feasibility. Different threats that impact businesses may be found in the construction industry as elsewhere. Moreover, construction projects face significant risks that put building projects at the risk of cost, over time, and poor standard of execution. The results showed that the construction industry in is exposed to many risk sources, internal and external, and the most important ones are financial risks such as fluctuation of the currency, inflation, and lack of solvency. Interpretation of various law codes and regulations is essential within construction processes; however, it also requires the collection of significant resources such as human resources, equipment, and materials. Moreover, good communication between the parties is important in every construction project. Additionally, diverse factors may be unknown at the beginning of the project, but the risk is an anticipated element of this business. In construction projects, risks are defined as the probability of an event that may negatively affect the life cycle or the schedule of the project and will expose the project to a viable loss. Various damaging consequences may occur on the project because of risks and uncertainty. The project success is correlated with three major aspects of cost, time, and quality where risks cannot be eliminated but can be effectively managed. Numerous risks that affect the productivity of the work can be recognized in construction projects. However, those risks differ between projects; to assure the wealth of any project, the contractor must identify and allocate those risks to be able to manage them at an early stage of the project, where the purpose of effective risk management is to reduce risk exhibition and it's a cost in construction projects (Burtonshaw-Gunn, 2017).

Numerous construction projects have encountered setbacks due to financial risks of high project cycle costs, poor quality, construction delays, and increased cost of borrowing, cost overruns and shortfall of revenue among others. To manage these financial risks on construction projects, project managers need to implement a holistic financial risk management models. The limited studies on a handful of construction projects appear biased in presentation and focus as they only identify the financial risks, neglecting other pertinent elements of a holistic financial risk management such as planning, assessing, responding, monitoring and controlling of financial risks. A supporting evidence of this claim is how most studies on construction projects (Fischer et al., 2010; Jung et al., 2012; Zou et al., 2008) mentioned financial risk management as a topmost determinant of performance of construction projects but little attention was paid

to investigate it holistically. Moreover, existing studies lump up all risk factors including financial risks of construction projects with no attempt to critically investigate and assess their impact on different sectors of construction. The results together with discussions of this study are organized into three sections: background analysis of relevant papers, key elements of financial risk management of construction projects and research gaps with future directions. In this section, the specific financial risks of construction projects are aligned to four lifecycle stages, namely: pre-construction, construction, operate and maintain, and disposal and decommission:

Pre-construction stage risks**:** This stage of the construction project has subdivisions such as project identification and inception, feasibility studies, tendering, competitive negotiations and award of contracts to construct the project. Due to their significance to the direction and completion of the construction projects, the financial risks commonly identified in this stage center around the high costs of tendering, competitive negotiations and feasibility studies with the engagement of professionals and consultants to assess the suitability, value for money, as well as the rate of return of the projects. Also, the adequacy of capital or investment to the project which normally turns to be a challenge when the project takes off due to fluctuations in macroeconomic factors is determined (Sun et al., 2019). Sound market testing is performed to know the interest of stakeholders in the projects and this comes with a huge cost. Consultative and brainstorming meetings are held between the potentially affected stakeholders and the project managers to ascertain the likely costs to be settled on the project such as resettlement and relocation costs. Next, the specific financial risks are identified on the documentation, planning and designing of the project (Liou & Chen, 2011). Drafting of the construction project contract documents, awarding the contract to a competitive bidder and the comprehensive design and development of the project increased the preliminary expenses of the project.

Construction stage risks**:** Huge construction costs emanate from many sources such as raw materials, labor, land, site preparation, supervision, construction insurance, health and safety as well as professional fees paid to sub-contractors, architects, planners and quantity surveyors (Shen et al., 2006; Valipour et al., 2015). An increase in any of these construction cost elements has the potential to derail the fruition of the project or setback the project. Project managers must envisage these challenges, and put measures to mitigate them before the construction starts. Additional costs of construction from delays in completing the project above the budgeted costs lead to cost overruns. Inefficiencies surrounding project cost management, inability to deliver projects on time, increased costs of operations, maintenance due to unfavorable external factors and budget forecasting errors could cause cost overruns. Cost overruns lead to delay in the construction of the project and escalate the project costs and completion deadlines. The project becomes more expensive when the cost overruns, and investors of the project lose trust in the project managers because unexpected costs is brought forth for them to pay. It ends up jeopardizing the financial success of the project.

Operation and maintenance stage risks**:** The financial successes and losses of construction projects are usually realized at operate and maintain stage. Expensive administrative costs of operating the project as well as maintenance expenditure for the project are the biggest challenges at this phase (Ke et al., 2011). When the anticipated patronage of the project falls below expectation, it triggers a low stream of cash inflows. Interest charges on borrowed capital on the project are not able to be paid, and if they're paid, there must be debt renegotiations and extension of timelines leading to additional charges (Flyvbjerg et al., 2004). This means the investors are likely to be denied of their investments and they will push investors away from investing in similar projects in future. Increased expenses on transfer of the project, concessions fees, contract cancellation as well as insufficient finance impede project (Han et al., 2017).

Disposal and decommissioning stage risks: As an extension of the maintenance, disposal and decommission of the project constitute a significant last stage of the construction project. The financial risks identified include the cost of deconstructing a plant, completely refurbishing a building, recycling of wastes and settlement of disputes on road tolls (Demirag et al., 2011; Xenidis & Angelides, 2005). Financial risks on decommissioning and disposing of construction projects could be very complex and should be critically considered, managing it to prevent the consequences of lasting financial burden on partners.

Systematic financial risks**:** systematic financial risks are explained as financial risks that affect a greater or entire lifecycle of the construction projects. Also, these risks are uncertain events that could occur to derail the completion and financial success of the construction projects. A number of local and international factors such as fluctuations in a country's macroeconomic indicators as well as global financial markets could account for these risks (Kardes et al., 2013). The economic conditions of a country or a geographical region in which a construction project is constructed plays a key role in the success of the project. An economy characterized by unstable economic conditions with no robust economic policies could affect a construction project, and unleash a couple of impediments to the financial strides of the construction project (Vasudevan et al., 2018). Factors such as unfavorable fluctuations in interest rate, exchange rate, unemployment, inflation rate and other macroeconomic indicators could escalate the economic risks. Project managers have no or little control over these issues. Thus, project managers must know these challenges in advance and put in place measures to hedge or do away with financial losses associated with them. High interest rates on loan finances is a prime example of this challenge. Debt finances contracted to support construction project cover a long-time frame, thus, they are normally long-term in nature. The interest charges on the principal amount contracted could be fixed or floating depending on the terms and conditions of the loan agreement. It has been noted that the value of these charges keep increasing irrespective of the form it takes (Xenidis & Angelides, 2005) especially after the global financial crisis in 2007–2008. This challenge has been heightened by the unfavorable economic policies which affect debt finances, high non-performing debts, increased loan loss provision, oversized bad debt, conflicting issues between the interests of lenders and borrowers, repayment risks, unrealistic timeframe to repay loans, poor returns from investments etc. These impediments discourage potential lenders from supporting the construction and the operation of a construction project. And those lenders who are willing to sponsor the construction projects enforce stricter terms and conditions, guarantees, higher charges, and quick debt repayment plans. In the end, borrowers either abandon the project or delay in completing the projects because of the high interest charges and other conditions which limits the financial benefits from the construction project. Another systematic challenge which affects all the stages of the project's lifecycle is a soaring inflation rates. This causes an increase in the prices of the materials used in the construction, operation, maintenance and disposal of a construction project could be attributed to high inflation rates. High inflation rates could also affect the wages, costs of designing, building, operating and maintaining the construction project (Wibowo & Kochendörfer, 2005). The cost from the high inflation is given to users and private investors to bear. This cause disaffection to them leading them to abandon the usage and investment in the project. High inflation rates affect returns negatively and increase the interest charges on a debt finance of a construction project. Also, unfavorable movements in the market prices and market forces of demand and supply affect the construction project negatively. This affects the investment portfolio of the project together with volatile movement in market conditions (Medda, 2007). Market risk encompasses a wide range of risks that affect the project such as a project-specific problem or generic macroeconomic factors including interest risk and exchange risk. A commercially unsuccessful project as a result of market risk hinders the concessionaire from satisfying its financial commitments to investors and in some cases, the lenders of the project (Aladağ & Işik, 2017).

Assessment of financial risks: The relevance of assessing, estimating and ranking of financial risks on construction projects has been ascertained in literature by different researchers (Kokkaew & Chiara, 2010). For instance, Aladağ and Işik (2017) assessed and ranked risks faced by construction projects. The study used the mean score ranking technique which resulted in financial risks placing third on the list of risks that affect construction projects. The occurrence and severity of these financial risks were scored as 3.52 and 3.80, respectively. Based on a risk significance index score, Ke et al. (2011) listed the top ten financial risks of construction projects. (Flyvbjerg et al., 2004) assessed the financial risks of 258 complex construction projects in 20 countries. They concluded that almost 90% of these projects suffer from cost overruns (a form of financial risks. Aside these studies, others researchers used different techniques in assessing, estimating and ranking financial risks. We summarize the techniques used to assess financial risks from the relevant papers. The top three most utilized techniques are briefly explained. The most used techniques for assessing, estimating and ranking financial risks of construction projects include the following:

Monte Carlo Simulation**:** It is used by researchers to compute numerical results with repeated sampling process through applied computer software or algorithms (Jung et al., 2012). The probability density function of the key variables on financial risks reflects as inputs. A random selection of the variables is captured by the Monte Carlo Simulation and processed repeatedly. The results are presented in the form of

cumulative density function or probability density function. Despite its numerous advantages of capturing and processing large data, Monte Carlo Simulation could be time-consuming, and generate unnecessary repeated outliners or iterations. It can also produce large variances which suggest an incoherent relationship between the variables. Stochastic financial risks analysis has been Monte Carlo Simulation has been used in various research areas to conduct stochastic risk analyses on construction projects have been conducted with Monte Carlo Simulation. Twelve research papers representing 25% of the relevant selected research papers utilized construction in assessing financial risks on construction projects. Han et al. (2017) employed Monte Carlo Simulation to assess and rank financial risks relating to construction projects on a toll charges of a construction project. Jung et al. (2012) utilized Monte Carlo Simulation and multi-optimization linear programming to determine the optimal cash flow from revenue distribution of a construction project. A model was developed, using Monte Carlo Simulation and a multi-objective generic algorithm, to draw an optimal level of equity ratio. Yun et al. (2009) employed Monte Carlo Simulation and generic algorithm to assess a range of financing options of construction projects by considering project-specific risks under varied conditions.

Net Present Value (NPV)**:** It was employed by researchers to assess the rank projects which were financially viable. Also, some of the studies assessed the appropriate financing options for the construction projects with the aid of Net Present Value. Traditionally, Net Present Value examines the net discounted cash flows of a construction project over a while (Fischer et al., 2010; Kumar et al., 2018). In cases where there are multiple projects, investors and project managers invest in projects which have positive and higher Net Present Value values compared to others. Although it is useful for the assessment of cash flows from projects by considering the time value of money and cost of capital. However, researchers have criticized it for its assumptions such as stable cost of capital over some time, and too much emphasis on Net Present values to make decisions without other considering realistic issues that affect a project. Kumar et al. (2018) investigated financial risks relating to cash flows of highway road projects in India with Net Present Value at-risk model. The findings of the study identified relevant parameters which could be used to assess the financial viability of a project like traffic flow, cost of investment as well as inflation and interest risks.

Internal Rate of Return (IRR)**:** Internal Rate of Return is determined at a point where NPV is zero or nil. It reveals the appropriate cost of capital or discount rate at which Net Present Value break-even or a project will record either a profit or a loss. Internal Rate of Return was found to be used alongside Net Present Value in some of the research papers selected. A study conducted by Fernandes et al. (2016) employed a type of Internal Rate of Return called “hidden IRR” which contributed to the theories on financial risks of construction projects. The least utilized and reported financial risk assessment techniques consisted of a mean score with Likert scale and Kendall’s concordance analysis, the least-present value of revenue, simulation-based bargaining model, discrete stochastic model, concession period and price model, bargaining game model, pareto-optimal model, option game model, simulation-critical path model, Bayesian algorithm, regression analysis and multi-linear programming.

RESEARCH GAPS AND FUTURE DIRECTIONS

Some significant contributions have been made to financial risk management of construction projects as shown in the previous sections. However, huge research gaps on this topic still exist. The present section highlights some of these gaps and suggests future directions for addressing these gaps.

- Struggling, low financial returns and failed construction projects are associated with poor financial risk management (Shen et al., 2006; Sun et al., 2019). Nevertheless, financial risk management models to control these financial risks on construction projects were found to be limited in literature. In addition, existing studies covered only identification of financial risks leaving other aspects of financial risk management models unexplored. A holistic financial risk management should be researched and designed to assist project managers to mitigate financial risks of construction projects.
- Analysis and selection of critical financial risk control factors underpinning financial risk management models is yet to be examined and developed. Studies should employ diverse analysis and selection criteria to choose the suitable financial measures to support the development of financial risk management framework.

- Pertinent external factors such as climate change, sustainability of projects, gas emission standards, geopolitical trade sanctions and trade wars, diversity, and regional competitiveness and the influence they have on financial risk management of construction projects have not been highlighted. Research that assesses and forecasts ways to mitigate financial risks are encouraged.
- The effects of financial risk management on the financial performance of construction projects have not been theorized and investigated in previous studies. Conceptualizing the relationships between these concepts and drawing support from practical construction projects will help broaden the understanding of financial risk management of construction projects.
- Financial research on Project Finance has focused very strongly on the a-priori benefits of structuring investments as Project Finance. Therein, it has not sufficiently acknowledged the ex-post dynamics in complex, multi-partner investments, especially when a project fails to achieve its pre-defined financial goals and as a-priori structures lose their efficiency. Finance research would benefit greatly by integrating findings from Management research and seeking to more thoroughly address deadlocks, cost-overruns and harmful social-dynamics. Ultimately, this would allow Finance to devise more flexible and responsive structures that could improve the efficiency of Project Finance. Including game-theory and real options perspectives more strongly, would enable Finance researchers to learn more about ex-post dynamics of Project Finance and the pitfalls that have resulted in so many project failures.
- Institutional perspectives in Finance research have focused almost exclusively on the legal environment of the host-country of the project. Project Management research, however, have identified inter-partner differences as important barriers to efficient collaboration
- Given the considerably shorter tradition of Project Finance research, there are numerous possible research avenues for Management research. First, Project Finance provides a practical example of how firms devise strategies to address clearly identifiable sources of risk in international investments. In its analysis, Management research has been very much focused on the much broader concept of uncertainty as a determinant of strategy. Early economic scholarship, however, has been very clear on the difference between unmeasurable uncertainty and measurable risks. Management research would benefit greatly from sharpening its perspective to differentiate between very broad uncertainty and specific sources of risk that are both measureable and manageable. This would allow Management to depart from very broad uncertainty related mechanisms such as hierarchy, control equity towards more micro, contractual risk management tools, with high practical relevance. Finance research has found early on that financial arrangements cannot be viewed in isolation from other parts of the nexus of contracts. A similar, more holistic approach, including contractual and socio-economic risk management, should be applied to internationalization strategy, in order to achieve higher validity and practical relevance. Using the example of Project Finance as a practical reference point, Management research could learn how firms orchestrate complementary risk management strategies in a way that allows firms to realize investments without the use of control or hierarchy.
- Project Finance provides evidence that, contrary to most applications of transaction cost theory, firms do not minimize transaction costs. In fact, transaction cost economics has been criticized for low managerial practicability, its static nature and for providing false normative prescriptions. Project Finance illustrates that firms base their strategy on risk-adjusted transaction costs and real options. Under certain circumstances, as found in large infrastructure investments, risk reduction can be the key driver of strategy, rather than transaction cost efficiency. Since firms differ in the degree to which they can manage a certain sources of risk, cooperating with firms that dispose of superior risk-management capabilities can be economically feasible, despite potentially higher costs. Further research in Construction Management should put more emphasis on important firm-specific advantages in terms of risk management and finance. Acknowledging these firm-specific advantages would help Construction Management researchers to learn why some investments are made despite high transaction costs and why some companies are more capable of taking on risks from uncertain environments.
- Project Finance clearly illustrates the pivotal role of lenders in financing foreign investments in risky contexts. This is in stark contrast to contemporary Construction Management research, which commonly focuses very strongly on equity side strategies. The role of the liabilities' side and the actors that it inevitably connects to the investment is often disregarded. Project Finance is practical proof that lenders can serve as political allies and providers expertise. Future Construction Management and Management research needs to address the important role of the liabilities' side as

a strategic complement to equity-based strategies. Additionally, Management research on international investments would benefit from addressing the pivotal role of debt providers in the dynamics of megaprojects' failures.

- Project Finance offers not only a superior empirical setting for Finance, Management and Construction Management research. It also instigates important theoretical contributions for both disciplines. Interdisciplinary perspectives, in particular, can help to advance our understanding of the financing and management of risky investments. Project Finance involves the most complex and challenging projects of our time, often in high-risk environments. It has repeatedly challenged the frontiers of financing and management practice, and it is time that research makes appropriate use of Project Finance in order to test the boundary conditions of existing theories.

CONCLUSION

This paper has shown that increasingly construction financial management is gaining attention of researchers and the construction market. The most reported financial risks identified were high interest charges, huge construction cost, cost overruns and increased market risk. From the lifecycle stages of the construction projects, the study classified and discussed financial risks. The study assessed financial risks on construction projects with techniques such as Monte Carlo Simulation, Net Present Value, and Internal Rate of Return. A further critical analysis of the relevant papers revealed that a holistic financial management models is limited in the literature. Little has been done to relate and theories construction financial management to financial performance of construction projects. Since few studies have been conducted on this topic in developing economies, future studies that focus on this region, reporting's failure of construction projects are encouraged. Discovery and establishing the significant issues on construction financial management could serve as a guide to project managers. The guide could support project managers to develop construction financial management models that mitigate financial risks on construction projects. This will put forward technical ideas about improving the existing to increase the financial success of construction projects. Also, this paper contributes to scanty the literature on construction financial management of construction projects. It will also assist future researches which examine holistically issues relating to construction financial risk management of construction projects.

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GREEN INNOVATIONS FOR THE GREEN FUTURE

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ABSTRACT

In facing environmental challenges for enhancing environmental conservation, the aim of the paper is to examine the role of green innovations in modern business. The paper explores the possibilities of generating green innovations with the intention of sustainable development in the global context. It seeks to encourage all business entities, especially with a recommendation for the implementation of green innovations in companies in the Republic of Serbia. An analysis of selected, according to the latest publications, scientific literature has enabled answering research questions and forming a theoretical model for the green transformation of companies based on green innovations. Based on theoretical considerations, proposals and guidelines have been identified. In addition to the implementation of new knowledge and technological solutions, the motivation of managers for green entrepreneurship and green financial incentives are just some of the significant factors for the development of green innovations with effects on the environmental and business performance of companies.

Keywords: Green Innovation, Sustainability, Performance, Green Transformation.

INTRODUCTION

Green innovation is defined as innovation created with the intention of reducing the negative impact on the environment through green methods and products (Yousaf, 2021:7), as an improvement of products, processes, or production in a way that minimizes environmental burden while achieving sustainability goals (Soewarno et al., 2019; Akbari et al., 2022). Green innovations represent an opportunity to simultaneously address consumption and conservation of available resources (Khanra et al., 2022), serving as a strategic driver in energy savings, pollution prevention, and waste recycling (Akbari et al., 2022), contributing to sustainable development and thus providing a competitive advantage (Mubarak et al., 2021; Khanra et al., 2022; Akbari et al., 2022).

According to Akbari et al. (2022:4), the research literature has identified four dimensions of green innovations: green management innovation (green supply chain management and environmental management systems), green product innovation, green process innovation, and green technological innovation. Improvements in the quality and variety of products from an environmental perspective are associated with green product innovations and market orientation. Enhancements of existing processes towards environmental efficiency determine green process innovations. Green technological innovations involve investments in equipment, machinery, and technological solutions to reduce the negative impacts of production on the environment.

Theoretical research for the purpose of this paper is focused on scientific references that have covered green innovations in the last three to five years. Through the analysis of selected literature, an attempt is made to answer the following research questions:

- What is the role of green innovations in contemporary business?
- How do green innovations enhance company performance?

GREEN TECHNOLOGIES AND GREEN INNOVATIONS

In achieving the goals of sustainable development set by the United Nations (UN), it is necessary to address environmental issues and implement cleaner production, which can be achieved through the application of green technologies. Some countries with environmental obligations can utilize investments in green technologies to reduce negative impacts on the environment, such as energy savings, waste recycling, and pollution prevention. In support of this, a study was published, which conducted an assessment of green technology indicators for cleaner production and sustainable investments in Pakistan. In the hierarchical structure, the authors presented 8 indicators (Environmental Quality, Resource Utilization, Agriculture & Forestry, Green Building, Energy Utilization, Green Transport, Life Health, and Ecology Safety) and 43 sub-indicators of green technologies according to which they assessed investments in cleaner production with investment for sustainability (Ikram et al., 2021:11).

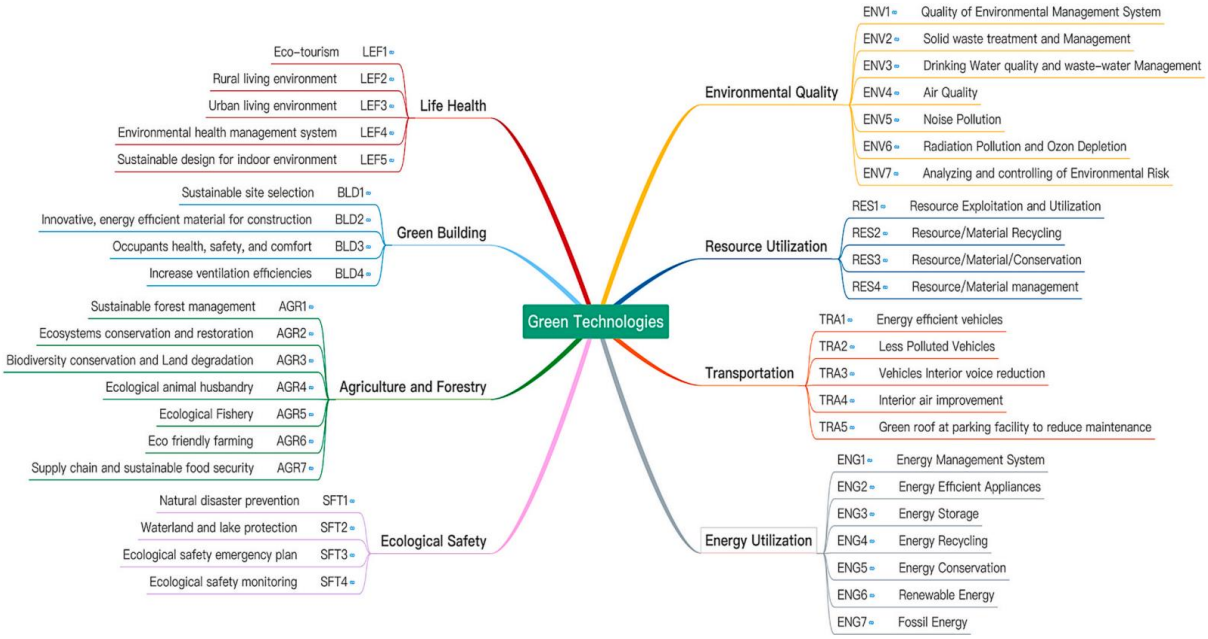

Figure 1: The hierarchical structure of green technology indicators and sub-indicators
Source: Ikram et al. (2021:11)

The most important investments, sustainable investments, and priorities of green technologies for cleaner production in the case of Pakistan are indicators of energy and agriculture (Ikram et al., 2021:10-11). Globally, the adoption and implementation of green technologies will reduce negative impacts and risks to the environment, enable social equity, and promote greater well-being (Guo et al., 2020). Considering the complexity of green technologies and multifunctional green innovations, new knowledge is needed to meet various shared goals, production efficiency, and product quality under standardized requirements, infrastructure, and institutional frameworks (Barbieri et al., 2020).

Green practices, according to Yousaf (2021), refer to practices and procedures adopted by a business organization so as not to harm the environment. Furthermore, green practices focus on green innovations guided by ethical effects on the environment (Yousaf, 2021:3). The results of research conducted in small and medium-sized enterprises have confirmed that green dynamic capabilities (the ability of a company to transform existing processes into green activities using its resources), green practices, and green value co-creation (the process of creating value for customers through environmentally safe activities and end products) enhance green innovations (Yousaf, 2021). Industry 4.0, in the context of open innovation, plays an important role in promoting green behavior and thus improving the performance of green innovations. This has been confirmed in manufacturing, small, and medium-sized enterprises in Malaysia (Mubarak et al., 2021). Another study suggests the exchange of external knowledge and open innovation, highlighting the application and advantages of smart technologies with the impact of Industry 4.0 on green innovative behavior (green process innovation, green product innovation), and the improvement of green innovation performance in manufacturing companies (Ogiemwonyi et al., 2023).

According to current knowledge, in the Republic of Serbia, companies are following sustainability trends and green innovations within their capabilities. In mining companies, research results by Jovanović et al. (2023) have shown significant direct effects of knowledge management on green innovations and sustainable business, as well as a significant positive and direct impact of green innovations on sustainable business. In the construction industry, Mosurović Ružičić et al. (2021) have confirmed that energy efficiency is supported by innovations. However, there is still insufficient activity in the green direction. In the context of eco-innovation and sustainability, authors Ilic et al. (2022) focus on the development of technology and knowledge, and the creation of green strategies. For the development and implementation of green innovations, Milojević et al. (2023) emphasize incentives in knowledge transfer, external and internal communication, and the exchange of environmental knowledge and information. Besides knowledge (Ilic et al., 2022; Milojević et al., 2023), green financing, which is not sufficiently present, is also necessary (Ostojić, 2023).

GREEN STRATEGIES AND GREEN INNOVATIONS

In synergy with the United Nations (UN) Sustainable Development Goals, multinational companies implement appropriate strategies to promote green innovations for sustainability. These strategies aim to design products that require fewer raw materials in production, are lower energy consumers, have less harmful environmental impacts, and are easily recyclable (Khanra et al., 2022). With the results of economic, environmental, and social impacts, for example, Coca-Cola is one of the major multinational companies that have engaged officials to design sustainable development strategies (Khanra et al., 2022). In the era of climate change and various environmental impacts, certain countries such as Japan, South Korea, and China, to maintain economic growth, have established policies to promote green innovations and provide funding for this purpose. These countries have seen an increase in green patents and the issuance of green bonds. According to Tolliver et al. (2021), the two fundamental components of sustainable development are green innovations and green financing.

Authors Soewarno et al. (2019) define the strategy of green innovations as the implementation of green innovations by a company with the aim of creating competitive advantages, satisfying all stakeholders, and primarily meeting market needs. It was examined in manufacturing companies. In the assessment of the green strategy by Soewarno et al. (2019:3068), seven items were identified, including adjusting business practices to reduce their impact on the environment (flora and fauna), environmental restoration actions, waste and emissions reduction, reduced use of non-recyclable materials and chemicals, decreased use of fossil fuels by replacing them with environmentally friendly alternatives, adjusting business practices to reduce energy consumption, and minimizing product impact on the environment. The strategy of green innovations according to Soewarno et al. (2019), based on the aforementioned items and maintained as a green organizational identity, will gain ecological organizational legitimacy and result in positive effects on the performance of green innovations. Viewing green innovations as a strategic resource of the company, Khanra et al. (2022), through bibliometric analysis of 951 articles, identified four areas: green supply chain management (Yousaf, 2021; Akbari et al., 2022), green product design, corporate environmental responsibility, and social sustainability. Through proactive environmental strategy (pollution reduction, product management, sustainable development), green innovations positively influence the environmental performance of companies (Rehman et al., 2021). In the same study, which included manufacturing companies, it was confirmed that green innovations mediate between green intellectual capital, green human resource management, and environmental performance.

In the era of environmental consciousness, green consumers, and green competitors, a focus on the green market has shown positive effects on the business performance of micro, small, and medium-sized enterprises in Indonesia. With the increasingly common purchase of environmentally friendly products, consumers encourage companies to produce such products and innovate processes that will reduce negative impacts on the environment. It has been confirmed that green innovations play a key role in these relationships. In addition to sustainable production and better company reputation, green innovations improve product quality, cost efficiency, and financial performance (Tjahjadi et al., 2020).

Green Entrepreneurship

In the context of small and medium-sized enterprises (SMEs) aiming to stimulate economic development and green economy in Saudi Arabia, a study by Abdelwahed et al. (2023) has shown that variables such as green entrepreneurial skills, green opportunities, entrepreneurial motivation, green incentives, capital

availability, and green entrepreneurial self-efficacy positively and significantly influence green entrepreneurship. It is important to highlight that green entrepreneurial self-efficacy, which involves trust in employees' ability to address environmental issues, mediates the relationships between the aforementioned variables and green entrepreneurship. The authors concluded that the observed enterprises have implemented environmental management education, green marketing strategies, and development. Adopting green technologies enhances green procurement, leading to increased profits and competitive advantages due to green activities and innovative solutions. According to the findings of the study by Soomro et al. (2024), conducted in knowledge-based Pakistani enterprises, a business orientation towards the green market, considering comprehensive factors (green product, green design, green supply chain, green production), and green innovations, has a significant positive impact on green entrepreneurship and sustainable development. To enhance green entrepreneurship and sustainable development, the authors recommended the necessity of generating and consolidating a green culture within the business organization (Soomro et al., 2024:1498).

Green Marketing

In promoting sustainable consumption, over the past decade, green marketing, according to Bhardwaj et al. (2023), is characterized by key terms such as sustainable, ethical, green, ecological, and eco-friendly marketing. In a study conducted among consumers familiar with environmentally friendly products in urban centers in the USA, Ahmed et al. (2023) confirmed the positive and significant impact of green consumer values, the green marketing mix, and attitude on the intention of green consumers. Additionally, green psychological benefit as a mediator and green advertising as a moderator have a significant impact between attitude and green consumer values, the green marketing mix, and green purchase intention. The green marketing mix 5P, according to Ahmed et al. (2023:11477), includes: green product, green packaging, green price, green promotion, and green place. In this regard, an explanation of the green price component is provided, indicating that the long-term benefits of green products make them more expensive due to the costs of factors in green production that cannot be changed. Companies opt for the green marketing mix for various reasons, including gaining green opportunities, building a positive image, increasing product value, competitive advantage, and following green trends (Ahmed et al., 2023:11477).

Based on theoretical considerations, a theoretical model for green business transformation based on green innovations with effects on environmental and business performance has been developed. In the industry, large corporations, small and medium-sized enterprises, the model for improving and sustaining business systems is presented in Figure 2 and can be modified as needed.

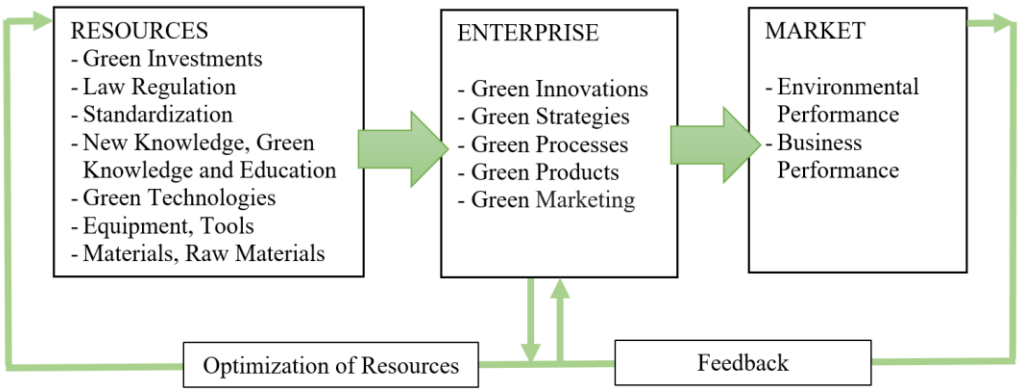

Figure 2: A model for green enterprise transformation based on green innovations

The model consists of three basic components. The first is the necessary resources required by the company to initiate green transformation and implement green innovations. The second component encompasses the company's green innovative activities. The third component involves market output with results on environmental and business performance. Market feedback indicates the necessary requirements for resource improvement and optimization.

The preceding findings demonstrate that the research questions can be addressed as follows:

- What is the role of green innovations in modern business? The role of green innovations is recognized in the green transformation of existing business processes within companies. By implementing appropriate green strategies for sustainable development, which will provide a healthier environment and preserve natural resources through new technical solutions. This is for the benefit of the global population and society as a whole in the creation and consumption of environmentally friendly products.
- How do green innovations enhance company performance? Starting from acquiring new, more complex knowledge and a broad range of applications, green innovations improve both the environmental and business performance of companies. Additionally, companies committed to green production behave responsibly towards society, not only creating a positive image but also positioning themselves competitively in the market.

SUGGESTION AND GUIDELINES

Based on the analyzed literature and the developed theoretical model, the following recommendations and guidelines could be derived for implementing green transformation in companies based on green innovations for sustainable development:

- Towards green entrepreneurship. Companies intending green transformation already demonstrate their responsibility towards society and readiness to embark on new business ventures.
- Acquiring new knowledge for generating green innovations. Inputs of new and more complex knowledge, exchange and sharing of knowledge with external collaborators and internal staff.
- Adopting new technology. Inputs of technology and technological solutions imply international cooperation, employee education, and knowledge management.
- Companies invest in processes for reduced consumption of natural resources according to their industry, needs, and capabilities.
- Application of legal regulations and international standards.
- Establishment of a green strategy. For the development of green innovations and implementation according to priority segments. Application of the 5P marketing concept for promoting, placing, and distributing green products.
- Government incentives and assistance to companies intending green transformation, as well as favorable bank loans for green business investments.

CONCLUSION

Green transformation of companies is a demanding process, simultaneously, initiating the transformation creates space for the diffusion of green innovations. For these activities, green entrepreneurial intentions are necessary, as well as some financial resources for investments in green purposes. Society should provide support and green incentives to motivate managers to empower themselves in green endeavors. Green innovations and green financing are a priority and the foundation for sustainable development (Tolliver et al., 2021; Ostojić, 2023). In addition to adopting new knowledge, education, and technology, adequate green strategies of companies ensure better performance, position, and reputation of the companies in the market. In conclusion, the contribution of all countries to achieving global goals regarding climate change (Ilic et al., 2022) is very significant in green transformation. In preserving and enhancing a healthy environment and sustainable development, the role of green innovations is crucial. Socially responsible behavior and developed environmental awareness indicate a growing interest in cleaner production and environmentally friendly products. In these intentions, the mutual encouragement of an increasing number of consumers of green products and producers significantly highlights the necessity of developing and accepting green innovations.

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DECISION MODELS, GAME THEORY: MODELS-ZERO-SUM MATRIX GAMES AND NASH EQUILIBRIUM

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ABSTRACT

The task of each of us is to choose from the multitude the option that will achieve the desired goal to the greatest extent, taking into account the objective limitations, which limit our freedom of choice to a greater or lesser extent. Decision-making is part of the managerial job, and the main job of a manager is decision-making. Due to the needs of new requirements in business, it is necessary to have quality management that can support new business concepts, an important part of the management process is making decisions, whether strategic, tactical or operational. This paper provides examples of the application of game theory in military, political, legal and economic sciences. Observing the models and examples in which game theory is directly applied, it can be concluded that for each of the segments studied and examined so far, the main role is how, when, in what way and with what intensity to make a decision.

Keywords: Decision models, Game theory, Models zero sum matrix games, Nash equilibrium.

INTRODUCTION

Every day, each of us makes a large number of decisions. We make most of these choices unconsciously, out of habit, or with negligible mental effort, using established procedures and rules. Our task is to choose from the multitude the option by which we will achieve the desired goal to the greatest extent, taking into account the objective limitations, which to a lesser or greater extent limit our freedom of choice. We make individual decisions, but we also make decisions in communication with others. As members of society or its various formal or informal groups, we participate in the process of so-called group decision-making (Fang et al., 2019).

THEORY

In recent decades, in increasingly complex business conditions, with growing uncertainty, as well as an increasingly pronounced division of labor, the importance of proper decision-making has been confirmed through the emergence of a new profession - manager, whose essence is decision-making (Newton, 2018). Decision-making is undoubtedly the most important activity that managers perform in all types of organizations and at all levels. It is an activity that clearly distinguishes managers from other professions in society (Zhang et al., 2019).

It follows from the above that a good manager is actually a good decision maker. Although good managerial decisions must rely on knowledge of the field in which the manager works, and although intelligence, imagination and experience undoubtedly contribute to better decision-making, they are still no guarantee of the correct decision (Garvin, 2006). Without intending to diminish the importance of the mentioned factors, it is important to emphasize that correct decision-making is not only a consequence of the mentioned factors, nor is it an ability acquired by birth, but it is a skill that can be mastered.

METHODS

Game theory as a field of operational research, is directly related to decision-making methods through practical application will be described in this paper through two theories, namely "Theory of zero-sum parent game" through three examples and "Theory of Nash Equilibrium", also through three examples (Sandholm, 2020).

FINDINGS

A detailed explanation of two game theories

Theory Zero-sum matrix game: we only have 2 players; one move game; the first player's gain is equal to the second player's loss, and vice versa → the sum of the payoffs is always 0; players have a finite number of strategies (possibilities) for conflict behavior.

$$C = \begin{bmatrix} C_{11} & C_{12} \\ C_{21} & C_{22} \end{bmatrix} \qquad (1)$$

The matrix C is called the payoff matrix, and its element cij represents the gain of player I and the loss of player II when player I chooses strategy ai and player II bj; the normal form of a two-player zero-sum game is triple (A,B,C) where: A={ai} set of strategies I players; B={bi} set of strategires II players; C is a function defined on the Cartesian product A x B so that cij=C(ai,bj), a real number (Krčevinac et al., 2006).

The simplest case of zero-sum games are simple matrix games that have a saddle point. If some element cij of the payment matrix C has the following properties: cij minimal element in a row i of matrix C; cij the maximum element in the column j of matrix C then we say it is cij saddle point C. Formal: cij*≤ ci*j*≤ ci*j; in saddle point it is valid: maxmin cij = minmax cij = ci*j*.

Mixed matrix games - Games that do not have a saddle point. An example is an even-odd game. The solution to the game cannot be found in the area of pure strategies, but must be tried with the new concept of mixed strategies. The answer was given by von Neumann's minimax theorem. Mixed matrix player I can be given by the probability vector p=(p1, p2 ... pi ..pm) , where pi represents the frequency with which the player I plays pure strategy ai.

Game with saddle - Players choose different strategies, and try to choose the best strategies in order to maximize their minimum gain and minimize their maximum loss (Krčevinac et al., 2006).

Minimax theorem - For each final game, two sides count: there is a real number v called the value of the game; there is a mixed strategy for player I that ensures him the highest expected minimum gain equal to the value of game v, regardless of which mixed strategy player II plays; there is a mixed strategy for player I that provides him with the smallest expected maximum loss equal to the value of the game v, regardless of which mixed strategy player I plays. Any matrix game with payoff matrix C has a saddle point in the space of mixed strategies, i.e. there are probability vectors p and q such that: maxmin pTCq=minmax pTCq=v (Ferguson, 2002).

Nash equilibrium theory

To determine the Nash equilibrium, we allow each player in the game to choose his probability distribution over the set of possible actions. This distribution is called a mixed strategy. So, in order for the player's mixed strategy to be fully determined, it is necessary to assign a corresponding

probability to each action that the player can take, which indicates the chance of taking that particular action. Let α be the portfolio of mixed strategies, and let αi denote the mixed strategy of player i. Clearly, a mixed strategy of a player can be such that he assigns a probability of 1 to an action, and this will mean that that player always chooses one and the same action, and this is also called a pure strategy.

The essence of the Nash equilibrium of mixed strategies is - The Nash equilibrium is that portfolio of mixed strategies α* which has the property that no player can be happier if he leaves it. Definition: A portfolio of mixed strategies α* in the case of mixed games with vNM preferences is a Nash equilibrium if for each player i and each mixed strategy α of player i and it holds that his expected payoff from the portfolio α* is at least as large as his payoff from the portfolio (αi α- and), relative to a payoff function whose expected value reflects that player's preferences (Hou et al., 2020).

DISCUSSION

Theory Zero-sum matrix game

Three examples (by theory) of using selected game theory.

Example 1: Game "Letter – head"

2 players: Player I and Player II; one-move game (each player can make only one move). Possibilities: turn the coin to the side "head" - strategy I or "letter" - strategy II; if both players turned "head" or "letter" the winner is player I, and if one player chose "head" and the other "letter" the winner is player II.

When flipping a coin, player I chooses strategy I - (corresponds to the first row of the matrix) and when flipping the coin, player II chooses strategy I - (corresponds to the first column of the matrix), then player I receives 5 din, which indicates the number 5 at the intersection of the first row and the first column of the matrix . When flipping the coin, player I chooses strategy I - (corresponds to the first row of the die) and when flipping the coin, player II chooses strategy II - (corresponds to the second column of the matrix) then player I loses 5 dinars and player II gains 5 dinars which indicates the number -5 on intersection of the first row and the second column of the payoff matrix. In both cases, the gain of one player is equal to the loss of the other player, so the sum of the gains of both players is equal to zero (Maschler et al., 2020).

Example 2: Game „Paper - rock – scissors"

Paper-rock-scissors is a game played, for example, in a football match when two players cannot decide which of the two will take a free kick, so they agree to play this game. Whoever wins - kicks. However, the game of Paper-Rock-Scissors is not only a game where the luckier one with the right choice wins, but also a game of skill. It is possible to determine a strategy that will ensure a sure profit for the player. In the game Paper-Rock-Scissors two players, each at the same time, show their hand in one of three configurations. The straight hand represents a sheet of paper, the fist represents a rock, and the outstretched index and middle fingers represent scissors. The possible outcomes of the game are given by the following rule: the scissors cut the paper; paper wraps stone; rock breaks scissors.

The normal form of this game can be represented by a simple table, as shown in Figure 2, whose utility values for win 1, loss -1, and draw 0 are shown from the point of view of the first player (the "row" player). This table is also known as the game matrix A = (aij) of the game in question. The game Paper - Rock - Scissors belongs to the category of 2-player zero-sum games. Anything one player gains is simultaneously lost by the other. If we assume that B = (bij) is the utility value matrix of the second player, then in a zero-sum game for 2 players the matrix ratio is always the same, that is, B=-A. The game Paper - Rock - Scissors can be identified with a symmetrical game for 2 players. An

intuitive approach to solving this game begins with the following considerations. The row player has a unique best response for each player's action in the column (eg, always choose a stone when the opponent chooses scissors). He can always come out victorious, assuming, of course, that he knows in advance what choice his opponent will make. Therefore, the player in the column is forced to hide his actions. In a replay game, such concealment can be achieved by the player's random selection of the various options available to him. The rules of the game are such that the manner in which players allow chance to determine their moves must be obvious to all players. The column player can now own scissors with ability p1 and stone with ability p2 . If this mixed strategy were known to the opponent, then he would in turn choose scissors, rock, and paper with relative frequency 1 - p1 - p2, p1, and p2. We cannot base this conclusion on just one game example. Therefore, we now follow a regular player who, as shown in Figure 3, with the help of a multi-round game, responds to each action of his opponent in one round by responding with the best response to that action in the next round.

		Column player		
		✌️	✊	✋
Row player	✌️	0	-1	1
	✊	1	0	-1
	✋	-1	1	0

Figure 2: Paper - rock – scissors

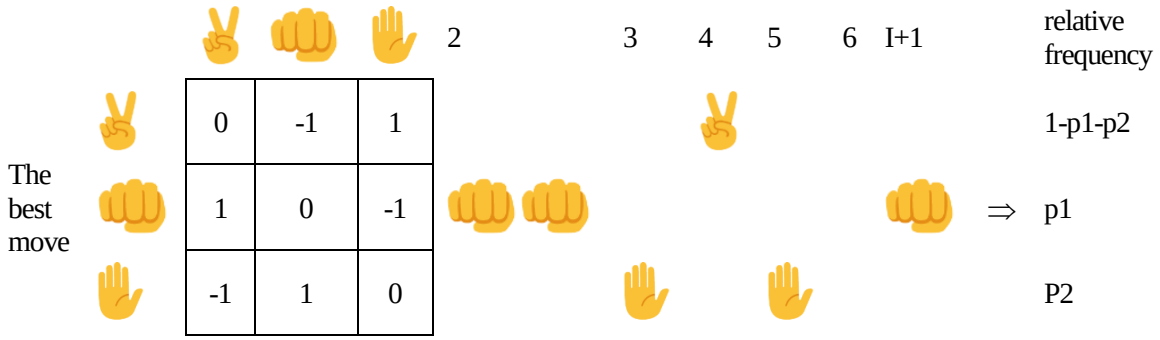

Figure 3: Regular player answers

This consideration again leads us to a consistent choice with possibilities p2, 1 - p1 - p2, and p1, for the actions of the column players. However, this conclusion agrees with the original assumption about the behavior of this player, ie. that the relationship p2 = 1 – p1 – p2, p2 = 1 – p1 – p2 and p1 = p2 holds. When this system of equations is solved, a valid mixed strategy p* = (1/3,1/3,1/3) is obtained. What properties can we attribute to strategy p*? No other strategy is better than it! Of course, there are other strategies, e.g. among (infinitely many) other so-called pure strategies, i.e. a strategy based on an established principle, such as always showing scissors, which work just right. Another property of this mixed strategy is that the player who implements strategy p* achieves at least the safety level of the game. This value is the largest possible gain that a player can be guaranteed to achieve regardless of the opponent's action (Jaskiewicz et al., 2018).

Example 3: Battle of the Bismarck Sea

A typical example of the application of zero-sum games to the problems of warfare is the famous battle in the Bismarck Archipelago, which was fought by the Americans in March 1943, with the help of the Australian Air Force, against the Japanese. During the fighting, the American command received disturbing information that the Japanese wanted to move their forces from the port of Rabaul, located in the far east of New Britain, to another port located in New Guinea. New Guinea can be reached in two ways: either along the northern part of New Britain, which is a shorter way, but the conditions are worse because visibility is

reduced, or along its southern part, where visibility is excellent, but the way is much longer. In both cases, the trip will take three days. The American command was faced with a dilemma: where to place reconnaissance and other air troops - on the northern or southern route. If the convoy is discovered, it will be bombarded until it enters the new port. If it happens that the Japanese convoy and the American planes are on different routes, it will take time to detect the convoy and to engage the available aviation. So, in front of the headquarters of both sides is the following game: player I is presented horizontally, which are the strategies of the American and Australian forces, while Player II is presented vertically, which are the strategies of the Japanese troops. From the "payoff" of the game, we can conclude that this is a zero-sum game, that is, a game in which the gain of one player is equal to the loss of the other player. Players make their decisions simultaneously.

What combinations of strategies are possible and what results (Deng et al., 2019)? If the convoy were to move along the northern line and if American troops were also located on this line, the Americans would need a certain amount of time to discover the convoy (say one day) and to reduce it in conditions visibility after that and bombard. In this case, the Japanese command can expect two days of heavy bombing. If the American forces were stationed on the northern line and the convoy went south, it would also take some time for the convoy to be discovered and the available troops to be diverted, but when this happens, bombardment follows with excellent visibility. In this situation, the Japanese convoy expects to be bombarded for two days. The situation that best suits the Japanese command is for the Americans to be stationed on the southern line, and for them to move along the northern line. Then, due to the time it takes to detect the convoy and move the forces, as well as due to the poor visibility, the shortest bombardment would take place and therefore the smallest losses for the Japanese. The worst possible outcome for the Japanese is that they take the southern line, with the Americans stationed exactly on that path. This is followed by rapid detection and, under conditions of excellent visibility, bombardment lasting three days.

What is balance ie. the solution to this game? US Command Headquarters. There is no dominating strategy for them, ie. there is no strategy that would bring a better solution than some other strategy, regardless of how the other party, that is, the Japanese command, would act. From the point of view of the Japanese command, we see that there is a strategy that is weakly dominant in relation to the other strategy "southern path" is weakly dominated by the "northern path" strategy. It is not in the interest of a rational player to play a strategy that is weakly dominated, that is, he will not send a convoy on the "southern path". We conclude that the equilibrium of this game is "North Track - North Track" with the equilibrium result of two days of bombing in low visibility conditions. We reach this conclusion if the players have the same game matrix in front of them and adhere to the criteria of rationality. This is exactly how it happened in reality. The convoy followed the northern line, was discovered during the first day and heavily bombarded for the next two days. Although the Japanese suffered heavy losses (a large part of the convoy was sunk and large human casualties), from the point of view of game theory, their commander cannot be condemned as an irrational player. This game can also be solved using the maxmin criterion. We start from the initial payoff matrix of the game and determine the guaranteed payoff of player I (the Americans). According to the maxmin criterion, they will look for a guaranteed payoff for each strategy (a payoff that is guaranteed regardless of player II's behavior). Since we are looking for the smallest payoff for each strategy of player I, we write it in a separate column of the game's payoff matrix (we mark min in green). With Player II, everything is reversed. As this is a zero-sum game, he wants to minimize his loss and will find the maximum loss value for each of his strategies. We record those values in a special type of game payout matrix. Player I now wants to ensure the maximum guaranteed gain and chooses a strategy that will allow him to do so, which is the "northern path" strategy. Player II tries to minimize the loss, that is, he looks for the smallest guaranteed loss and opts for the "northern path" strategy. That's how we came to the solution of the game and the result that we know from before. Player I gains two units, equal to player II's loss. (Hou et al., 2020).

CONCLUSION

Decision-making significantly affects organizational behavior. Decisions made by recognizing perceptual biases are better than decisions we tend to make based on mistakes made. The approach to decision-making should be adapted to the culture of the environment and the criteria of organizational values. One should not feel compelled to follow models of decision-making or try to make decisions

seem rational. The most important thing is to adapt your decision-making approach to ensure compatibility with the organizational culture. Good decision making creates a healthy and positive relationship between the hierarchy and the environment. If we want to make a decision with quality, we must first think about whether there is really a need for it and be aware of the time limit that exists when making a decision.

Since we spend most of our lives making various decisions, game theory can serve as both a guide and a signpost in this movement, since we use it to model many situations from real life, and then, using analytical tools, we arrive at the direction in which we need to go. to move and situations to avoid. On the surface, it may seem that these tools are too simple, but it is precisely this simplicity and their accessibility that allow us to gain a certain intuition about the complex problems that we face every day by solving them. Game theory has many applications. This paper provides examples of game theory application in military, political, legal and economic sciences. From everything studied, games can be divided into zero-sum games and non-zero-sum games, where the optimal solution defined for zero-sum games makes no sense in bimatrix games, which are divided into non-cooperative and cooperative games.

By looking at the models and examples in which game theory is directly applied, it can be implicated that for each of the segments studied and examined so far, the main role is how, when, in what way and with what intensity to make a decision, and that it is precise, reliable and as fair as possible, i.e. that it is the right decision.

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IS GIS PRESENT IN LOGISTICS 4.0 AND 5.0? EXPLORING THE POTENTIAL OF USING GIS IN SMART LOGISTICS

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ABSTRACT

With the development of new technologies, industrial processes are nowadays changing rapidly. The essence of logistics has remained unchanged – to enable the most efficient flow of goods between the two parties. However, with changes in individual needs, it is now necessary to use new tools in order to be effective at a satisfactory level. As a system for collecting, storing, analyzing and visualizing spatial data, Geographic Information System (GIS) comes to the fore here. The aim of this paper is to show how GIS and GIS experts fit into the framework of smart logistics and what would be the path for further development of GIS application in logistics.

Key words: Geoinformatics, Engineering management, Spatial analysis, Industry 5.0.

INTRODUCTION

In the age of digital revolution, new technologies are taking over all aspects of human lives. The same applies to the industry. Currently the world is undergoing the fourth and fifth industrial revolution and the underlying digital transformation. In both scientific and business world, these processes are commonly referred to as Industry 4.0 and most recently Industry 5.0. Industry 4.0 is based on information technologies (IT) and operational technologies (OT). Those technologies include, among other, internet of things (IoT), cyber-physical systems (CPS), artificial intelligence (AI), big data and analytics, cloud computing, mobile-based systems, social media-based systems, and many others (Bai et al., 2020; Ghobakhloo, 2020; Winkelhaus, Grosse, 2019). The concept Industry 5.0 appeared soon after Industry 4.0. While Industry 4.0 focuses mostly on making smart products and making machines the most productive, Industry 5.0 focuses more on human-machine interaction, skills and knowledge of the workers. It can be said that it combines human and artificial intelligence, through human subjectivity and unconventional ways of thinking and precision of machines. Both Industry 4.0 and 5.0 are focused on sustainability, efficiency and solving individualized customer demands (Golovianko et al., 2023; Leng et al., 2022; Rane, 2023; Zizic et al., 2022).

In this research the focus is put on logistics, as a part of industrial processes. Logistics is defined as "planning, implementing and controlling efficient, effective flow and storage of goods and services from the beginning point of external origin to the company and from the company to the point of consumption for purpose of confirming to customer requirements" (Lummus, Krumwiede, Vokurka, 2001). With the development of new technologies, logistics is also changing. Based on the aspects of mass customization, new digital technologies and human aspect, either as employees, customers, stakeholders or as drivers of climate change, the definition of Logistics 4.0 is made. According to their research of 114 papers on logistics and new technologies, Winkelhaus and Grosse (2019) define Logistics 4.0 as "the logical system that enables the sustainable satisfaction of individualized customer demands without an increase in cost and supports this development in industry and trade using digital technologies. The conceptual framework of Logistics 4.0 consists of three dimensions: external, technological and human factors. External dimension is defined by the changes of customer demands, individualization of needs and products, as well as globalization and sustainability. According to the reviewed literature in Winkelhaus, Grosse (2019) most common technological factors are IoT, CPS, big data-based systems, cloud-based systems, mobile-based systems and social media-based systems.

Of course, many more technologies are used in Logistics 4.0, but these six are the main ones. The human factor is related to human-machine cooperation. This factor is closely related to the definition of Industry 5.0, which aims to use technology in favor of humans, and not change humans for machines. With the development and definition of the term Industry 5.0, the term Logistics 5.0 can also be discussed. The main difference between Logistics 4.0 and Logistics 5.0 is their focus. As with industry, Logistics 4.0 is mainly technology-oriented, while Logistics 5.0 human-oriented. Goals of Logistics 5.0 would be to create a balance among economic, environmental and societal sustainability by using new digital technologies (Jafari, Azarian, Yu, 2022).

With the development of digital technologies, new perspective of geospatial data came about. The first Geographic Information System (GIS) was developed in Canada in 1960's for the Canada Land Inventory. Since then, GIS came a long way, and in 2016 the GIS Market was valued USD 5.33 Billion and it is growing at a compound annual growth rate of 9.6%. There are many definitions of GIS, but most importantly it is a "computerized system capable of assembling, storing, managing, analyzing, modelling and displaying spatial information" (Zhou, 2021). Main components of GIS are hardware, software, data, people and applications/methods. GIS methods can be used in the variety of fields – from geography, geology, hydrology, geomorphology, to demography, economics, urban planning, geodesy and civil engineering (Zhou, 2021). GIS can also be used in the domain of logistics to optimize routes and significantly reduce the cost of distribution (Chen et al., 2021), make evaluation of logistics performance (Özceyan et al., 2016), plan routes for green vehicles and decrease air pollution (Pamučar et al., 2016) and many more areas of logistics.

This paper aims to give a brief overview of using GIS in logistics, specifically in the light of Logistics 4.0 and Logistics 5.0, and discuss the future development of using GIS technologies in the field of logistics.

BRIEF INTRODUCTION TO GIS

The combination of all the components of GIS makes this system able to analyze spatial data and answer spatial-related questions. Broadly speaking, there are six main domains of using GIS for mapping: mapping where things are, mapping quantities, mapping densities, mapping change, mapping what things relate and how and answering 'what if' questions (Zhou, 2021).

There are two main types of data models that can be used in GIS – vector and raster data. They are actually mathematical constructs for representing geographic objects or surfaces as data. In vector data model, the data is represented as collections of points, lines and polygons. On the other hand, the raster data model depicts geographic data as cell matrixes that store numeric values – pixels (ESRI, GIS Dictionary, 2024). Different types of data are visually represented by layers (Figure 1).

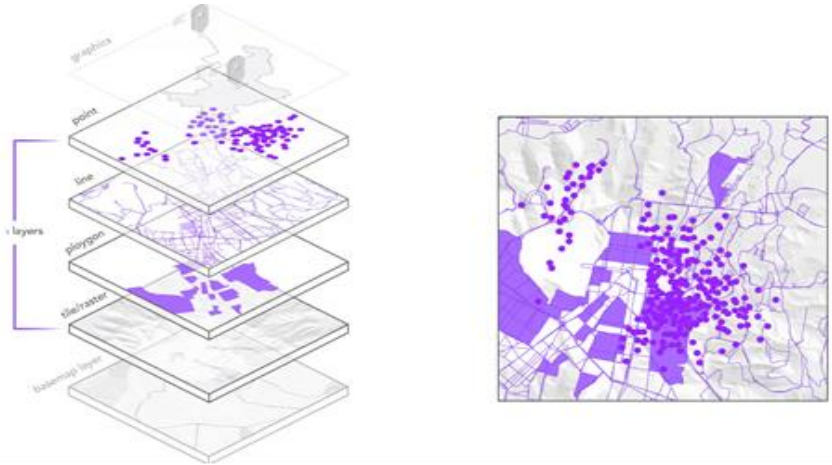

Figure. 1: Map layers (on the left) and map view (on the right)(ESRI, Data Layers)

On the left side of the Figure 1 different layers of data types are represented. The type of data chosen for representation of geographic features depends on the size of the feature, map scale, but also on the analysis that needs to be done. Some analyses are only conducted on raster data layers, and some on vector layers.

Typical workflow in GIS is as follows:
1. The geospatial problem is identified;
2. The needed data is acquired and the project database is formed with all its attributes, coordinates and accurate formatting;
3. The method of analysis based on the problem and data types is decided on;
4. The analysis is conducted;
5. Visualization and presentation of the results is communicated to the parties involved in the research. After this step, the GIS project is finished (Zhou, 2021).

As it can be concluded, conducting geospatial analysis and using GIS requires a high level of knowledge about both geographic data and GIS tools that need to be used for analysis. After finishing the analysis, the results then must be represented in a simple way, that all parties involved may understand (Zhou et al., 2020). All this is closely related to the objectives of Industry 5.0, and therefore Logistics 5.0 – to have knowledgeable and educated working force, that can provide maximum results and performance, while working with advanced technologies.

GIS AND LOGISTICS 4.0 AND 5.0 TECHNOLOGIES

In this chapter, the role of GIS in the light of key digital technologies of Logistics 4.0 and 5.0 will be presented. The technologies that will be reviewed are the ones sorted out by Winkelhaus, Grosse (2019): IoT, CPS, big data-based systems, cloud-based systems and mobile-based systems (Figure 2). As Figure 2 suggests, none of these technologies are isolated from each other, they are all a part of a bigger system and many studies have used more than only one. The aim of this chapter is to examine the place of GIS in Logistics 4.0 and 5.0.

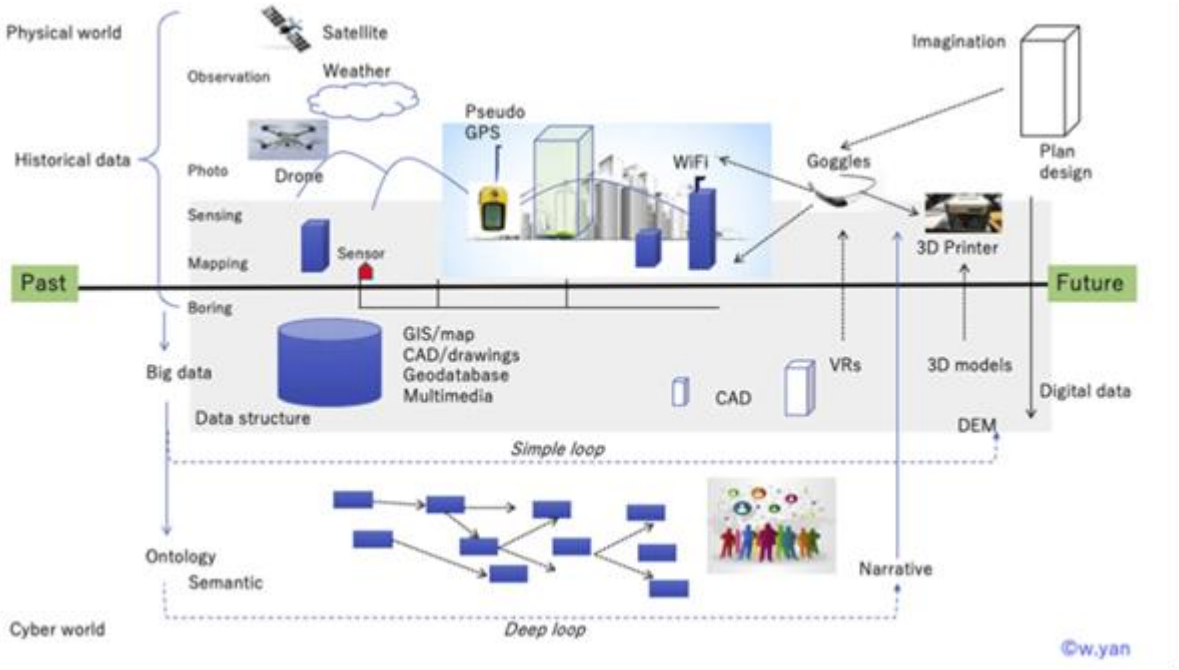

Figure. 2: Concept of integrating GIS and Logistics 4.0 and 5.0 technologies (Yan, Sakairi, 2019)

Internet of Things is one of the most widely used terms regarding new technologies. It can be defined as a "global network of machines and devices capable of interacting with each other…via physical objects embedded with different types of sensors and actuators" (Kraijak, Tuwanut, 2015). GIS and IoT can be connected via sensors that collect spatial data in real time (Figure 2 and Figure 3). In this case, the sensors are represented by satellites, drones, different types of sensors that detect soil moisture, air quality, river water level and flow, etc. – any kind of measuring device that measures the values of some spatial phenomenon and is connected to the internet. Sensors collect the data, and then data management, query, analyses and display of the data can be done using GIS.

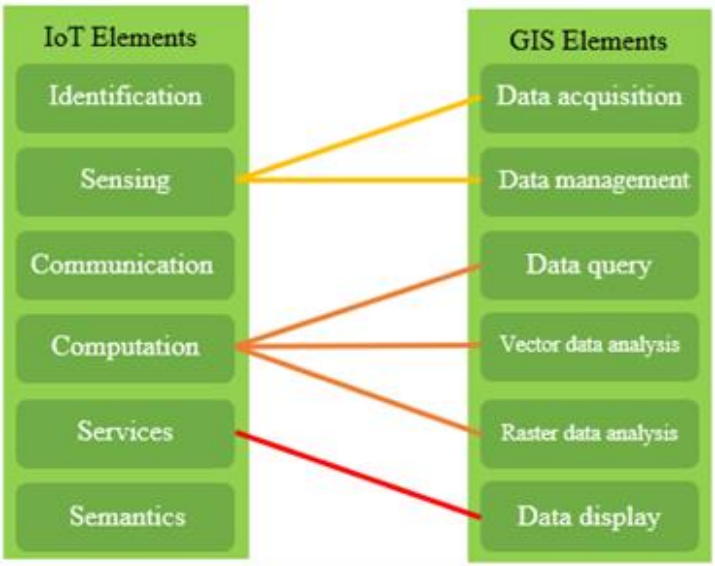

Figure 3: The scheme connecting the elements of IoT and GIS (Safari Bazargani, Sadeghi-Niaraki, Choi, 2021)

There are many possibilities for using these technologies combined – smart mobility solutions, disaster management, smart environment solutions etc. As Miloudi, Rezeg (2018) indicate, some U.S.A. airports, Indian and Japanese railways use sensors connected to the GIS software to track luggage to overcome loss. Similar sensors are used in taxi services to monitor traffic, ensure the fastest communication with the clients and best service. Some vehicles are even connected to the GPS sensors so it is possible to track their geolocation, thus secure them from theft and enable the most efficient transport (Ivankova, Mochalina, Goncharova, 2020).

CPS, IoT and GIS are all closely related to each other – IoT is all about cyber systems, GIS about physical world, and CPS about the intersection of the physical and cyber worlds and systems. The traditional examples of CPS are smart electric power grids, intelligent transportation systems, urban utilities etc. Adding spatial dimension to the cyber world adds complexity, since the real world comes with a lot of factors that cannot always be integrated and analyzed inside only cyber systems. One of the logistical examples of integration of IoT, GIS and CPS is *City Brain* in the city of Hangzhou (population of about eight million) in China. By placing sensors in the downtown area of the city, urban utilities, healthcare, hospitals and road transportation can organize in a most effective way according to the real-life events. One of the results is that "traffic accidents can be detected automatically with an accuracy of 92% in the city" (Yan, Sakairi, 2019).

In 2019, an overview study on transport decision-making via development of Public Participatory GIS was conducted. The goal of this concept was to motivate the public to improve and influence government policy on transportation and environment. In most of the reviewed papers (60%) the citizens were involved in the collection of geographic data, and about one fourth of citizens were involved in creating and editing the content. The data was being collected by mobile phones. Since the amount of collected data was of considerable size, GIS was connected to big data-based and cloud-based systems in order to facilitate data storage and processing. The conclusion was that future

research and the involvement of the public in transport decision-making will significantly improve the state of logistics and transportation (Giuffrida et al., 2019).

DISCUSSION

There are a lot of positive aspects of using GIS technologies in the field of logistics, such as greater efficiency of transportation, saving time and fuel, thus protecting the environment as much as possible and achieving greater safety with constant geolocation of objects. Nevertheless, there are also several challenges. For instance, with the fast-paced development of new technologies, they are not always completely compatable, some older versions of softwares and hardwares are not able to work with the newer data, and the newest versions are usually very costly. Another problem is that all the data is stored on the internet and cyber platforms, which are not perfectly protected from cyber-terrorists (Yan, Sakairi, 2019). However, every progress has its challenges and it is up to the experts to find the best solutions for all potential problems.

In Industry 5.0 and Logistics 5.0 a great emphasis is placed on experts and the link between humans and machines. In order to build a stable foundation of smart industry, the most important thing is to have expert people in the right positions. GIS is a very complex system, which is based on geospatial data, and for which it is necessary to know a lot about the field of analysis (Zhou et al., 2020). GIS analyses cannot be done by one person alone, but rather teams of qualified people from different fields are needed in order to achieve maximum performance. Visualizing the results in an understandable way is almost as important as the data analysis itself. If the results are incomprehensible to people outside the scientific community, they will never be implemented in industry and there will be no development. It is also the job of experts. Progress will only be achieved through the cooperation of science, industry and humans with machines.

CONCLUSION

After analyzing the terms Industry 4.0, Industry 5.0, Logistics 4.0 and Logistics 5.0, it can be said that the new technologies are essential for the development of these fields and for the future development of the human kind. Implementing GIS technologies, as seen from previous examples, is something that is being realized in the world and has positive outcomes, but there is still a lot to be done. The main objectives of Industry 5.0 and Logistics 5.0 are human-machine interaction and having the experts on the fields to give their contribution to the development of the industry by using their knowledge in the best way possible. Through the use of GIS and new technologies by the experts, it is certain that the goals of Industry 5.0 and Logistics 5.0 would be met and even exceeded.

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THE INFLUENCE OF USING LEAN TECHNOLOGY FOR IMPROVING THE ORGANIZATION'S ADMINISTRATIVE AREAS

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ABSTRACT

This paper shows the influence of the use of Lean technologies and tools on the improvement of organizational activities and processes in administrative areas. Lean implementation requires the company to be flexible and up-to-date with developments and innovations in the market, so that this transitional improvement process can take place continuously. These processes are mainly carried out through certain projects, which require a long time and the realization of complex activities. Also, in order for the Lean concept to be successfully applied in any company, there must be equal desire and motivation of both management and all employees. The paper aims to show the benefits of implementing Lean tools in manufacturing organizations in order to reduce delivery time and meet customer requirements. Since the influence of Lean technologies is multiple, the paper highlights the benefits of applying Lean tools and technologies to shorten delivery times to customers and reduce the time of human resource engagement for service routines and administrative functions.

Keywords: Lean technology, Manufacturing Response Time, Administrative functions, Service routines.

INTRODUCTION

The unstable market the frequent introduction of innovations in production processes and the development of technologies require the manager of the production system to constantly adjust the system architecture and operating parameters in order to meet profitable business conditions and remain competitive in the global market (Ali and Deif, 2014). Modern business conditions and the complexity of production processes impose the need to use different techniques to improve organizations' performance as a function of time as an important efficiency factor. There is no single model or concept, the application of which would guarantee success in competitiveness in the market. The Lean technology stands out as one of the most applicable organizational strategies in recent years. The Lean concept is a systematic approach to the management and organization of industrial and manufacturing companies, i.e. the way of interaction between human resources, production resources, and means of work, organization, and technologies within the organization system. It is also a systematic method for eliminating waste within the production system (Nagy and Wan, 2017). The application of the Lean technology is conditioned by customer requirements and requires constant improvement of work and production processes following the given circumstances. Lean technology aims to shorten the length of the production cycle, which directly affects product delivery times, an important factor in the fight for competitive dominance in the market. Industrial enterprises are increasingly applying Lean technology in order to improve their operations, differentiate and innovate their products, and improve the quality of services, using less resources and time. This technology enables the successful elimination of various losses in organizational processes, such as excessive production, unnecessary stocks, waiting, excessive processing, waste, excessive transportation, unnecessary movements, and underutilization of employees' potential. The transition from traditional to Lean production begins first of all in the production sector, where, among other things, most

financial resources are spent. There are many reasons why many companies have started Lean business transformation in the past few years, the most significant being the achievement of economies of scale through cost control of the production support group, increasing speed to market, and improving quality in production. It is not only the benefits in the area of production that justify the Lean transformation, other benefits also make the beginning of the transformation in manufacturing worthwhile. Manufacturing Response Time (MRT) can be significantly reduced after completing a Lean transformation. It is possible to orient the production strategy to supply chain services with random demand (Yang et al., 2023). Time reduction is also achieved by developing a system dynamics model to examine the effects of continuous improvement in repair and setup time on the cycle time of the production system (Filho and Uzsoy, 2013). A generic optimization model for order release scheduling in stochastic, non-stationary manufacturing systems is developed that includes a well-defined interface to the forecasting model (Missbauer et al., 2023). A general framework is also presented that aims to provide an efficient modeling prototype for supply chain systems supported by accurate quantitative analysis based on response time (Ding et al., 2022). Faster production completion time for customer needs offers a huge competitive advantage for the company. Reduced manufacturing response times mean shorter customer-specified delivery times. If the customer's supplier selection criteria include the shortest lead time, the Lean manufacturer will often become the supplier of choice for this customer.

This paper presents various possibilities of applying Lean tools and technologies to improve the organizational performance of companies in administrative areas. Using these tools, possible solutions are presented that achieve reduced delivery times and the reduction of resources needed for service routines and administrative functions.

USE OF LEAN PRODUCTION TOOLS FOR IMPROVEMENT OF SERVICE ROUTINE FLOW DOCUMENTATION

The results of the service routine require transformation into a final form, as a consequence of a series of realized processes. These processes are grouped together in departments based on the experience of the employees who perform them, such as: engineering department, customer service, financial service, and accounting. In order for production processes to become Lean production, it is necessary to understand the relationship between the processes used to complete the service routine and the sequence of procedures used in it. It is necessary to answer the questions which process is performed before the other and where is the document or service request forwarded. One way to visualize the sequence of the process would be to remove the roof of the office spaces in the facility and then track the movement of service requests throughout the facility. The paper presents the use of Lean manufacturing tools as a possible proposal for documenting the service routine or document flow using a value stream map (VSM), process flow diagram (PFD), standard wok definition (SWD), and value-added analysis (VA).

The value stream map. VSM is a very, practically applied, Lean tool used in the Lean transformation of organizations in administrative areas to document the flow of information and materials, obtained based on customer requirements before the delivery of finished products, in the conditions of serial production. Masmali (2021) proposes the application of VSM to implement further improvement and makes an action plan to mitigate unwanted activities. It can also focus on the quality of information for the control of production processes (Busert and Fay 2021). By applying the ubiquitous VSM in Lean manufacturing, it is possible to incorporate digital elements into traditional product value streams (Arey et al., 2021). VSM is a tool that consists of two parts, the upper part documents the loop that shows the flow from receiving the demand from the customer, to the planning and purchasing process from the supplier, to the production plant, and back to the delivery of the demand to the customer. In the lower part of the map, the production processes in which the transformation takes place are documented, and the location of the inventory, the number of days of delivery time, the cycle time, the working time of the machine, and its utilization are shown (Figure 1).

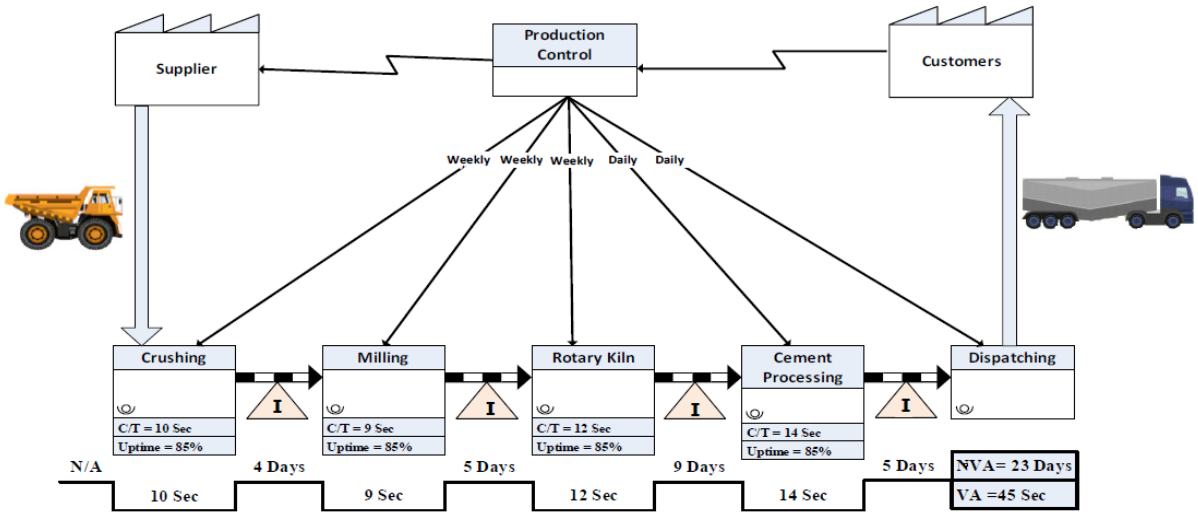

Figure 1: A value stream map

If the same processes are used for the production of products, the use of VSM tools can achieve a satisfactory level of documentation of repetitive processes. But there are also non-repetitive processes, as well as processes that are divided into sub-processes, which are more common in production. The negative characteristics of the application of this tool can be reflected in the fact that although it represents a flow of material, it provides very little information and details necessary for the implementation of a new operating system.

The process flow diagram. This tool provides a more detailed and better understanding of the flow of the sequence of work processes in the conditions of mass production in contrast to VSM. A PFD is a tool used to document processes and their interrelationships.

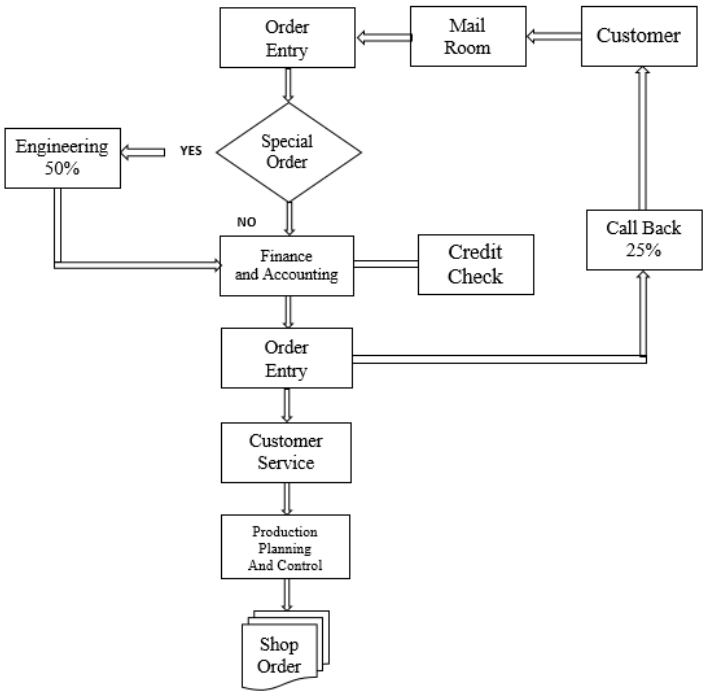

Figure 2: A flowchart: customer order to shop order

Applying this tool ensures that all processes in which work is completed can be identified for each product family and shows the relationships of the processes and how they flow together to produce the service routine. This tool also shows the flow of processes necessary to provide service to the client, in the case of service routines and administrative functions. By applying the PFD tool, it is achieved that there is no mixing of cycle time with measures of utilization performance or overall efficiency of the equipment. In

some processes, a flow chart can also be used to document service processes as a substitute for a PFD (Figure 2). In the service routine, the process refers to the functional department of the company. A department is formed to group them as if they work together and to concentrate the skills and knowledge required for the function.

The standard work definition. For the processes defined for each product family using the PFD, SWD is further used to document routine service tasks, consistently describe work tasks, standard times for each task, and document quality criteria for each task for each PFD process. Although work can be completed using multiple methods, a decision must be made on the best correct way to complete the service routine, and that correct way is documented. All work in the service routine must be completed in accordance with a predefined quality specification, which is determined by the management of the company, so that decision-making for choosing the best way to complete the task is not left to individuals.

The value-added analysis. For each work task on SWD, the determination of VA or NVA must be documented. A VA analysis document as a Lean tool documents the individual tasks for each process chronologically and in detail (Table 1). Standard time is recorded in a separate column based on the work task, work type, time, value-added (VA), or non-value-added (NVA), distance, and observation. The work types are represented by icons for the different time categories: setup (Δ), queue (O), value-added (□), and move (→). Setup time is the time spent preparing to perform other work, such as gathering all the authorized signatures needed to approve a requested activity or to complete the value-added work of that process. A queue represents the time that a workstation waits in an inbox or batch computer before the VA work of that process is performed. A move represents the time required to move a job to the next process or task within a process.

Table 1: A VA analysis template for a product process

Sequence	Work Task	Type	VA	NVA	Distance	Observation
1		Δ O □ →				
2		Δ O □ →				
3		Δ O □ →				
4		Δ O □ →				
5		Δ O □ →				
…	…	…	…	…	…	…
Total			**0**	**0**	**0**	

After identifying the times for the work tasks of the process, they are then recorded in the most appropriate column on the VA work of that process. If the task does not change the form, fit, or function of the service routine, its time is recorded in the NVA column. At the same time, the corresponding icon indicating the type of work is selected. Once completed, the times recorded in the individual columns are summed to indicate the time required for each category. Marking the date of time received and time of departure of each functional department helps to determine the total elapsed time spent in the department. VA analysis breaks down the individual activities that make up the total time spent in the department by separating the times into VA and NVA activities. A series of NVA tasks can easily increase the cycle time of a service routine, which is why they should be eliminated.

USING LEAN METHODOLOGY TO DETERMINE SERVICE ROUTINE VOLUME AND THE REQUIRED RESOURCES

Production volume has the greatest impact on defining the number of production resources that should meet customer expectations. It also affects the reduction of MRT, which allows to shorten the delivery time specified by the customer. The forecasted volume of production can never be determined precisely enough, and it is equally difficult to predict the volume of service routines and administrative functions. As a possible solution for predicting the volume of service routines and administrative functions, it is proposed to accept the probability of errors in the prediction and optimization of the number of resources by harmonizing with customer requirements. Excessive use of resources in production processes represents a significant waste of time. In the continuation of the paper, Lean methodologies will be presented, the use of which enables a more precise determination of the scope of routine services and required resources.

Using Takt Time to determine output speed for utility routines and administrative functions. Using Takt Time, the company using the Lean methodology has the ability to regulate the production cycle on a daily basis in accordance with customer requirements. The Takt Time application has the task of analyzing the relationship between the total available production time on a daily basis and the daily produced quantities (Hobbs 2004). The time that a productive resource is available to perform work is known as available minutes per day (AMD) and can be calculated as follows (Hobbs 2011):

$$\text{AMD} = \text{Total Time} - (\text{Time for breaks} + \text{Lunch} + \text{Training} + \text{Personal time away from a workstation}) \quad (1)$$

By applying this Lean technology, the speed at which each service routine or administrative function must be completed to meet customer demand can be identified by dividing the available minutes per day by the expected volume of flow at full capacity. The flow volume for a service routine must project the expected volume for that process for a predetermined period into the future.

Using Standard Work to determine how many labor resources are needed to complete a service routine. The Standard Work must also be known to determine how many labor resources (human and machine) are required to complete the service routine and administrative function within the target Takt Time. The processes required to produce the routine service output are identified on the PFD for each product. Standard work and individual work tasks are documented on the SWD and the value-added analysis form. The required amount of resources for the planned volume can be calculated as the quotient of the Standard Work specified on the SWD and the Takt Time. This relationship determines the required number of people for the realization of that volume of Standard Work in order to achieve the rate of output Takt Time. The number of workstations required to accommodate all the resources necessary for the implementation of the work is also determined. Need to adjust resources on a daily basis, adding or subtracting resources to match the volume of customer demand for that day. In the case when human resources are not needed for Standard Work on a given day, it is suggested to allocate the resource to another activity outside the process, there are always other unfinished activities, and this achieves significant time savings.

Using Work Cells to complete Sandard Work. Most service routines and administrative functions require the Standard Work of many processes. These processes typically involve work being assigned to functional departments that may be located across the facility, in an adjacent building, or even in another state or country. Because of this typical layout of administrative departments, SWD often finds that significant wait and movement times are associated with completing service routines, even with high-speed electronic records. Typically, wait time and movement time are required before Standard Work in the next process of the service routine can begin. Applying this Lean methodology allows companies to regroup and relocate human resources from distant departments. Also, the service routine, administrative functions, and production processes must have the same goal: to complete the Standard Work only in the sum of the value-added working hours. Developing the Work Cell helps to achieve that goal. Also may require relocating human and workstation resources from their functional departments to a shared location where all of the processes are laid out to resemble the PFD. The Work Cell must accept the number of resources determined to be required to complete the Standard Work within capacity. The possibilities for developing the flow of service routines and administrative functions are very limited and depend on the development skills of the manager. Lean methodology can be used to develop multifunctional cells whenever multiple processes are required to produce a specific solution, achieve a goal, or produce an outcome. Service routine for cell formatting includes:

- The purchase order request and three-way match through the supplier payment cycle
- The research and development concept, engineering design, and manufacturing cycle
- The customer order receipt, manufacturing, and invoice cycle
- The receiving, quality approval, warehousing, material issues, and production cycle of raw materials
- The customer demand, manufacturing, purchasing, and supply chain cycle

A manager of a functional department may feel that moving his workers to other locations may jeopardize the department's operations. Maintaining a primary reporting relationship with the department's current

functional managers ensures that core competency and ongoing functional expertise and training are maintained.

CONCLUSION

All organizations focus on customer demand and thus produce high-quality products and services in the most efficient and cost-effective manner. The application of Lean technologies means that the company is always in transition and constantly improving. If the implementation of Lean tools is applied in an appropriate way, it can lead to various positive improvements in the organization, aimed at increasing the flow of value in customer demand and eliminating losses in processes. The paper shows the advantages of using Lean tools and Lean technologies, which can be used to reduce delivery time to customers and reduce the time of human resources engaged in administrative areas in the organization. This concept also shows many advantages and positive results that play a vital role in the success of the company, related to the improvement of service routines and administrative functions. The presented possibilities of using Lean technologies can be of significant help to many managers who aim to transform traditional production into Lean production.

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LEAN PHILOSOPHY AND INDUSTRY 5.0: A BIBLIOMETRIC ANALYSIS APPROACH

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ABSTRACT

Industry 5.0, an emerging strategy, has started to influence and transform the way of doing business on a global level. The effects Industry 5.0 causes when intertwined with different life aspects, such as work, education, and health have already been analyzed. However, the changes which Industry 5.0 causes when combined with the Lean philosophy are not extensively investigated. Therefore, this paper aims at filling in the literature gap by conducting a bibliometric analysis on the topic of Lean philosophy and Industry 5.0. The results presented in this paper give information about the most productive authors, the most cited articles, the most relevant sources, and main keywords in the mentioned field.

Keywords: Lean philosophy, Industry 5.0, Bibliometric analysis.

INTRODUCTION

Lean has originated in the automotive industry, and is also known as the Toyota Production System (Holweg, 2007). Assembly line, which made mass production possible also originates from the automotive industry, from the Ford Motor Company, and it is one of the main inventions of the Second industrial revolution (Chen et al., 2021). Today, while Industry 5.0, also known as the Fifth industrial revolution, is becoming a part of many companies worldwide, it is needed to adapt manufacturing practices to Industry 5.0's needs and values (Leng et al., 2022; Slavic et al., 2024). Those needs and values are presented through Industry 5.0's main pillars – human-centricity, sustainability, and resilience (Slavic, 2023). Although Lean is known for emphasizing the importance of people i.e. workers and respecting them, which suits Industry 5.0's human-centricity, it is crucial to enhance Lean practices so they can contribute to sustainability and resilience (Alves et al., 2023; Branger & Pang, 2015; Shah & Ward, 2003).

With an aim to give insights into where to start the research of how to elevate Lean onto the Industry 5.0's level, authors are proposing following research questions:

RQ1: *Who are the most productive authors in the field of Lean philosophy and Industry 5.0?*
RQ2: *Which are the most cited articles in the field of Lean philosophy and Industry 5.0?*
RQ3: *Which are the most relevant sources in the field of Lean philosophy and Industry 5.0?*
RQ4: *Which are the main keywords in the field of Lean philosophy and Industry 5.0?*

The rest of the paper is structured as follows: section 2 describes the methodology of the conducted research, section 3 shows main results and discussion, and section 4 concludes the research, discusses the limitations of the paper, as well as suggestions for future research.

METHODOLOGY

Data sample for this research was conducted through the Scopus database. Terms "Lean" OR "Continuous improvement" OR "Total Quality Management" OR "TQM" AND "Industry 5.0" OR "Fifth industrial revolution" were included in the search query. Additionally, only articles and conference papers which have these terms in their title, abstract or keywords, and which were written in English language were used in the research, narrowing the data sample to 34 search results. The gathered data was analyzed using the R studio bibliometric tool. The analysis includes author production, article citation, relevant sources, and main keywords.

RESULTS AND DISCUSSION

The most productive authors

In this research, authors' production was determined by the number of published articles in the relevant field. Table 1 shows the most productive authors, and the number of articles they have written in the field of Lean philosophy and Industry 5.0.

Table 1: The most productive authors in the field of Lean philosophy and Industry 5.0

Number	Author	Number of published articles
1	Alves A. C.	3
2	Margherita E. G.	3
3	Braccini A. M.	2
4	Pizoń J.	2
5	Alarcón F.	1
6	Arezes P.	1
7	Balog M.	1
8	Barret J.	1
9	Bastos T.	1
10	Bauernhansl T.	1

As shown in Table 1, Alves and Margherita are the first and second most productive authors with 3 published articles each. They are followed by Braccini and Pizoń, who took the third and the fourth place, with 2 published articles each. The rest of the authors have 1 published article each, and they are Alarcón, Arezes, Balog, Barret, Bastos, and Bauernhansl.

The most cited articles

Table 2 gives insights about the most cited articles in the field of Lean philosophy and Industry 5.0, their first author, and the number of total citations.

Table 2 shows the most cited articles. In the first place is the article titled "Global Value Chains and Industry 4.0 in the Context of Lean Workplaces for Enhancing Company Performance and Its Comprehension via the Digital Readiness and Expertise of Workforce in the V4 Nations" written by Kliestik et al, which has 28 citations. Next is the article "The Human-Centric SMED" which was cited 22 times, and written by Fonda et al. Third place is taken by an article which was cited 16 times, and which is titled "ManuChain II: Blockchained Smart Contract System as the Digital Twin of Decentralized Autonomous Manufacturing Toward Resilience in Industry 5.0". This article is written by Leng et al. Following, article "Beyond playful learning – Serious games for the human-centric

digital transformation of production and a design process model" written by Brauner et al has 14 citations. In the fifth place is an article written by Cantini, and cited 11 times. This article is titled "Towards Forklift Safety in a Warehouse: An Approach Based on the Automatic Analysis of Resource Flows". Sixth place is taken by "Cobots Implementation in the Era of Industry 5.0 Using Modern Business and Management Solutions" which is written by Pizoń et al, and which was cited 9 times. With 2 citations less, in the seventh place is the article titled "Human–Robot Collaboration and Lean Waste Elimination: Conceptual Analogies and Practical Synergies in Industrialized Construction", written by Marinelli. In the eight place is an article which has 7 citations, written by Mladineo, titled "Human-centric approach of the Lean management as an enabler of Industry 5.0 in SMEs". Ninth place is taken by article written by Alves and titled "Lean Thinking: An Essential Mindset". This article has 5 citations. Finally, tenth place is taken by article titled "Lean Thinking: An Essential Mindset", which has 3 citations and is written by Margherita et al.

Table 2: The most cited articles in the field of Lean philosophy and Industry 5.0

Number	First author	Article title	Number of citations
1	Kliestik T.	Global Value Chains and Industry 4.0 in the Context of Lean Workplaces for Enhancing Company Performance and Its Comprehension via the Digital Readiness and Expertise of Workforce in the V4 Nations	28
2	Fonda E.	The Human-Centric SMED	22
3	Leng J.	ManuChain II: Blockchained Smart Contract System as the Digital Twin of Decentralized Autonomous Manufacturing Toward Resilience in Industry 5.0	16
4	Brauner P.	Beyond playful learning – Serious games for the human-centric digital transformation of production and a design process model	14
5	Cantini A.	Towards Forklift Safety in a Warehouse: An Approach Based on the Automatic Analysis of Resource Flows	11
6	Pizoń J.	Cobots Implementation in the Era of Industry 5.0 Using Modern Business and Management Solutions	9
7	Marinelli M.	Human–Robot Collaboration and Lean Waste Elimination: Conceptual Analogies and Practical Synergies in Industrialized Construction	7
8	Mladineo M.	Human-centric approach of the Lean management as an enabler of Industry 5.0 in SMEs	7
9	Alves A. C.	Lean Thinking: An Essential Mindset	5
10	Margherita E. G.	The impact of Industry 4.0 technologies and the soft side of TQM on organizational performance: a multiple case study analysis on manufacturing organisations	3

The most relevant sources

Key indicator which was used to define 10 most relevant sources is the number of articles published in the field of Lean philosophy and Industry 5.0. Table 3 shows the most relevant sources.

According to Table 3, the most relevant source in the field of Lean philosophy and Industry 5.0 is Lecture notes in Mechanical Engineering with 4 published articles. Second place is taken by Sustainability (Switzerland) which has 3 published articles. With 1 published article less, Advances in Science and Technology Research Journal, Applied Sciences (Switzerland), and IFIP Advances in Information and Communication Technology come in the third, fourth, and fifth place. The rest of the places are taken by Advanced Engineering Informatics, Arabian Journal for Science and Engineering, ASME International Mechanical Engineering Congress and Exposition, proceedings (IMECE), Buildings, and CEUR workshop proceedings. These sources have 1 published article each.

Table 3: The most relevant sources in the field of Lean philosophy and Industry 5.0

Number	Journal	Number of published articles
1	Lecture notes in Mechanical Engineering	4
2	Sustainability (Switzerland)	3
3	Advances in Science and Technology Research Journal	2
4	Applied Sciences (Switzerland)	2
5	IFIP Advances in Information and Communication Technology	2
6	Advanced Engineering Informatics	1
7	Arabian Journal for Science and Engineering	1
8	ASME International Mechanical Engineering Congress and Exposition, proceedings (IMECE)	1
9	Buildings	1
10	CEUR workshop proceedings	1

The main keywords

Total of 50 different keywords were conducted during this research. The authors have chosen to present only 10 most used keywords in the field of Lean philosophy and Industry 5.0 by showing the percentage of occurrence in articles used in the research. Results are presented in Table 4.

Table 4: The main keywords in the field of Lean philosophy and Industry 5.0

Number	Author	Occurrence (%)
1	Industry 4.0	38
2	Industry 5.0	38
3	Lean production	26
4	Human-centric	15
5	Knowledge management	12
6	Workers	12
7	Industrial revolutions	9
8	Lean	9
9	Lean thinking	9
10	Manufacturing	9

As shown in Table 4, two most used keywords are “Industry 4.0”, and “Industry 5.0” with 38% each, meaning they have appeared as keywords in 38% of the selected articles. “Lean production” is a term which has occurred in 26% of the articles, and it has taken the third place. Following, “Human-centric” is in the fourth place with 15% of occurrence. “Knowledge management” and “Workers” are in the fifth and sixth place with 12% each. “Industrial revolutions”, “Lean”, “Lean thinking”, and “Manufacturing” have taken the rest of the places, and have the occurrence of 9% each.

CONCLUSION

In order to keep their place in the market or to improve their competitiveness, companies have to follow globally emerging trends, such as Industry 5.0 (Akundi et al., 2022). Although both Lean philosophy and Industry 5.0 emphasize the importance of people, it is crucial to incorporate sustainability and resilience as a part of Lean processes (Ivanov, 2023). With an aim to investigate which articles give valuable information about combining Lean philosophy and Industry 5.0, this paper gives insights in the most productive authors, the most cited articles, the most relevant sources, and the main keywords. Dataset used in this research was gathered through the Scopus database, and 34 articles were analyzed.

The most productive authors are Alves and Margherita with 3 articles published in this field each. However, the most cited article, which has 28 citations in total, is written by Kliestik et al and titled

"Global Value Chains and Industry 4.0 in the Context of Lean Workplaces for Enhancing Company Performance and Its Comprehension via the Digital Readiness and Expertise of Workforce in the V4 Nations". The most relevant source is Lecture notes in Mechanical Engineering with 4 articles published in the field of Lean philosophy and Industry 5.0. Finally, the main keywords are "Industry 4.0", and "Industry 5.0" which have been used in 38% of analyzed articles.

The main limitation of this paper is that it uses data gathered only from the Scopus database. Accordingly, future research should include data from other databases, such as Web of Science. Also, future research could show in-depth analysis of e.g. most relevant affiliations, networks of authors which collaborate when writing articles, as well as authors' co-citation.

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COMPARING THE DURATION OF DIFFERENT TYPES OF EXCAVATOR DOWNTIME

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ABSTRACT

In the mining industry, excavator uptime is crucial for maintaining productivity and meeting project deadlines. Downtime, or periods when excavators are not operational, can significantly impact project costs and efficiency. This paper examines various types of excavator downtime, including mechanical, electrical, technological, organisational, and meteorological, to identify patterns and potential mitigating strategies. By comparing the duration and implications of different downtime categories, this study seeks to highlight effective strategies for minimising non-operational periods, thereby enhancing the overall productivity and safety of excavator operations in the industry. The descriptive statistics indicated that the data exhibited non-parametric characteristics. The non-parametric Mann-Whitney U-test was used to compare the data. The results of the research showed that, in most cases, there is a difference in the duration of downtimes between different categories of downtimes. This analysis aims to contribute to the optimisation of excavator use, offering valuable insights for industry stakeholders.

Keywords: Mann-Whitney U-test, Excavator downtime, Mining industry.

INTRODUCTION

The operational efficiency of excavators in the mining industry is pivotal, directly impacting project timelines and financial outcomes (Kassem et al., 2021). One of the critical factors influencing this efficiency is excavator downtime, a period during which the excavator is non-operational due to various reasons. Understanding and comparing the duration of different types of excavator downtime is essential for developing strategies to minimise these interruptions, thus enhancing overall productivity (Spasojević Brkić et al., 2023).

Excavator downtime can be categorized into several types, including mechanical, electrical, technological, organizational, and meteorological, each with unique causes and impacts on operations. Recent studies, such as those by Lee et al. (2019) and Pałęga and Rydz (2018), have delved into aspects influencing excavator efficiency, from ergonomic cabin designs to innovative unmanned excavation systems, shedding light on potential areas to mitigate downtime.

This paper aims to compare different types of excavator downtime, drawing on existing literature to offer a nuanced understanding of each category's characteristics and implications. By synthesising these insights, we aim to contribute to the ongoing discourse on improving excavator efficiency, ultimately benefiting industries reliant on these crucial machines. The paper is divided into several sections, starting with a review of the existing literature. It then goes on to discuss the methodology and present the research findings. Finally, the overall findings are summarised in the conclusion.

LITERATURE REVIEW

There are a few papers that provide a comprehensive analysis of factors affecting safety in the mining industry. The study by Knights and Scanlan (2019) investigates the link between coal prices and fatalities in Queensland's coal mines, revealing that economic downturns may compromise safety, leading to an increased risk of multiple-fatality incidents when coal prices drop below a certain point. In another study, Mirzaei Aliabadi et al., (2020) utilised a Bayesian network approach to pinpoint critical human and organisational factors, like skill-based errors and environmental conditions, that contribute to mining accidents, emphasizing the need for holistic safety management. Employs lost workdays as a novel metric to assess safety performance, providing a nuanced understanding of the injury impact across different mining sectors and highlighting the importance of this metric in enhancing safety programming (Coleman and Kerkering, 2007).

The studies by Spasojević Brkić et al., (2022) and Edwards et al., (2002) focus on the impacts of excavator downtime in the mining industry, emphasising risk management and cost prediction. Spasojević Brkić et al., (2022) identify mechanical issues as primary downtime contributors, advocating for proactive maintenance strategies. Edwards et al., (2002) introduce a model to estimate downtime costs, enhancing operational and financial decision-making. Both papers highlight the importance of integrating downtime analysis into mining equipment management to improve efficiency and reduce costs. These papers collectively underscore the necessity of an integrated approach to safety in mining, considering economic pressures, human behaviour, and organisational dynamics to improve miners' safety and operational safety standards.

Komljenovic et al., (2017) advocate for integrating organisational factors into mine safety management, drawing from nuclear industry practices to elevate safety performance in mining. Stemn et al., (2019) focus on assessing and advancing the maturity of safety culture within mining organisations, emphasising structured evaluation and improvement. Verster et al., (2023) explore the use of simulation techniques using synthetic and real-world data to improve traffic management and vehicle safety in mining operations. Together, these studies highlight the necessity of a comprehensive approach to mining safety that includes organisational culture and advanced operational strategies.

Pontt et al., (2006) examine electrical system failures in mining, advocating for improved engineering practices to boost safety and reliability. Ma (2020) explores constraints in coal mining safety management, suggesting methods to identify and address these to enhance safety efficiency. Li et al., (2020) analyse trends in coal mine safety, emphasising the need for continuous improvement in safety standards. Mondal et al., (2023) introduce a mathematical model for mining safety analysis, highlighting its potential in risk assessment. Verma et al., (2023) investigate safety in the steel industry using ARIMA models to predict incidents and improve safety protocols. These studies collectively highlight the importance of innovative strategies and continuous advancements in safety management within high-risk industries.

Pałęga and Rydz, (2018) highlight the importance of ergonomics in excavator cabin design, linking operator comfort and safety to reduced downtime. They suggest that well-designed cabins can improve operational efficiency by minimising fatigue and health-related absences (Pałęga and Rydz, 2018). Lee et al., (2019) present an unmanned excavator system employing 3D scanning and remote controls, reducing operator-related downtime by safely operating in hazardous areas, potentially minimising health and safety-related downtime.

METHODOLOGY

This study examines the duration of various types of downtime, including technological, electrical, mechanical, third-party, organisational, and meteorological factors. In addition, these periods of inactivity can be further classified into two categories: planned and unplanned. Table 1 provides the labels utilised for different types of downtime.

Table 1: List of utilised labels

Label	Meaning
TEH UP	Unplanned technological
The P	Planned technological
El UP	Unplanned electrical
Mech UP	Unplanned mechanical
TP UP	Unplanned third-party
Org UP	Unplanned organisational
Org P	Planned organisational
Met UP	Unplanned meteorological

Table 2: Descriptive Statistics

	TEH UP	Teh P	El UP	Mech UP	TP UP	Org UP	Org P	Met UP
Valid N	2919	39	121	1044	35	31	589	70
Mean	6,948270	5,923077	6,851240	6,939655	7,171429	6,967742	6,212224	7,428571
Median	7,000000	6,000000	7,000000	7,000000	7,000000	7,000000	6,000000	8,000000
Minimum	5,000000	0,000000	0,000000	0,000000	6,000000	6,000000	6,000000	6,000000
Maximum	9,000000	8,000000	9,000000	9,000000	8,000000	9,000000	8,000000	8,000000
Range	4,000000	8,000000	9,000000	9,000000	2,000000	3,000000	2,000000	2,000000
Std.Dev.	0,470220	2,168975	1,130348	1,001053	0,746983	0,546740	0,612334	0,693059
Coef.Var.	6,76743	36,61906	16,49844	14,42512	10,41609	7,84673	9,85691	9,32965
d	0,3894	0,32011	0,21624	0,21973	0,21933	0,35573	0,52689	0,24685
p	<0,01	<0,01	<0,01	<0,01	<0,1	<0,01	<0,01	<0,01
	n.p	n.p	n.p	n.p	n.p	n.p	n.p	n.p

Table 3: Maan-Whitney U-test

Variable			Maan - Whitney U	p - value
TEH UP	**vs**	**Teh P**	**34107,50**	**<0,01**
TEH UP	**vs**	**El UP**	**199194,00**	**<0,01**
TEH UP	**vs**	**Mech UP**	**1575393,50**	**0,05**
TEH UP	**vs**	**TP UP**	**60690,50**	**0,00**
TEH UP	vs	Org UP	45996,50	0,81
TEH UP	**vs**	**Org P**	**1449468,50**	**0,00**
TEH UP	**vs**	**Met UP**	**59351,00**	**0,00**
Teh P	**vs**	**El UP**	**1752,00**	**0,01**
Teh P	**vs**	**Mech UP**	**14377,00**	**0,01**
Teh P	**vs**	**TP UP**	**374,50**	**<0,01**
Teh P	**vs**	**Org UP**	**364,00**	**0,02**
Teh P	vs	Org P	13107,50	0,11
Teh P	**vs**	**Met UP**	**581,00**	**<0,01**
El UP	vs	Mech UP	66201,00	0,36
El UP	**vs**	**TP UP**	**2577,00**	**0,04**
El UP	vs	Org UP	2107,50	0,25
El UP	**vs**	**Org P**	**19824,00**	**0,00**
El UP	**vs**	**Met UP**	**5796,00**	**<0,001**
Mech UP	vs	TP UP	21009,00	0,11
Mech UP	vs	Org UP	16728,50	0,74
Mech UP	**vs**	**Org P**	**165428,00**	**0,00**
Mech UP	**vs**	**Met UP**	**47649,00**	**<0,001**
TP UP	vs	Org UP	645,00	0,13
TP UP	**vs**	**Org P**	**16995,50**	**0,00**
TP UP	vs	Met UP	991,00	0,08
Org UP	**vs**	**Org P**	**2899,00**	**0,00**
Org UP	**vs**	**Met UP**	**637,00**	**<0,001**
Org P	**vs**	**Met UP**	**5271,00**	**0,00**

RESULTS

The observed data is presented in Table 2, containing descriptive statistics. According to the analysis conducted using Kolmogorov test of normality, it was determined that the data is non-parametric, meaning it does not follow a normal distribution.

Since the data fails to demonstrate parametric behaviour, the Mann-Whitney U-test was used to compare the downtime groups. The test results are shown in Table 3. Results indicating a significant disparity in the duration of various downtime periods are highlighted.

CONCLUSION

The outcomes of the study revealed significant differences in the duration of downtime across different observed categories. There is no statistically significant difference between technological unplanned downtime and organisational unplanned downtime alone. Technological planned downtimes do not differ only from organisational planned downtimes, while there is no statistically significant difference for electrical unplanned downtimes, mechanical unplanned downtimes, or meteorological unplanned downtimes. In the case of mechanical unplanned downtime, a third-party-caused unplanned downtime does not significantly differ from mechanical unplanned downtime. There is also no statistically significant difference when comparing the group of unplanned downtimes caused by a third party with the downtimes caused by organisational unplanned downtimes, that is, with meteorological unplanned downtimes. In all other downtimes, it was found that there was a statistically significant difference. It would be beneficial to conduct additional research by increasing the database of downtime and developing a model that can predict the duration of downtime using artificial neural networks, based on the specific type of downtime.

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PERSONALIZED TRAINING FOR SUCCESSFUL IMPLEMENTATION OF ADVANCED TECHNOLOGIES IN THE IT INDUSTRY

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ABSTRACT

In today's dynamic business environment, the changes are going on as fast as can not be imagined. Consequently, adopting new technologies poses one of the major challenges for organizations. Yet, embracing new and advanced concepts brings numerous benefits alongside barriers and difficulties due to the high robustness of the existing technology and proficiency of the current workforce. In that direction, the need for well-structured training program development, customized for the specific field evolves as one of the key organizational goals. Technically, the process of employee empowerment is laid on three pillars, (i) top management commitment, (ii) employees' preparedness to accept the novel approaches, and (iii) the design of training content including personalized programs tailored to diverse employees' backgrounds. This paper aims to create a conceptual model for the effective empowerment of employees to increase their ability to adopt and utilize advanced technological know-how apart which leads to improvement of overall organization performance and higher competitiveness in the market. The relations between the variables in the model are validated by the survey conducted in IT organizations. The findings show that training program customization can increase employees' commitment to adopting and utilizing new technologies and best practices.

Keywords: Advanced technologies, Employees, Personalized training programs, Organizational performances.

INTRODUCTION

Numerous researchers confirm that training and development programs are crucial because the workforce gains the opportunity to acquire specific knowledge and enhance their abilities as a main prerequisite for further improvement of the overall organizational performance. In other words, training is the methodical development of the expertise, talents, and competencies that employees must have to perform proficiently in a current activity or job. The training requirements analysis should constantly supply information connected to every aspect of the current business (Chetana and Noronha, 2023).

Additionally, the increasingly rapid growth of advanced and innovative technologies implicates the need for appropriate adoption of business-changing practices (Maity, 2019). In that sense, the training programs' content and quality, strongly influence the effective implementation of new technologies and efficient utilization and task performance, especially in the IT industry organizations. The training and development initiatives strongly prioritize employees' overall personality development (Siddiqui and Sahar, 2019). From that point of view, the individual training programs should be designed for each employee according to their level of knowledge and experience. Besides that, appropriately structured training programs help employees to integrate the acquired skills into the workplace. Therefore, personalized training that can fill the gap of required knowledge and lack of experience, becomes standard practice (Kraft and Blazar, 2018). Moreover, the training and development efficiency is determined by the employees' preparedness to be couched and the suitability of the program's content (Jeni and Al-Amin, 2021).

In the overall context, the organizations cope with two perspectives, substantial initial investments in novel technology and workforce training are essential components of achieving higher

competitiveness on the market. These are necessary investments to create a strong foundation for the organizations in facing an increasingly changing future (Lindström et al., 2023).

However, the discussion regarding the initiatives for the implementation of new methodologies and coaching programs always starts with the top management and their commitment. It is more than clear, that the top management is responsible for coping with both perspectives. With mature preparedness of employees and strong commitment of top management, organizations can successfully adopt new technologies and achieve sustainable competitive advantages in the evolving business environment (Rêgo et al., 2022). Therefore, the influence of top management to develop personalized training programs customized to fill the gap in each employee's knowledge and to fit to the employee's background diversity is crucial for the effective adoption of new technologies. In conclusion, top management and their support towards designing personalized training programs, and also the employee's readiness to be coached and sufficiently knowledgeable, can boost the empowerment of the workforce. In that sense, the goal of this research is:

G: To evaluate the relationships in the created conceptual model regarding the importance of personalized training programs tailored to employees' knowledge, skills and the background, for the successful adoption, and utilization of advanced technologies, in current operations.

The purpose of this paper is to examine how the three aforementioned pillars correlate with employee empowerment to the successful implementation of new technologies in existing operations. This study focuses on IT sector. In the next section, the designed conceptual model is given, followed by findings gathered from the conducted survey, and a discussion of the findings. Finally, conclusions are drawn in the last section of the paper.

LITERATURE REVIEW

It is more than obvious that businesses that incorporate advanced technology into their business models are more competitive in the market (Perifanis and Kitsios, 2023; Gope et al., 2018; Lindström et al., 2023). Many researchers stated that implementing cutting-edge technologies enhance the overall organization's performances (Agustian et al., 2023; Diamantidis and Chatzoglou, 2019; Siddiqui and Zamir, 2018; Kumari and Vangapandu, 2021; Parry and Battista, 2019; Sinha and Sengupta, 2020). Hence, companies are expected to be more flexible in facing market changes, especially in IT companies as a fast-growing industry (Wantini et al., 2022; Ibrahim and Ali, 2023; Jodi and Hapzi, 2023). In that sense, it is worth emphasizing top management's role and responsibility to provide adequate training to their employees, in the same spirit. Moreover, the top management must actively communicate the company philosophy to the employees and fully involve them in the implementation activities (Stahl et al., 2020; Florkowski, 2018; Stanojeska, 2022). Thus, the inclusion of employees should be permanently encouraged and strengthened towards the entire adoption of advanced technologies and wealth maximization (Chowdhury et al. 2022; Batool et al., 2021; Wright and Geroy, 2001: Chetana and Noronha, 2023; Kum et al., 2014).). Additionally, the research of Pane and his collaborators (2015) confirms that the adoption of personalized learning approaches has increased significantly in recent years. From that point of view, it is expected that this new paradigm, which employs advanced technologies will dramatically improve organizational performance and competitiveness (Howaldt et al., 2017; Stentoft and Rajkumar, 2020; Ahmad et al. 2020; Demeter et al., 2020; Ghobakhloo et al., 2021; Dalenogare et al., 2018).

RESULTS AND DISCUSSION

The conducted research included (1) collecting data from a survey to quantify the reliability between the variables in the conceptual model, (2) developing the conceptual model, and (3) discussing the gathered results.

Data collection from the survey

The questionnaire was designed to gather data from the Macedonian IT organizations on the six studied variables. For the evaluation, a five-point scale was used (1- poor significance, 2- below average significance, 3- average significance, 4- high significance, 5- excellent significance). The study was conducted in the period of 1st March, to 30th April, 2024.

A total of 80 IT organizations participated in the survey. The participation of surveyed organizations according to criterion of number of employees was 47% of small organizations (number of employees less than 50), 27% of medium-sized organizations (number of employees 50-251) and 26% of large organizations (number of employees up to 251).

The collected data and the reliability of the questionnaire items were analyzed using a software for statistical analysis (JASP 0.18.3.0 version). This included calculating Cronbach's Alpha to measure internal consistency, item-rest correlations to see how each item relates to the rest, and the mean and standard deviation to understand the average score and variability.

Design of the Conceptual Model

The basic conceptual model is presented on Figure 1. The model is created with the following variables: top management commitment in motivating employees and supporting training programs; employee's preparedness to be empowered for successful adoption of advanced technologies; designing personalized training programs structure; using flexible training program content tailored to the employees experience background; empowerment of employees based on individually designed programs' structure; and improvement of the overall organization performance and the competitiveness on the market.

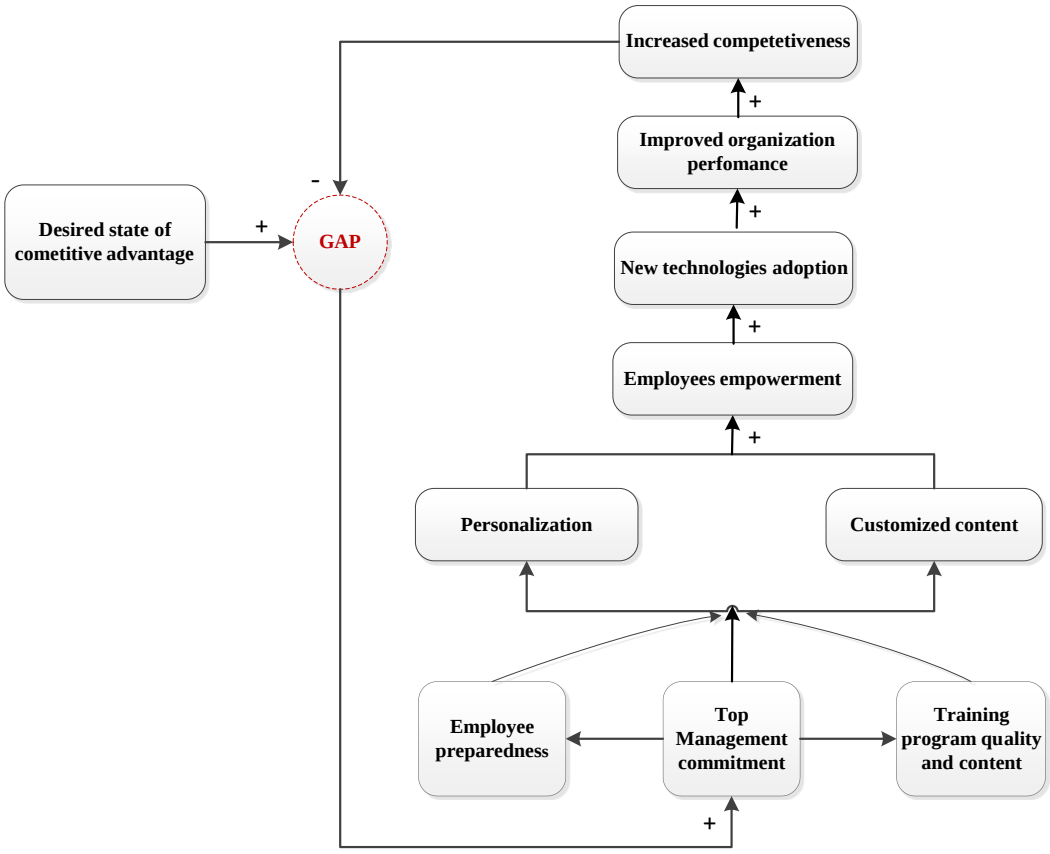

Figure 1: Conceptual model for employees empowerment based on personalized training programs

The model is built on the three previously discussed pillars. Essentially, top management with their strong commitment to improving the competitiveness of the organizations on the market encourages the readiness of employees to be trained accordingly. Increased employee motivation correlates with a greater willingness to participate in training programs. Establishing an effective system for employee motivation is crucial. Top management is also responsible for organizing coaching tailored to the organization's needs. Training quality and content must address employees' knowledge gaps and be customized to the organization's specific issues and challenges. Given the diversity of individual competencies, training programs should be designed to address skill deficiencies on a personal level. By enhancing individual knowledge, organizational learning improves overall. In addition, training programs must be flexible and aligned with the employees' background experience. Consequently, personalized and customized training fosters the empowerment of employees. On the other hand, empowered employees are more efficient in adopting new technologies, which significantly benefits organizational success and overall performance., enhances the organization's competitiveness. In further, the organization becomes more capable of being more competitive. Those needs were confirmed by the participants in the conducted survey (the findings are presented in the following section of the paper). The model includes one more variable named the desired state of competitiveness. Technically, top management strives to reach the goals continuously. Besides that, the current level of the achieved position on the market can be improved. The difference between the current and desired competitive levels represents a major trigger that positively influences the increase of the top management commitment and effort to improve the other two pillars, presented at the base of the created conceptual model.

Discussion of the results

By the analysis of the collected questionnaire data a strong relationship between the all the treated variables used for the creation of the conceptual model can be confirmed. Specifically, 75% of respondents, believed that the training of employees is an excellent significant for successful adoption of new technologies and efficiently utilization in further, while 22% consider it very significant. The vital role of top management in supporting the employees' empowerment and providing the quality and relevance of the training programs content, is high rated, 70% of respondents rate it as excellent, 19% as very high, and 10% as of average significance. The next variable used for model creation, quality of the training programs and the properly structured content was highest rated by the 64% participants in the conducted survey. Furthermore, the option for personal approach based on the individual level of knowledge, skills and competences during coaching of employees are recognized by 84% of respondents. Of these, 52% rate its significance as excellent and 24% as very high. Beside this, the 63% of respondents evaluated the flexibility of the training content customized regarding the background experience of employees with excellent significance, and 24% of them with very high significance. Only 11% of total respondents assess the flexibility of training program as average significant. At last, the influence of the employees empowerment through flexible and personalized training on the improvement of the overall performance and competitiveness, by 66% of respondents is rated with excellent significance and 26% of respondents evaluate it as high significance.

The reliability statistics values of conducted survey, measured using Cronbach's alpha to assess the internal consistency of a selected set of variables is present in the Table 1.

Table 1: Frequentist Individual Item Reliability Statistics

Item	Cronbach's α	Item-rest correlation	Mean	SD
Top management commitment	0.650	0.464	4.56	0.74
Employees preparedness for coaching	0.643	0.471	4.747	0.496
The training programs quality and content	0.515	0.74	4.493	0.76
Personalization in coaching employees	0.648	0.452	4.56	0.663
Flexible training program content	0.691	0.333	4.04	0.257
Organizations performance and competitiveness	0.711	0.208	4.027	0.162

The calculated Cronbach's alpha value, generally above 0.70 suggests that the items have relatively high internal consistency and thus, the measurement is reliable (Table 2).

Table 2: Frequentist Scale Reliability Statistics

Estimate	Cronbach's α	mean	sd
Point estimate	0.695	17.386	12.709
95% CI lower bound	0.619	15.053	11.247
95% CI upper bound	0.76	19.719	14.613

CONCLUSION

The created conceptual model and the validated correlations in the survey confirm the paper's objectives. With a Cronbach's alpha of 0.695, the reliability of the data is considered acceptable. In addition, the descriptive statistics provide basic information about each item. The survey findings highlight the importance of personalization and customization in the training and development process. Specifically, personalization and customization are drivers in the efficient empowerment of employees for the successful adoption and utilization of advanced technologies. Thus it is necessary to retool the training programs and tailor them according to the employees' needs and knowledge gaps, particularly in the fast-evolving IT sector. Tailored individual coaching programs will facilitate the effective integration of acquired knowledge into the workplace. In addition, the vital role of the top management and their commitment to motivating employees to be coached and support adequate training programs represent the three initial pillars of further increasing the IT organizations' performance and competitiveness globally.

In the following step, the role of AI technology in designing personalized training programs will be researched...

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INCREASING THE EFFICIENCY OF GAS DELIVERY TO THE MAIN GAS PIPELINE BY INSTALLING A THREE-STAGE RECIPROCATING COMPRESSOR

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ABSTRACT

In the course of the research, experimental studies will be conducted on a specific compressor station as well as on specific compressor units, with the aim of increasing the efficiency and safety of gas delivery to the main gas pipeline. The aim of the research is to increase the efficiency and safety of gas delivery to the main gas pipeline, determining the operating parameters before and after the system modification, as well as justifying the newly designed system. The expected results are for the newly designed system to be stable, meaning that the new output operating parameters are constant and within permissible limits. By modifying the current gas delivery system, i.e., by reducing the number of compressor units within the compressor station, efficiency is increased as well as safer gas delivery to the main gas pipeline.

Keywords: Pipeline, Compressor station, Efficiency improvement

INTRODUCTION

In order to transport gas to the refinery, it is necessary to increase its pressure, which is achieved through compressor stations. To prevent production delays and potential losses due to compressor downtime, it is essential for compressor stations to operate flawlessly (Stroud, 1995; Cao, et al., 2022). Compressor stations are responsible for compressing gas and are located within gathering and dispatching stations. Modern compressor stations consist of container-type compressors, which require less space than earlier compressor models. Gas pipeline transportation requires constant gas pressure at the inlet, or at the beginning of the pipeline, hence autonomous operation of compressors is necessary (Liu, et al., 2021; Cheng, 2019).

Newer generation compressors are designed to require minimal operator intervention, consisting mainly of setting operational parameters, checking essential fluid levels, and conducting visual and acoustic inspections.

If a compressor unit experiences downtime, it can result in reduced gas delivery to the refinery, while any untransported gas must either be flared or redirected to another compressor station. To prevent such occurrences, proper handling of compressors is crucial, and these situations can be mitigated by utilizing information on potential defects from established fault trees, thus enabling proactive maintenance of potential weak points in the system.

Container-type compressors are designed to operate in harsh conditions and can compress gases of varying compositions. They have no expiration date if properly maintained (Stroud,1995; Liu, et al., 2021; GE High Speed Recip (HSR) compressor, 2020).

MATERIAL AND METHOD

Technological description of the compressor station

After the separation of oil and gas, it is necessary to increase the pressure of the gas for shipment to the main gas pipeline as well as for the requirements of the gas-lift system. This compressor station increases the pressure of the separated gas from low and medium pressure to high pressure (the pressure required for operation for shipment to the main gas pipeline or the gas-lift system). Natural gas at low pressure delivered from the gathering gas station, as well as dissolved gas separated from oil at medium and low pressure, is directed to the compressor station where its pressure is increased by compression to the operating pressure of the system (42-48 bar), and then it goes for separation in the horizontal collecting separator installed at the gathering and dispatching station.

During the operation of the compressor station, gas balancing is carried out based on gas quantity measurements and flow parameters at the following points: low-pressure suction 2 - 3 bar, medium-pressure suction 7-8 bar, discharge gas from the compressor station at a pressure of 42 - 48 barg, discharge gas for the needs of the "gas-lift" system.In order to increase the efficiency and safety of gas shipment to the main gas pipeline, a new three-stage compressor unit RAM 54 of container type has been installed at the compressor station, and thus a part of the station has been reconstructed (Technical documentation, Nis Gazprom Neft, 2020, GE High Speed Recip (HSR) compressor, 2020). This three-stage compressor unit is tasked with raising the gas pressure from 2-2.5 bar to a pressure of 42-48 bar.

During the connection of this three-stage reciprocating compressor, it was necessary to connect the compressor unit to the pipeline of the technological system, connection to the low-pressure gas collector - suction connection of the compressor, connection to the high-pressure gas collector - discharge connection of the compressor, as well as other connections.

Pulsation testing at the newly installed compressor station

The project included acoustic and mechanical analysis of the discharge pipeline of the newly installed compressor from the compressor flange to the connection to the existing discharge line. Existing pipelines were also included in accordance with this analysis.

The acoustic analysis was conducted according to the requirements of the API 618 standard. According to the API 618 standard, the analysis of the mentioned compressor includes: checking pressure amplitudes, checking dynamic force amplitudes, and checking the mechanical natural frequencies of the pipeline. Since the subject pipeline is of small diameter and at a low elevation, and the risk of earthquakes at the subject location is not significant, occasional loads (wind) were not considered in the calculation. Considering the rigorous requirements for pipeline support due to the acoustic analysis, it can be expected that stresses due to occasional loads will also be low and within allowable values (Liu, et al., 2023; Technical documentation, Nis Gazprom Neft, 2020).

According to the project requirements, the gas pressure is 42 ÷ 48 bar, and the molar mass of the gas is 20,40 g/mol. Because the compressor manufacturer specifies that the gas is cooled to 50°C within the compressor unit, with the consent of the investor, this temperature was adopted as the reference value (GE High Speed Recip (HSR) compressor, 2020).

The computational model with characteristic nodes and boundary conditions is depicted in Figure 1.

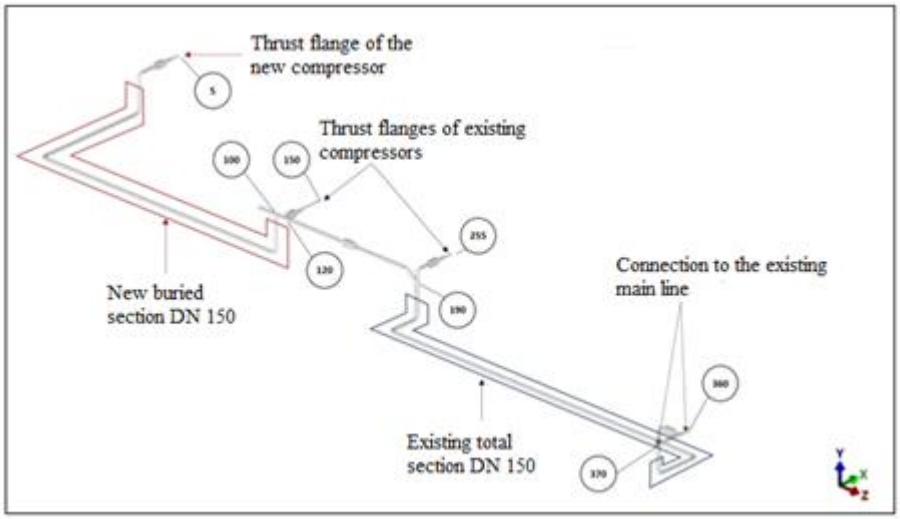


Figure. 1: The computational model of the pipeline

RESULTS AND DISCUSSION

Acoustic frequencies of the pipeline

The first step in the analysis is to check the natural frequencies of the pipeline. During the calculation, assumed gas characteristics at a pressure of 48 bar are used. A shock wave is applied to the system to obtain the values of the acoustic natural frequencies. The assumed profile (Figure 2) implies that the specified pressure at the boundary of the model (node 5) suddenly jumps (as seen in the figure, the time is very short, only 0,001 s), leading to the excitation of acoustic natural frequencies in the pipline. (Technical documentation, Nis Gazprom Neft, 2020; Jankov, 2020).

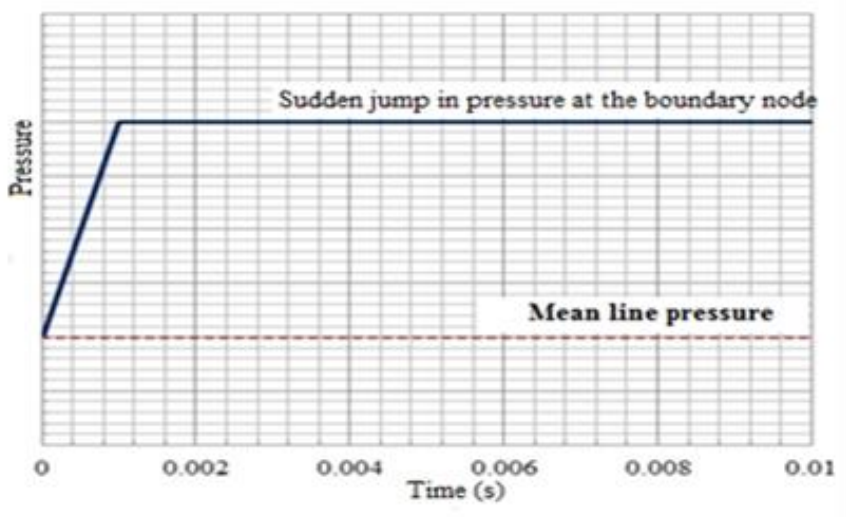


Figure 2: Dependence of pressure on time line

By conducting a preliminary analysis, it was determined that it is necessary to install damping baffles to eliminate certain acoustic frequencies of the system. When creating the acoustic model, the pipeline route with damping baffles defined in the subsequent text was considered. These baffles are installed to eliminate certain acoustic modes and are necessary for the smooth operation of the system (Trifunovic, 2022).

Based on the acoustic analysis conducted, it has been determined that it is necessary to install damping baffles with a 40 mm opening and a thickness of 3 mm on the flanges of all compressors, as well as

damping baffles with a 50 mm opening and a thickness of 3 mm behind each blade valve, as shown in the illustration (Figure 3.).

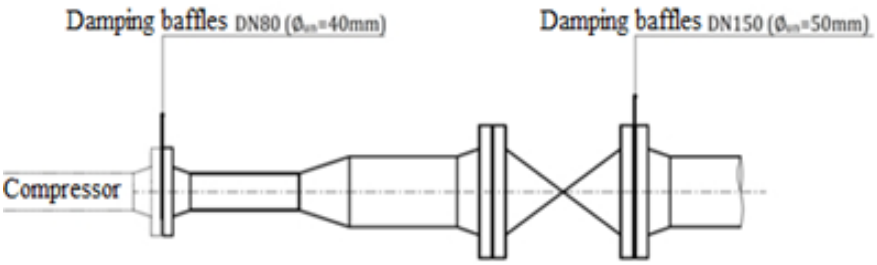


Figure 3: Detail of baffle installation

Further analysis was conducted based on the model that includes the above-defined baffles in front of and behind each ball valve (Trifunovic, 2022; Jankov, 2020).

The pressure drop across the baffle (Δp, Pa) is determined by the formula:

$$\Delta p = \left[\left(1-\frac{A_o}{A_1}\right)+0.707*\left(1-\frac{A_o}{A_1}\right)^{0.375}\right]^2 * \left(\frac{A_1}{A_o}\right)^2 * \frac{\rho * w_1^2}{2} \quad (1)$$

A_o - area of the free opening of the baffle,
A_1 - area of the internal cross-section of the pipe,
ρ - ensity of the fluid,
w_1 - velocity of the fluid flow reduced to the internal cross-section of the pipe.

The allowed pressure drop on the equipment expressed as a percentage of the average absolute pressure in the line (Δpmax, %) depends on the compression ratio of each stage of the compressor. Analysis of 26 operating scenarios processed in the compressor operation report revealed that the average compression ratio of the final stage of the compressor is R=2,35, corresponding to the following values of the allowed pressure drop for the middle pressure in the 42 barg line: Δpx=0,412 bar, and for the middle pressure in the 48 barg line: Δpmax=0,470 bar. By performing these analyses, it was concluded that the pressure drop value at the DN 80 baffle and the middle pressure in the 42 barg line is higher than prescribed but acceptable, considering that the installation of baffles avoids complex modifications to the discharge (Trifunovic, 2022).

According to API 618 standard, pressure amplitudes must fall within the limits prescribed by the following equation:

$$P_1 = \sqrt{\frac{a}{350}} * \frac{400}{\sqrt{P_L * D_i * f}} \quad (2)$$

P_1– maximum pressure amplitude [%],
α – speed of sound in gas [m/s],
P – average absolute pressure[bar],
D_i– internal diameter of pipeline [mm],
f – analyzed frequency[Hz].

The analysis for this specific compressor station was conducted for two gas pressure values (42 bar and 48 bar), as defined by the project task specifically tailored for this compressor unit. The input pressure amplitudes at the model boundary for the first ten compressor harmonics were adopted based

on the image (Figure 4) from the manufacturer's compressor acoustic analysis report (Jankov, 2020; Trifunovic; 2022; GE High Speed Recip (HSR) compressor, 2020).

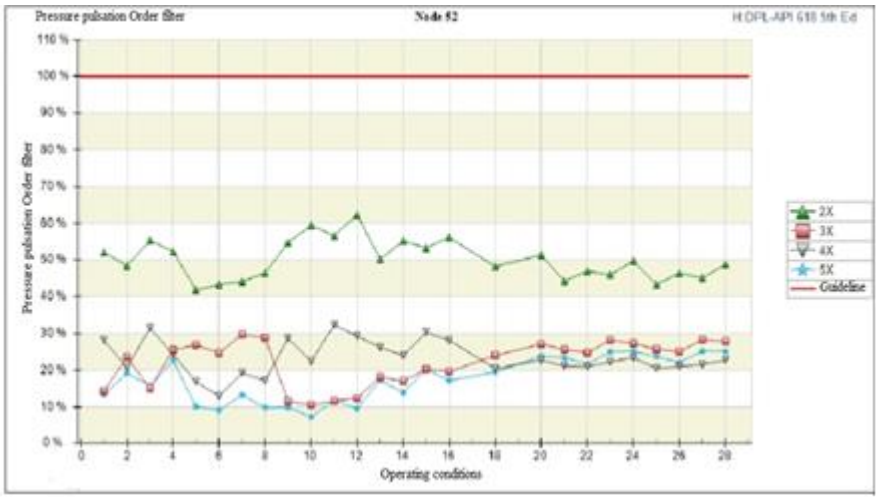


Figure 4: Profile of pressure amplitudes in the frequency domain at the compressor boundary

For frequency values (harmonics) not shown in Figure 4, values equal to 30% of the maximum allowed amplitudes have been adopted. Considering that the amplitudes values after the first 5 harmonics are lower than 20%, a clear downward trend in maximum amplitude with increasing harmonics is noticeable. All adopted values of frequencies and amplitudes are presented in Figure 5.

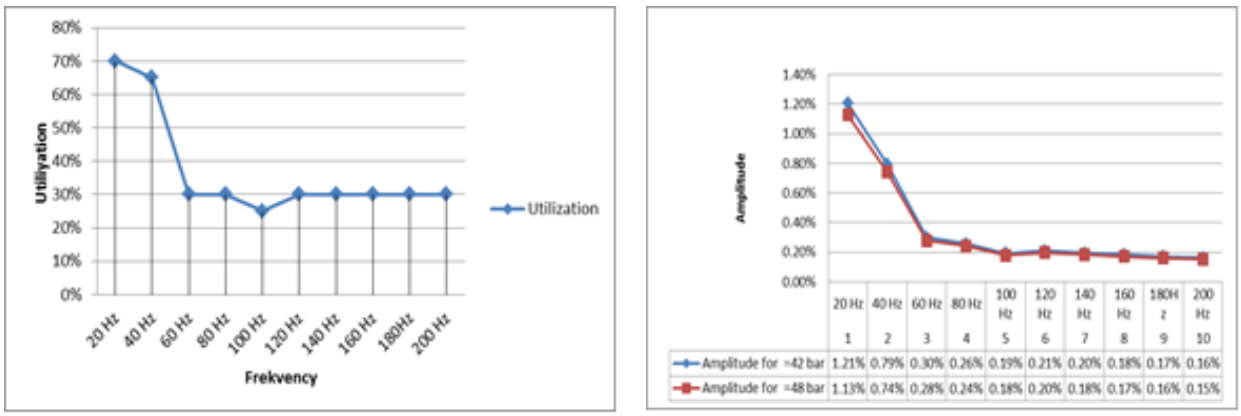


Figure 5: Pairs of frequency, amplitude used in the analysis

The actual values of maximum pressure amplitudes in the pipeline obtained from the acoustic analysis of the pipeline and the permissible values for each analyzed frequency are provided in Figure 6. As can be seen, the actual pressure amplitudes are lower than the permissible values, i.e., within the limits prescribed by the standard.

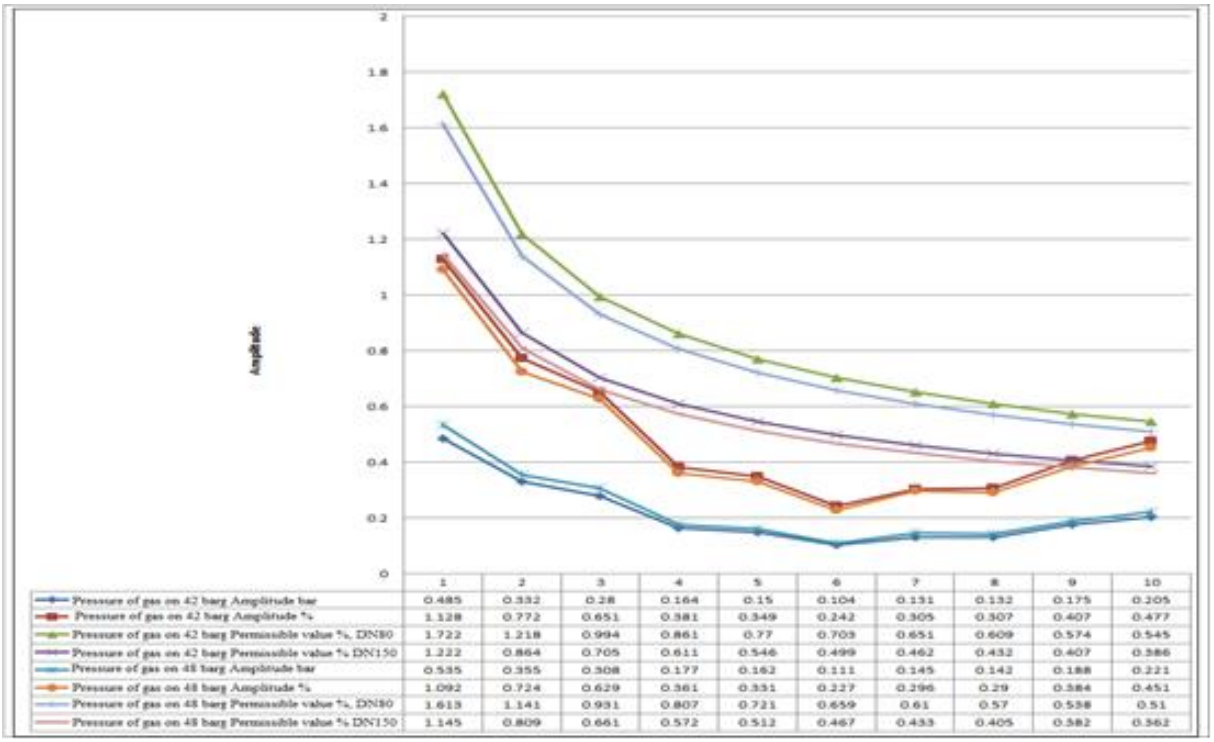
CONCLUSION

This study illustrates the increase in efficiency of the compressor station through: reducing the consumption of process gas and increasing the gas delivery capacity to the main gas pipeline.

By installing the new compressor unit RAM 54, three other compressor units have been decommissioned, reducing the total number of compressor units by two. The installation of the new compressor unit has eliminated the need for gas compression from low pressure to medium pressure and from medium pressure to high pressure, as the compressor station RAM 54 compresses the gas

directly from low to high pressure. Despite the reduced number of compressor units, an increase in the gas delivery capacity to the main gas pipeline has been achieved.

Reduced consumption of process gas has been achieved by reducing the number of compressors, simplifying the system. As a result of reducing the number of compressor units, the number of potential failures and maintenance requirements has decreased.



	1	2	3	4	5	6	7	8	9	10
Pressure of gas on 42 barg Amplitude bar	0.485	0.332	0.28	0.164	0.15	0.104	0.131	0.132	0.175	0.205
Pressure of gas on 42 barg Amplitude %	1.128	0.772	0.651	0.381	0.349	0.242	0.305	0.307	0.407	0.477
Pressure of gas on 42 barg Permissible value %, DN80	1.722	1.218	0.994	0.861	0.77	0.703	0.651	0.609	0.574	0.545
Pressure of gas on 42 barg Permissible value % DN150	1.222	0.864	0.705	0.611	0.546	0.499	0.462	0.432	0.407	0.386
Pressure of gas on 48 barg Amplitude bar	0.535	0.355	0.308	0.177	0.162	0.111	0.145	0.142	0.188	0.221
Pressure of gas on 48 barg Amplitude %	1.092	0.724	0.629	0.361	0.331	0.227	0.296	0.29	0.384	0.451
Pressure of gas on 48 barg Permissible value %, DN80	1.613	1.141	0.931	0.807	0.721	0.659	0.61	0.57	0.538	0.51
Pressure of gas on 48 barg Permissible value % DN150	1.145	0.809	0.661	0.572	0.512	0.467	0.433	0.405	0.382	0.362

Figure 6. Representation of actual and permissible pressure amplitudes for pipes DN150 and DN80 (gas pressure 42 and 48 bar)

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Session B: HUMAN RESOURCE MANAGEMENT

Papers (pp. 99-156):

ONBOARDING PROCESS EXCEPTIONS IN SMALL IT COMPANIES

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ABSTRACT

This paper deals with the analysis of onboarding processes in small IT companies, with special reference to the adaptation of these processes for different roles and projects within a dynamic technological environment. Using qualitative methodology and thematic analysis of interviews with managers, the paper identifies key exceptions and adaptations in standard onboarding procedures that contribute to the effective integration of new employees. The results of the analysis in two companies show the importance of customized approaches that include technical, cultural and psychological aspects, necessary for successful adaptation and integration in small IT firms. The analysis also highlights how flexibility and personalization of the onboarding process can improve employee engagement, productivity and satisfaction, while simultaneously supporting corporate goals of innovation and competitiveness.

Keywords: Onboarding, Small IT companies, Onboarding exceptions, Adaptive approaches.

INTRODUCTION

In the modern business environment, the onboarding process is a key element for the successful integration of new employees into the organizational structure. Onboarding is not only an opportunity for new employees to familiarize themselves with the technical and operational aspects of their job, but also with the corporate culture and expectations that the company places before them (Becker, 2021). Organizations use onboarding to help socialize new employees, and the onboarding process often includes specific adjustment practices (Klein, 2015). This process is particularly important in the IT sector, where the speed of adaptation to changing technological requirements and projects can significantly affect the company's productivity and innovation. In small IT companies, where teams often work on dynamic projects and where each team member has multiple roles, the onboarding process can be particularly challenging (Sharma, 2020).

This paper focuses on exceptions in the onboarding process in small IT companies through the prism of qualitative analysis and thematic analysis of interviews with managers (Braun & Clarke, 2022). Exceptions to the onboarding process may include adjusting the process depending on the specifics of the job, the level of experience of the new employees, as well as their ability to adapt to the organizational culture. These exceptions are important because they allow a better understanding of how standard onboarding processes can be modified or adapted to maximize efficiency and minimize the risks of failed integration.

The aim of this paper is to identify, analyze and explain the various exceptions that occur in the onboarding processes in small IT companies, with an emphasis on the specific challenges and

strategies that these companies use for effective onboarding of their employees. Through in-depth interviews with managers and analysis of the data obtained, the research aims to provide insight into the adaptive aspects of onboarding that can help small IT firms improve their practices and strategies for integrating new team members.

THEORETICAL BACKGROUND

The onboarding process is a set of activities aimed at facilitating the integration of new employees into the organization and equipping them for efficient work. Onboarding can be described as an important factor for reducing employee turnover and increasing their engagement and job satisfaction (Kumar, 2017). The onboarding process is part of human resource management, important for the transition of employees and represents the moral and ethical duty of managers. In addition to the transition of new employees, onboarding participates in building trust, commitment, reduces the stress of new employees and increases their productivity (Caldwell, 2016). In the context of the IT industry, where technological advances and changes require rapid adaptation, effective onboarding becomes even more important. Small IT companies in particular rely on the adaptability and flexibility of their onboarding processes to stay competitive and innovative in the market (Brodsjo, 2023). The onboarding process has been widely researched in various sectors, including the IT industry, with particular attention paid to the impact of effective onboarding on employee retention, productivity and overall job satisfaction. A structured and comprehensive onboarding program can reduce the risk of early employee turnover and increase employee engagement (Klein and Heuser, 2008; Cable, 2013). In the context of the IT sector, technical orientation is only one part of a complex process that should include the socialization of employees within the organization (Pratiwi, 2018).

Today's employees expect onboarding experiences that allow for a much greater degree of flexibility, customization and personalization. Similarly, many new hires expect recruitment, onboarding, learning and development to be interconnected to create new learning and career opportunities. However, these expectations require changes in how onboarding is implemented, evaluated and linked to other HR practices, especially with the successful and dramatic increase in remote work arrangements in response to the global impact of the 2020 pandemic (Jeske, 2021). Tailoring the onboarding process to the individual can significantly contribute to the success of the overall integration process. Adaptive approaches allow managers to address the individual needs and abilities of employees, which is particularly relevant in the IT sector where different jobs require different skills and knowledge. Small IT companies often have to be flexible in their working methods due to limited resources and the high degree of innovation expected of their employees.

Small IT sectors face unique challenges that require tailored onboarding approaches and small IT companies must be particularly agile and adaptable in their approach to onboarding due to frequent changes in technologies and project requirements. Small companies often use innovative onboarding methods to accelerate the adaptation of new employees while maintaining a corporate culture that promotes creativity and innovation (Davidson, 2018). When it comes to the role of adaptability and personalization in the onboarding process, adaptive approaches to onboarding are increasingly present in the literature as a key success factor in rapidly changing industry sectors like IT. Personalization of the onboarding process can increase the effectiveness of employee integration by tailoring education and support to individual needs and experiences (Kassymtayeva, 2020). Therefore, adapting the onboarding process is important in order to improve the speed and depth of integration of new team members.

When it comes to the cultural aspects of onboarding, cultural adaptation is a key component of onboarding, especially in globally oriented IT companies. Successful integration into the corporate culture can improve long-term effectiveness and reduce feelings of isolation among new hires. Understanding and embracing corporate values can significantly improve overall employee satisfaction and commitment to the company (Godinho, 2023). Cultural adaptation is an important aspect of onboarding that can have a long-term impact on employee success in an organization.

Understanding and integration into the organizational culture are key to full employee engagement (Frogeli, 2023). Small IT companies, which often have unique corporate cultures, can especially profit from carefully designed onboarding programs that promote values and norms of behavior within the company. Specific exceptions that arise in small IT company onboarding processes can include different customization tactics for individual roles, experience levels, and project requirements. These exceptions are essential to understanding how standardized processes can be modified to achieve optimal results. For example, research shows that tailoring onboarding to the requirements of specific projects can significantly affect the speed and efficiency of new employee integration.

METHODOLOGY

This paper is part of a qualitative research that deals with the onboarding process conducted in small companies in Serbia. This section of the paper contains the presentation of data collection, thematic analysis and the identified theme arising from it, as well as the identified codes generated during the processing of the obtained data.

Data collection

Data from the qualitative research from which this paper emerged were obtained by conducting interviews with employees of small IT companies on the domestic market. The identified topic for this paper was created by coding two transcribed interviews, i.e. interviews with two employees in managerial positions in two IT companies. The first respondent has over 20 years of experience in the IT industry, while the second respondent has over 10 years of experience. The interviews were conducted live and contained open-ended questions (Given, 2008). The interview consists of 25 questions divided into 6 sections:

- The basics of onboarding,
- Onboarding process,
- Alignment of onboarding with organizational issues,
- The impact of onboarding on business,
- Onboarding problems,
- Knowledge management in onboarding.

Thematic data analysis

Thematic analysis represents a framework with identified topics about the observed problem, or phenomenon. By applying thematic analysis in qualitative research, themes were identified that together represent one research concept. The application of thematic analysis in qualitative research enables the identification, analysis and reporting of themes within the data, while at the same time organizing and describing the resulting data set (Braun & Clarke, 2022).

All qualitative data were prepared in MS Word format and then coded using QDA Miner software for qualitative data analysis. The codes were formed based on the responses of the respondents. Codes generated using the software were analyzed and reviewed and then grouped to provide themes for further analysis. One of the identified topics relates precisely to the exceptions in the onboarding process, which this paper deals with. The list of codes created by the authors, which led to the identified theme named „Onboarding process exceptions in small IT companies“, is shown in Table 1.

FINDINGS

Theme description

The identified theme named „Onboarding process exceptions in small IT Companies“ revolves around the specific nature of the onboarding process in small IT companies, highlighting the importance of

tailoring onboarding experiences to accommodate various exceptions. These exceptions are pivotal because they underscore the diversity of roles within IT companies and the necessity of adapting the onboarding process to meet the specific needs of different positions. This theme is important for describing inquired practices as it reveals the complexity of integrating new employees into an organization, not just in terms of their technical skills but also their fit within the organizational culture and their role-specific knowledge. It reflects on the dynamic nature of IT roles and the criticality of a flexible onboarding strategy that can address the unique aspects of each position, from administrative roles to project-specific developer roles, and even considers the individual's level of experience and adaptability to the organizational culture. The theme of this research revolves around the adaptive onboarding processes within IT companies, focusing on how these processes are tailored based on job descriptions, employee experience, project requirements, and cultural fit. This theme highlights the critical importance of customization in the onboarding process to address the diverse needs and roles within IT companies. It reflects the understanding that the integration of new hires into the company is not a one-size-fits-all procedure but requires a nuanced approach that considers the individual's role, the specific project they will be working on, their level of experience, and how well they adapt to the company's culture. This theme is crucial for capturing the essence of modern onboarding practices in IT companies, where flexibility, adaptability, and personalized approaches are key to successful integration and knowledge management.

Table 1: List of identified codes

Code	Code name
C1	Exceptions depend on the employee's position
C2	Differences in process based on employee position and experience
C3	The employee shows productivity, but does not adapt to the organizational culture
C4	The required characteristics of the employee are predetermined
C5	Exceptions in onboarding for beginners and experienced workers
C6	Onboarding includes managing different positions
C7	Getting to know the projects
C8	Depending on the role within a project
C9	Resourcefulness
C10	Psychological profile for the workplace
C11	Checking the level of acquisition of soft skills
C12	Being not adaptable
C13	Making harm to the team and the company
C14	Determining people profile for work positions
C15	Having different learning approaches depending on candidate experience

Parts from the interviews related to exceptions to the onboarding process and extracted codes

Participants' responses highlight that the onboarding process is not universally applicable across all roles within an IT company. Administrative roles require knowledge different from developers, and even within the developer roles, the onboarding process varies significantly based on the project and the individual's role within that project. Participant 2 highlighted the dilemma of integrating individuals who are technically proficient but struggle with adaptability to the organizational culture, emphasizing the importance of a fit beyond technical skills. The authors of this paper emphasize that onboarding must be adaptable to the specifics of the job description and the individual's position, suggesting a flexible framework that accommodates role-specific knowledge and skills. We also touch on the importance of psychological adaptability and the necessity for a cultural fit within the organization, indicating that technical skills alone are not sufficient for successful integration. The interviews collectively suggest that while the core of the onboarding process might be standardized, significant variations are necessary to address the diversity of roles, experience levels, and individual characteristics within small IT companies. Selected interview excerpts illustrating these codes are:

> Participant 1: „*The characteristics of the person for each workplace are determined, and based on that, the psychological profile for the workplace is defined...*"

Participant 2: „*Exceptions exist depending on the job description that person is supposed to perform...*“

Participant 2: „*In general, exceptions do not exist, and there may be differences according to projects...*“

DISCUSSION

This theme and its underlying codes suggest that a one-size-fits-all approach to onboarding may not be effective in the diverse and dynamic environment of IT companies. The exceptions to the onboarding process, as identified through the interviews, highlight the need for a more customized approach that considers the specific role, project requirements, individual experience levels, and the psychological fit of the new hire with the organizational culture. This nuanced understanding of onboarding can help IT companies enhance their integration strategies, ensuring that new employees are not only technically prepared but also well-aligned with the company's values and work dynamics, ultimately contributing to a more cohesive and efficient organizational environment. The emergent theme from the conducted interviews underscores the complexity and variability of the onboarding process within IT companies. It demonstrates a clear need for a personalized approach that considers not only the technical requirements of the job but also the adaptability of the individual to the organizational culture and their role-specific knowledge and skills. This theme suggests that effective onboarding in IT companies goes beyond mere technical orientation to include a comprehensive integration strategy that promotes both individual and organizational growth. The identified codes and themes underline the importance of flexibility, adaptability, and a detailed understanding of both the role requirements and the individual's capabilities and fit within the company culture. This nuanced approach to onboarding is essential for maximizing productivity, enhancing knowledge management, and ensuring a harmonious and efficient workplace environment.

Trustworthiness of this paper refers to the credibility and reliability of the research findings. Trustworthiness is highlighted in qualitative research in which the method of data collection and interpretation is taken into account, so that the research has appropriate credibility (Given, 2008). Considering the small number of respondents in this paper, different strategies were applied to present the experience and perspective of the company's employees. Through semi-structured interviews, respondents were enabled to freely express their opinion based on experience, through open communication during interviews. All authors of this paper participated in data analysis and development of conclusions, which increased the reliability of the findings. During data collection and analysis, we followed a systematic approach, following guidelines for conducting thematic analysis (Braun & Clarke, 2022). Researchers individually identified themes through data analysis, and coding discrepancies were resolved by discussion between the authors.

CONCLUSION

This paper explored the specifics and challenges of the onboarding process in small IT companies, emphasizing the importance of adapting the onboarding process to adequately address the needs and expectations of new employees in a dynamic technological environment. Through qualitative analysis and thematic processing of interviews with managers, key exceptions were identified that influenced the adaptation of standard procedures, including variations based on the specifics of work, the experience level of employees and the needs of projects. The paper shows that small IT companies require flexible approaches to onboarding processes that are not only technically oriented, but also promote cultural integration and psychological adaptation. Adaptive approaches, which are personalized to fit individual characteristics and roles within projects, are key to the rapid and efficient integration of employees, which directly contributes to their productivity and job satisfaction. Adjusting the onboarding process in small IT companies is a key element that can significantly affect the efficiency and success of organizational processes. The paper suggests that managers and HR

professionals should continuously evaluate and adapt their onboarding strategies to ensure they remain relevant and effective in light of the constant changes in the technology sector. This adaptability will not only help integrate employees, but will also serve as a foundation for developing resilience and innovation within the organization. Future research should investigate the impact of various personalization techniques of the onboarding process on the long-term retention of employees in small IT companies. Additionally, it is important to conduct comparative studies that would assess the effectiveness of onboarding practices between small and large IT companies to identify specific needs and challenges. Finally, further research is recommended on the impact of organizational culture on the effectiveness of the onboarding process, especially in the context of globally distributed IT companies.

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USING DISCORD AS AN ONLINE CLASSROOM

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ABSTRACT

The main goal of this work is to introduce the reader with the application called Discord, and the idea of using it as an online classroom. The paper specifies the meaning of servers in the application, and explains Discord's most representative features and how they contribute to a better communication. It also lists challenges students could run into while using it, and brings up their potential solutions. As the end of the paper approaches, an example of a Discord server adjusted to work as an online classroom is given, with its elements, as well as parts of user interface, thoroughly explained.

Keywords: Discord, Learning management system, Online classroom, Knowledge management.

INTRODUCTION

Even though the lockdown is no longer present and students are attending classes in person, learning management systems are still very popular way of sharing data online in the field of student education (Bradley, 2021). Professors and students got used to this way of contact, and the whole purpose of these tools is to provide a simple and accessible communication. Main premise of this work is presending Discord with its features, and how this application, even though developed for gaming circles, can be used as an alternative to popular tools for having classes online.

APPLICATION OVERVIEW

Discord is a free communication application founded in 2015 by Stanislav Vishnevskiy and Jason Citron, which can be used in a form of desktop or mobile aplication, or as a web application through a browser. It was primarily supposed to be a voice chat application which would run in the background and allow people to vocally communicate during gaming sessions, but as the years went by it became much more than that (Lunden, 2020).

Since its release, it had a steady growth of users, but the period around the COVID-19 lockdown was where the application gained in popularity. People started using Discord for many things, from private chats and watch parties, all the way to creating large communities based on certain topics, or even running servers for specific regions in the USA. Nowadays, it is used for a broad spectrum of things, which include content creator communities, businesses and marketing, education and gaming of course, and just about anything (Rodriguez, 2021).

DISCORD SERVERS AND THEIR STRUCTURE

What differentiates Discord from other popular social media platforms is its potential to provide a stable environment for real-time communication among larger group of users, both vocal and textual. It does it through forementioned concept of servers and its channels, which are crucial for understanding how to properly use Discord.

Discord server is a virtual hub, a space where people can gather and communicate. It holds a collection of text and voice channels.

Text channels works as any other group chat, and are used for sending messages, images and files to other participants. By default, messages are not deleted, and therefore a new member can view messages sent prior to them joining the server.

Voice channel, as the name suggests, are used for vocal communication, with the possibility of becoming a video chat. Voice channels even have their own text sub-channels, which are preferably used for sending images and files related to the current topic in the voice call, or for sending messages by a user who, for any reason (personal or technical), is not able to speak. In voice calls, users are able to use a feature to share their screen, whether it was showing only view of a single application or an entire screen. Option to share only a view of a certain application comes in handy when users with a single screen have to often switch applications during the time of screen-sharing, and want the viewers to have access to only that one application.

Discord does support direct messaging as well, where two or more users can talk to each other without that chat being a part of any particular Discord server, just like most of chat applications.

Setting up a server

When it comes to creating a Discord server, it is a feature available to each user, and can be done in couple of seconds. After that, it is all up to the creator of the server – channels, permissions, and basically any type of organization. It may be overwhelming for new users, but the potential of customization is rather large, which can lead to arranging high quality servers.

After creating a server, first step is to create channels. By default, it already holds a general text and voice channels, placed in their corresponding folders. When creating a new channel, it needs to be selected which type, text or voice, the channel is going to be, it needs to be named, and whether or not it will be a private channel. In case of it being a private channel, it is asked which roles or individuals are going to have access to it. It is a rather simple process, and its custommization is completely split from the process of creation.

In the goal of setting up Discord server as an online classroom, it can be used in many ways, some of which could be:

- using a separate server for every subject,
- having a server for a group of subjects that all belong to a specific professor or assistant,
- or even having a huge server for an entire department of its university, and restricting access to the subjects depending on which year of the coarse the student is attending.

Important features

Custommization of the server is what makes it stand out of the crowd and help its members more efficiently navigate through it.

Roles and permissions

Roles are a feature in Discord that act as a set of rules assigned to a user marked by the role. This rules can vary from general rules about what a user can do on the server, such as if they have permission to make a custom emoji or sticker, if they are allowed to participate in the administration of the server, all the way to channel specific permissions. Channel specific permissions allow the administrator to decide which roles can have access to certain channels, whether they can send the messages or only view them, attach files and embed links, and many more. These options help in server organization a lot when it comes to using Discord as a classroom, as it can be set that only professor and assistant can act as moderators when it comes to deleting unnecessary messages and restricting the content to be in appropriate form for their students.

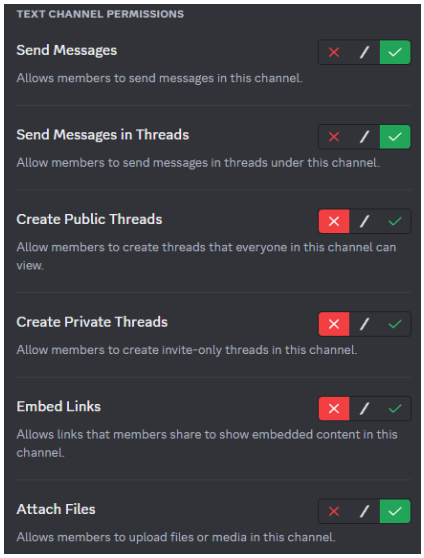

Figure 1: Part of permissions for a specific role

Channel categories

Categories work as containers for holding channels inside of a server. Not only do they help in organizing the structure of the server, but they also have the ability to apply permissions to all the channels they are holding. They can be used as containers for multiple subjects, or to split parts of a single subject into specific groups.

Markdown text

Markdown is a simple plain text formatting system that Discord uses in order to make text stand out (Official Discord documentation, 2024). It helps in making certain information more visible, especially when trying to find something specific quickly, making an important announcement, or just making sure something is emphasized. Some of the most used text formatting options can be seen in the Table 1:

Table 1: Commonly used text formatting in Discord [4]

Italics	*italics* or _italics_	Underline Italics	__*underline italics*__
Bold	**bold**	Underline Bold	__**underline bold**__
Bold Italics	***bold italics***	Underline Bold Italics	__***underline bold italic***__
Underline	__underline__	Strikethrough	~~strikethrough~~
Header, with adaptable size	# big, ## smaller, ### even smaller	Block Quotes	> block quote
		Code Blocks	`single-line` ``multi-line``

Threads

Threads are yet another form of organizing text, as they allow users to instantiate a conversation inside of a text channel, helping in reducing the clutter, and removing the potential of overlapping conversations. This feature can be really useful in cases where literature needs to be split inside of a channel to accomplish better visibility, or to split conversations with different students in case they asked a question which requires a complex answer.

POTENTIAL PROBLEMS AND THEIR SOLUTIONS

In a study from 2023 (Lauricella, et al., 2023), amongst numerous positive comments, a couple of negative ones emerged, which included:

- students being unfamiliar with the application and having difficulties navigating through channels,
- forgetting to check for notifications,
- unexplained, general dislike for the application,
- technical issues due to bad Internet connection.

The problem of unfamiliarity with the application could be solved by introducing students to a written guide, or by arranging an introductory class for them, where basics could be explained in an interactive way. After that, the students could also mutually help each other, which would lead to better development of the community, which Discord is all about.

When it comes to Discord being yet another application that students have to use, which leads to them forgetting to check for notifications, potential solution could be having Discord application running on their computers all the time in the background. Other option could be using Discord's mobile application, and receiving the push notifications on their phone. Discord also allows users to mute not only servers, but even the single channels inside of it, which leads to a very good control over notifications.

Third challenge could be tied with the previous two, where not understanding and not using the application properly leads to disliking it, but could just be the general dislike towards Discord as the students in the study gave no explanation to why that is the case.

As for the forth problem, the technical issues due to student's bad Internet connection can't be blamed on the application, as it is not known with certainty if Discord had to do anything with that.

SERVER EXAMPLE

The next figure (Figure 1) shows an example of a Discord server made to work as an online classroom. It is only an example whose purpose is to showcase a potential server structure.
Interface components marked with borders in the image represent:

- List of all the servers this user is a part of;
- Currently selected server;
- All the channels inside of the server, placed inside of their categories;
- Chat space, which shows a conversation in the selected text channel;
- A single thread, opened from the chat, with its content.

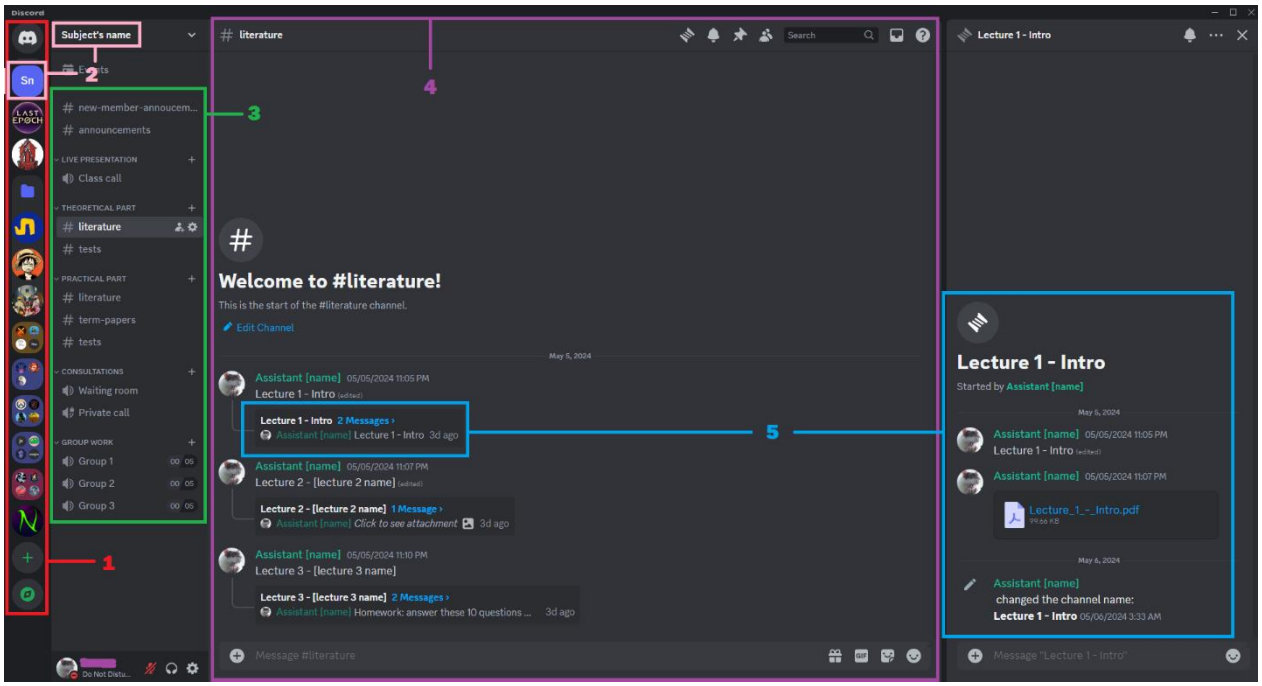

Figure 2: Example of a Discord server

As seen in the image, channels are split in a way to accommodate the structure of a subject, which is split into theoretical and practical parts. Voice channels, which are marked by the sound icon (not to be mixed with text channels which are marked by "#" symbol), are being split into couple of spaces, with the main "Class call" being near the top of the list, while consultations and channels for potential group calls can be found near the bottom as they are less important. The "Private call" for consultations has restricted access to it, and it is intended for the professor to "drag" the student into it when they are both ready.

As mentioned before, threads can be used to split the literature based on the lectures. It allows for better visual clarity when searching for a specific information.

As for permissions, students would be restricted from typing in the announcement and literature channels, as to avoid the unnecessary clutter. As expected, only the moderators would be able to manage the server and its messages, but their options of using emojis, gifs and stickers would be restricted based on decided level of formality.

CONCLUSION

Discord as an application provides a considerable amount of features that contribute to better organization of communication. Well structured server arrangement helps in making information more accessible to its students, and having channels for less formal texting can make contacting those in charge of a subject more approachable. Slightly less formal communication can help both sides, professors and students, as the students could answer each other's questions without burdening the professors as much as formal emails would.

With the appropriate utilization of Discord's features, it is possible to further broaden the spectrum of possible uses for its servers. Potential suggestion would be in the filed of Human Resource Management, as servers structured similarly to the ones described in this work, could be used for training employees in enterprises and organizations. With the right permissions and channels, it could be ensured that the content for employees is published gradually in a manner that most effectively helps them in overcoming potential challenges and tasks.

As for the final conclusion, it would be fair to say that Discord requires more time investment when it comes to customization than its alternative solutions in the field of knowledge management. Its out-of-the-box product is not as appropriate for having classes online, since that isn't primary goal of this software. But with proper customization and structure organization, it can be adjusted to secure high quality transfer of information in a way suited for universities and enterprises, which can potentially surpass features of many software solutions solely made to serve this purpose.

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KNOWLEDGE AND CREATIVITY OF EMPLOYEES AS FACTORS OF BUSINESS SUCCESS OF THE COMPANY

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ABSTRACT

The world we live in today is characterized by rapid changes, faster than ever before. The globalization of the market, the development of modern technologies and the development of society increasingly influence the fact that organizations must be ready to respond to these challenges. The only resource that cannot be replaced by any other appears as an adequate answer, namely employees. Employees with their knowledge and willingness to improve and share that knowledge are one of today's key resources. In addition to knowledge, employees must be creative and innovative in order to respond to the increasingly diverse demands of the market. In order for organizations to achieve business success, they must invest in their employees. For this reason, it can be said that the task of organizations is to encourage employees to learn, improve and share knowledge, but also to motivate them to use their creative potential. This paper will show the effects of employees' knowledge and learning, as well as their creativity and innovation on the business success of organizations, as well as ways to improve and encourage the improvement of employees' knowledge and creativity.

Keywords: Knowledge, Creativity, Innovation, Business success.

INTRODUCTION

In the 21st century, due to the globalization of the market, increasing competition, rapid development of technology, changes in the wishes and demands of consumers, organizations are forced to change their business strategies (Shank, et al., 2012). Today, it is not enough for an organization to produce and sell its product making a profit. It needs to achieve and maintain a competitive advantage in a highly volatile market. Material resources contribute to business success, but they are not the key to business success. The key resource that contributes to business success is employees with their knowledge, skills and abilities. In addition to the knowledge and practical skills that employees acquire through practice and experience, one of the key competencies required of employees today is creativity.

The knowledge possessed by employees in an organization determines its economic strength and the ability to develop other resources and increase the efficiency of their use (Krstić & Vukadinović, 2008). In the new era of development, modern society has no perspective of further progress without lifelong learning and knowledge sharing (Kovačević, 2019). The success of organizations today, and especially in the future, will depend on highly educated employees, who will be ready to constantly upgrade their knowledge and share it with other colleagues at work.

Global competition has imposed the need for products and services to be different, more unique. To meet these demands, employees must be creative. For this reason, employee creativity is considered a necessary feature in modern business. It is the creativity of employees that is the starting point in the workplace for creating innovations (Zhou & George, 2001). In order to survive and thrive, organizations need to use the creative potential of their employees to respond to change, create innovation, and ultimately achieve positive performance (McAdam & Keogh, 2004).

The success of the organization depends on the adequate use of knowledge and creativity possessed by its employees. For this reason, in order to survive in today's market, it is necessary to invest in the knowledge and creativity of employees in order to ensure the future of the organization.

KNOWLEDGE AS A FACTOR OF COMPETITIVENESS

In modern business, knowledge represents an important economic investment, that is, knowledge becomes capital, which is also called knowledge-based capital (Švonja, 2018). According to Nonaka (2007), knowledge is divided into explicit and implicit (tacit). Explicit knowledge is objective, open, tangible knowledge, which is expressed in formal and systematic language. It can be found in the form of written reports, books, manuals, various electronic forms. Implicit knowledge is subjective, hidden, intangible, difficult to formalize. Explicit knowledge, unlike implicit knowledge, is very easily shared. Knowledge sharing involves the exchange of knowledge, experience and skills of employees across certain departments or the entire organization (Elrehail et al., 2016). However, knowledge sharing among employees often encounters obstacles, i.e. employees do not share knowledge voluntarily or are completely resistant to it. The reasons for this are most often the lack of trust in the team, i.e. colleagues and in the leader (Edú-Valsania et al., 2016, Elrehail et al., 2018). For this reason, leaders have the task of building trust, to motivate employees, to increase their level of self-confidence and to build such an organizational culture in which their implicit knowledge will be openly shared (Alzghoul, et al., 2018).

Knowledge by itself is not enough in today's times, which are characterized by neglect and constant changes. It constantly needs to be upgraded and enlarged, so it can be said that modern society has no perspective of progress without applying the concept of lifelong learning. Lifelong learning is a concept that includes all general education, vocational education and training, non-formal and informal learning during life, which results in the improvement of knowledge, skills and competences within the personal, educational, social and/or employment perspective (ILO, 2019).

Organizations must "know what they know", that is, they must use the competencies of their employees in the right way. For this reason, it is very important to manage knowledge in the right way. Knowledge management implies the individual knowledge of employees into collective knowledge, which is available at the legal moment and in the right way to all members of the organization at all its levels (Ristić & Ristić, 2012). The knowledge management process consists of the following stages (Lacković, 2024):

- identifying and collecting knowledge - first of all, it is necessary to determine what knowledge the organization, i.e. its employees, possess, after that, the analysis and collection of the missing knowledge is carried out. There are various techniques for identifying and gathering knowledge, such as: knowledge mapping, interviews of different experts, document analysis, etc.;
- organizing and storing knowledge - storing and organizing collected knowledge. This allows employees to use it more efficiently;
- sharing and transferring knowledge - creating a culture in the organization where employees share everything they know and can do. Ways to do this include team meetings, training sessions and using platforms where people can collaborate;
- application of knowledge - knowledge that has been collected is used to solve problems, make decisions and create new ideas in the organization.

The knowledge of employees in organizations determines its economic strength and the ability to develop other resources and increase the efficiency of their use, thus positively affecting competitive advantage. Knowledge is the only resource that increases with its use. For this reason, it is necessary to motivate employees to constantly improve their knowledge and skills and strive to be the best in their work. The main role in all this is played by the leader, who himself learns, upgrades and shares his knowledge, but also rewards employees who do the same

CREATIVITY OF THE EMPLOYEES - "WEAPONS" OF THE ORGANIZATION'S SUCCESS

In today's dynamic work environment, creativity and innovation are key resources for gaining competitive advantage. To respond to fierce global competition, rapid technological development, uncertain and turbulent economic environment, organizations must promote creativity (Alzgohul, et al., 2018). Employee creativity refers to the generation of new and useful ideas related to products, services, and processes (Amabile, 1983). Creativity can be based on curiosity about novelty, flexibility of mind and adventurous spirit (Grant & Berry, 2011). According to Hargove and Nietfeld (2015), creativity is defined as the ability of an individual to produce original and useful work. When employees show creativity at work, they develop new responses, which are useful for solving certain tasks and problems in the organization (Amabile, 2013).

Employee creativity is the starting point for innovation in organizations (Zhou & George, 2001). The successful implementation of new products, services or procedures depends on whether a person or group has a good idea and develops it. Every innovation starts with creative ideas (Gonz´lez-Gonz´alez & García-Almeida, 2021). Innovative work behavior is the behavior of an individual that aims to achieve the initiation and introduction of new and useful ideas, processes, procedures or products (De Joung & Den Hartog, 2008). Innovative proposals are a measure of an employee's innovative behavior (Choi et al., 2016). Ideas or suggestions are the result of creative employees, and that creativity leads to employee-driven innovation (Lasardo, et al., 2016). For this reason, in order for the organization to have as many innovations as possible, it is necessary to stimulate creativity among employees.

People are born with the trait of creativity, but if it is stifled and repressed, that trait remains neglected. For this reason, it is necessary to develop creativity throughout life. Achieving creativity is the result of an individual's interaction with the environment, i.e. with the family, close people, the workplace, the environment in general. Individual interactions involve emotions, both positive and negative. Therefore, if emotions are not managed properly, it will affect employees' ability to develop creative ideas. By knowing their emotions, managing them and using them appropriately, employees can motivate themselves and others to build lasting relationships that will encourage the sharing and development of creative ideas (Atrhur, et al., 2022). Employees who are inclined to take risks, possess internal motivation, think proactively, develop problem-driven ideas, believe in personal responsibility for their choices, and are oriented towards the future and transformation are employees who possess radical creativity (Wang, Wang & Xu, 2022). An important role in creating and encouraging creativity is played by leaders who have self-confidence and who try to stimulate the code so that both the employees build it. These are leaders who show positive emotions, creating a positive, fair and transparent atmosphere that supports and stimulates creativity (Rego, et al., 2014). Subordinates will be more creative if they are motivated by work, that is, if their task is challenging, they feel a certain pressure to perform it and for the realization of which they will receive an adequate reward (Da Costa, et al. 2015). What negatively affects employees and hinders their creativity is the restriction of freedom and constant supervision by superiors.

Creativity is considered a powerful "weapon" for organizations (Zhou, Zhong & Zhang, 2024). Employee creativity can effectively promote organizational development as a key driver of innovation within the organization and achieve organizational growth and competitiveness (Wang et al., 2022).

For this reason, modern organizations invest all their resources in finding effective ways to encourage creativity among employees, and this is the main task of leaders in the 21st century (Liu et al., 2020).

IMPROVEMENT OF KNOWLEDGE AND STIMULATION OF CREATIVITY AMONG EMPLOYEES

Organizations that want to be one step ahead of their competition, in today's competitive market, must have employees in their ranks that are ready to constantly improve and educate themselves. In addition to formal education, which must be of high quality and at a high level, the task of organizations and their managers (leaders in particular) is to stimulate their employees to constantly improve themselves. For this reason, it is recommended to conduct training in organizations. There are different training methods, such as: presentations, lectures, group work, case study, role play, practical exercises, etc. After conducting the training, it is necessary to determine the results it brought and they include the following categories (MeritPlan, n.d.):

- reaction of the participants - through feedback, it is determined whether and to what extent the participants of the training are satisfied;
- learning - by conducting various tests, it is possible to determine how effective the training was;
- change in behavior - involves checking the results of training in practice;
- results - it is estimated what the final results are, if the goals that were set before the training are taken into account.

Organizations must motivate their employees for continuous learning, and this can be done primarily by managers by example. Also, the possibility of increasing earnings, secure job retention, different types of praise, the possibility of advancement, etc. (Saop, 2021)

Creativity helps employees come up with ideas for new products, services, and ways of working. Any problem or need that arises can be viewed from multiple angles and in this way come to new, better and unique solutions. For this reason, it is necessary to encourage creativity among employees, and some of the ways to do this are (Vuković, 2019, Mirić, n.d.):

- organize a work space - a relaxed work space, with comfortable furniture, the appropriate color of the walls, plants, has a positive effect on the creative potential of people;
- encourage diversity - when hiring new people and forming teams, it is necessary to take care that they are different, that they have different attitudes, ideas, thoughts, because then the best ones will emerge from a bunch of ideas;
- encourage risk acceptance - in order to create something new, organizations must be ready to take risks;
- reduce constraints – where there are strict and strict rules and too much bureaucracy, creativity is stifled;
- encourage ideas - people are afraid of presenting ideas, because they are afraid of judgment and mistakes. For this reason, it is desirable to capture every idea and every effort.

CONCLUSION

The world in which today's organizations operate is changing more, and the challenges they face are increasingly unpredictable. Due to constant changes, organizations need a workforce that possesses a wide range of knowledge, where people think creatively and are able to innovate. These must be people who are ready to constantly improve. In addition to formal education, which must be of high quality, they must constantly upgrade their competences. It is precisely the task of organizations to provide their employees with trainings, where they will invest in improving their knowledge and skills. Therefore, a well-rounded businessman must strive for the concept of lifelong learning. Knowledge as such is certainly not enough. In today's turbulent economy, organizations need the creativity of their employees if they want to survive and be successful. To achieve this, organizations must stimulate creativity in their employees. It is necessary to forget about strict rules and forms,

because they largely stifle creativity. Employees should feel free to express their ideas, to take risks, but also to take credit for successes and be adequately rewarded for them. If leaders, managers and their employees in organizations do not become aware of the necessity and need for knowledge and creativity, they will not be able to cope with changes in a turbulent environment and provide adequate responses, in order not only to survive, but also to achieve a competitive advantage in the market within who do business and function.

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THE ROLE OF LEADERS IN MOTIVATING EMPLOYEES IN ORDER TO ACHIEVE SUCCESSFUL BUSINESS RESULTS

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ABSTRACT

Leadership is a term that has been studied for years. The situation with which encounters today's market is such that it puts increasing emphasis on the individual who will be able to motivate all employees to act in the direction of progress organizations. Leaders are recognized as individuals, who possess special characteristics, which are innate and acquired, and which can be sources competitive advantages of the organization. Depending on the leadership style, their changes are also opportunities in the organization. If it manifests itself democratically in the organization leadership style, it will be supported by the opinions of all employees, who are bearers of numerous values, knowledge, abilities and who will be under the influence appropriate motivational system, want to leave their competencies organizational success. Then when the autocratic style of leadership is manifested, the leader is the one who makes all the decisions, who does not create a positive atmosphere in collective, because certainly productivity is not encouraged by treating the individual as a person in charge of work only. Situational leadership style adapts specifics of the situation and leads to variable results, accordingly the response of employees to the manner of behavior that the leader manifested. The leader has to take all important steps to motivate employees to achieve both personal and organizational goals through effective and efficient work lead to mutual satisfaction.

Keywords: Leadership, Leadership style, Motivation, Successful organizational results.

INTRODUCTION

Leadership is manifested through a person's ability to use the right methods, techniques and procedures to act on people, who in turn will mobilize their knowledge, skills and abilities in order to achieve the set goals. It is clear that leadership as a phenomenon cannot be viewed in isolation, but only as part of a systematic set of factors that influence it and predetermine it.

These factors primarily include motivation, leadership style, and risk appetite. It is very important to find an adequate system of motivation within the leadership process that will enable the leader to mobilize his employees so that they achieve the maximum within their business tasks. Thus, it is of key importance for the employee to identify with his organization, so that by realizing its goals, he also realizes the realization of his personal preferences. Employees are very productive when they are motivated, only success is finding a way to motivate the leader. Which system will be applied depends on several factors, which are discussed in more detail in this paper.

As leadership also implies motivation, it is clear that several different managers will apply different systems of motivation and will approach employees and groups within the organization from different aspects. The process of realization of the previously mentioned goals also depends on the style that the leader applies. Each leader, depending on his character traits, knowledge, skills, abilities, situation, employee characteristics and other factors that are precisely defined in the work, decides which style to apply within the leadership process. The overall approach to employees and other activities in the organization depends on that style (Lutfi, Rivai, A., & Widodo, D. S. 2018).

Each leader can manifest some kind of management of his followers. It is important that this style leads to organizational success. Leadership style must be such that it fully supports the requirements, needs, desires of individuals, because in this way it can lead to the commitment of the entire organization to achieve business results. The study of the interdependence between leadership, motivation and organizational results is becoming more common, because this connection is characterized as key to the prosperity of the business system.

THE ROLE OF LEADERS IN MOTIVATING EMPLOYEES

Burton (2012) by motivation implies the predisposition of the employee to behave in a purposeful way in order to achieve specific, unmet needs and encourage the will to achieve and the inner force that drives individuals to achieve organizational goals .
Latham points out that motivation should be defined as a psychosomatic process that directs a person to behave and react in a way that helps him meet certain unmet needs (Latham G, 2012).

All factors that may in some way affect the motivation of employees are classified into groups: • individual characteristics, job characteristics, characteristics of the organization, wider social environment (Almer, Djamhur, & Iqbal. 2017).

People usually act or work for one reason: to achieve a goal. Motivation is, therefore, a goal-oriented urge and as such rarely happens for no reason. Words such as need, desire, plan, goal, intention, impulse, purpose and instinct are similar to motive. When asked what the motive is, there are many answers. The motive is most often spoken of as the cause of behavior, then as a factor that encourages the actions of individuals and manages them, or as a decisive factor of activity. Some consider motives to be ideas or concepts that explain behavior (Brown, D. 2014).

One group of authors believes that eight basic motives can be identified in the basis of human behavior: Internal desirability of immediate results, Internal desirability of feasible results, Social comparison, Social pressures, Aspirations at the aspiration level, Observed probability of realization, Habits and customs, Other wishes and actions, Action structure (Orlic,2005).

Figure. 1. Impact of Job Satisfaction on Organizational Performance (Kuzey C, 2018)

It is clear that job satisfaction is closely related to achieving good business results. Then when people are satisfied with what they do, they have more strength, desire, zeal, to perform each individual business task as expected of them, and sometimes even better than that. (Chiniara, M., 2017). They want to include all their knowledge, skills, abilities, in order to achieve an enviable result and to help their business system to survive in the market and to form a strong basis for further growth and development.

It is very often identified that those employees who are rewarded for their work are much more motivated and satisfied than those who are not rewarded. It is also known that this principle of motivation appears as efficient and effective when the rewards are tied to the productivity of workers. If the situation is reversed, then it does not necessarily mean that productivity will grow. It is very important that the entire system is fair and equal to all workers, so that workers' dissatisfaction and the manifestation of the impact on organizational results do not occur.

If the employee notices that good commitment at work brings him material security and social status, he will try to make his competencies a part of organizational knowledge. Employees will consider their organization a part of their personality, they will identify with it and they will experience the realization of its goals as the realization of their own. If he realizes that this connection is not causally consequential, he will just look to do his job, anyway, as the minimum set criteria require, and maybe worse than that.

It is the leader who must take care of all the elements that affect the motivation of workers. He must determine both the factors and the effects of the factors, but also the organizational environment. A systematic approach to action within the organization, reappears as the key to the success of leaders in mobilizing the organization to achieve its goals. Only with a comprehensive analysis, one can get a complete picture of the organization and the way of motivation that would suit its employees.

Special personality characteristics of workers are crucial in establishing a system of motivation. Each worker is a story for himself and each of them has his own system of values and habits that he shows. Of particular importance are the following characteristics of workers, which leaders must take into account when defining the means of motivation:Social origin,Level of Education,Gender, Family status, Material security .

The basic tasks of each leader within the process of motivating employees can be classified into three groups:
- Defining and designing business tasks,
- Providing preconditions for efficient and effective work,
- Stimulating efficient and effective work (Schein, 2010).

If we look at the process that involves defining and designing business tasks, it is a very complex task that a leader must face. Within this process, he gives the task a kind of motivating factor. If the task is not monotonous, if it is interesting, it will encourage the motivation of the worker to do it as well as possible. Tasks must be complete, logically designed, and explained to employees. It is very important that every worker knows what the result of his work is, and not to be a clean workforce that will repetitively perform one operation. It is especially important to provide a certain degree of autonomy within each task.

Schein (2010) under organizational culture implies a set of assumptions, beliefs, values, customs, structures, norms, rules and traditions.

First, a strong culture strengthens the bond between members and helps them show a common understanding of a particular problem. When there is a risk of conflict in the organization, common norms and values are elements that unite people and help them to properly assess the situation and behave properly (Turner, N., et.al., 2002.)

In order for the organizational culture to encourage a high degree of motivation among employees, it must have characteristics, and these are the following characteristics (Guillén, M. F. 1994):
- linking core values to human resources, quality work and providing quality services to consumers and clients,
- providing a large space and adapting to the needs and requirements of creative and capable people,
- creating an informal friendly atmosphere that makes hard work more fun and enjoyable,
- developing a climate that encourages rewarding innovation and creativity, encourages risk-taking, does not punish mistakes and requires continuous experimentation, change and improvement of the organization,
- spreading the spirit of community and care for employees,
- creating and spreading a sense of success, satisfaction and pride for effective and efficient business.

YehiChien (2012)further argues that creativity while performing their tasks, job satisfaction, risk-taking, involvement in work, and the ability to leave work influence organizational culture.

EMPLOYEE MOTIVATION STRATEGIES

Employee motivation strategies are diverse. Each strategy has its own specifics and is especially reflected in accordance with the characteristics of the business environment. Once employees within one company, they have completely different habits and motivators compared to another business environment. Managers must devise certain employee motivation strategies in their environment and clearly define the tangible and intangible elements that will encompass the employee motivation system.

The framework of material compensations that are applied during the employee motivation strategy includes: salary, bonuses, rewards and benefits of a material nature, pension, resolving the housing issue, employee

participation in the profit distribution process, employee participation in the company's shares (Augustine et.al., 2016.)

The framework of intangible compensations that are applied during the employee motivation strategy includes: feeling of satisfaction due to the entrustment of the work task, the possibility of advancement in the company, feedback on work, flexible forms of working time, job design, goal management, the possibility of participating in the decision-making process on important issues, harmonization of relationships and interactions.

Managers may choose to motivate employees with an approach that is undifferentiated. They can define only one system of motivation that they will apply to all employees. Also, they have the opportunity to adapt the motivation system to certain segments of employees, whereby a differentiated approach will be identified. Very often, they decide to motivate only one segment of employees, which they consider to contribute the most to the sales process. Each of these strategies has its advantages and disadvantages.

Sometimes managers, regardless of the individual characteristics of employees, opt for an undifferentiated system of motivation. They apply the same motives to all employees. (Chiniara, M,2016) Sometimes e.g. they decide only on material benefits if they want to motivate them to a certain behavior. The downside of this strategy is that there is certainly a part of the employees that is not motivated. They are very often used by those companies that are in crisis situations, where no other way of motivation can be applied.

If it is a differentiated system of motivation, it means that the manager defines certain groups of employees, within which he classifies employees who have similar motives. The manager defines a special system of motivation for each group, which he believes will lead to the desired behavior. (Wright 2012.) This system of motivation is very expensive and takes a lot of time to implement, but it is very effective.

If companies have strengthened their position in the market, they can apply this system of motivation. This system of motivation stands out especially with those companies that take care of their employees and understand how important they are a resource.

Concentrated motivation strategy refers to directing employee motivation to only one segment of employees. Other segments of employees are completely neglected. Sometimes you can e.g. motivate only employees who are young and who work, in order to acquire a higher level of ability, knowledge and skills. (Arfah, A et.al,2019) Managers must be aware that this strategy will cause negative effects in the short term, because other employees will feel dissatisfied. In the long run, positive results can be expected, because targeting a certain group of employees will certainly pay off.

They will succeed in achieving the goals set before them, because all means and all efforts will be directed towards stimulating their behavior that leads to the achievement of the goal. When choosing an employee motivation strategy, it is necessary to analyze the entire environment and take into account all the factors that may affect the success of the motivation process. The employee motivation strategy must be compatible with all higher order strategies.

The social climate and culture in the organization are an important motivating factor. Therefore, great importance is attached to the organizational culture of the company. It represents a segment of the organization which indicates to employees the positive and negative forms of behavior, as well as what is respected and valued in the company (Harwiki, W. 2016).

It is assumed that greater performance is achieved in an organization with a strong organizational culture as a result of broad sharing and strong norms and values, which comes in three forms:

- enhanced coordination,
- control within the organization,
- improved alignment of goals between the organization and its members, which leads to increased motivation and effort of employees (Vecchio, R.P.,2008)

The basis for greater success of organizations with strong cultures is that a strong organizational culture supports the efficient transfer of information, knowledge, processes, programs, resources and people. Having the same

perception of values and beliefs, employees can have a strong connection with each other and with the organization, so employees have a strong feeling in the group and motivate each other. (Jayaweera, T. 2015).

Connectivity and unity within the organization also influences new employees who join the organization to make an effort to understand the organization and be members who participate. Employees are motivated to understand their environment and understand how and why things are done a certain way.

Weak organizational cultures, compared to strong organizational cultures, are less successful in achieving an organizational goal due to the perceived connection between culture and motivation. Organizations with a weak organizational culture focus more on the actions of an individual employee, so sharing norms, values and philosophies among employees is less important. There is also less group thinking and less group action in organizations with a weak organizational culture, so there is less influence and motivation among employees (Vigoda-Gadot,2012).

Weak organizational culture, by encouraging individual action, triggers intrinsic values such as responsibilities and challenges in the individual employee. An individual approach to an obviously weak organizational culture has benefits such as independent decision-making and a risk-taking spirit and can lead to greater innovation. (Chawla, 2017)

It can be concluded that while organizations with a strong culture use intrinsic motivation to produce desired behaviors by employees, weak cultures initially use external motivators by rewarding desired behaviors in the organization, and as an individual assumes roles and responsibilities and relies more on independent decision making and innovation, intrinsic motivation develops over time.

CONCLUSION

The core of the earlier interpretation of the concept of leadership is related to the claim that leaders are born with certain qualities, abilities, knowledge that give them the opportunity to carry that title and that they are, simply put, destined for such a life role. Now the situation is somewhat different and there is an interpretation that leaders can still upgrade all their qualities, and skills, knowledge and abilities, regardless of their initial level, can be improved in courses, trainings.

Defining the right set of factors that make up a leader is a very complicated job and a generally accepted solution will probably not come. The reason for that lies in the fact that each time carries some of its own specifics that characterize a certain type of leader that corresponds to that time.

Leadership style depends on a number of factors and it is clear that it is important to consider a number of factors when deciding on an effective and efficient leadership style. People cannot be managed according to plans and procedures, because there are many exceptions. The best approach is the one that uses the theoretical settings and results of the conducted research, but in such a way as to adapt them to the internal and external situational factors of a business system. Leadership style largely determines the business of the organization, because the right choice of leadership directly affects the process that is crucial in the field of employee management.

Motivation is that process, which plays a major role in the human resource management process of a company. It is very important that employees are motivated. Different systems of motivation are presented, which take into account different drivers on which depends how the employee's behavior will manifest itself and how it will affect the final results of the company. Regardless of the factors used, it was concluded that the situational approach plays a major role here as well. Each employee must be approached separately, the specifics of his personality should be noticed and the set of motivators should be adjusted to these characteristics.

There is no rule that motivates employees. Again, the leader has the main task, to study all the important features and to choose the ones that are most important for the given context.

Organizations must be aware that prevention is very important in everything and that every aspect of the organizational system must be adequately managed in order for the overall end result to be satisfactory. As situational factors are increasingly changing, it is important to identify weaknesses in a timely manner, in order

to turn them into the strengths of the organization as soon as possible and so that continuous improvement is part of the day-to-day activities of the business system.

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THE IMPACT OF ARTIFICIAL INTELLIGENCE ON HUMAN RESOURCE MANAGEMENT: AN ANALYSIS OF CHALLENGES AND PROSPECTS

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ABSTRACT

This paper explores the impact of Artificial intelligence (AI) on Human Resource Management (HRM) and the challenges and prospects associated with its implementation. The integration of AI in HRM revolutionizes various HR functions , such as recruitment, selection, onboarding, training and performance management. AI tools and methodologies, including automated resume parsing, video interviews, and predictive analytics, enhance the efficiency, accuracy, and personalization of HR processes. However, the implementation of AI in HR also presents challenges that require careful consideration, such as job displacement, data security, and the loss of the human touch in interactions with employees. To overcome these challenges, organizations need to support employees during the transition to AI technology, ensure data security, maintain a balance between efficiency and the human touch, and promote continuous education among employees regarding AI applications in HR.

Keywords: Artificial Intelligence, Human Resource Management, Recruitment, Employees.

INTRODUCTION

The integration of AI in HRM has transformed traditional HR processes by introducing innovative tools and methodologies that optimize various functions. This paper aims to analyze the application and benefits of AI in HRM, focusing on recruitment, development, and performance management. The implementation of AI in recruitment processes automates the selection of candidates and matches their skills and experiences with job requirements, improving efficiency and accuracy. AI also enables intelligent onboarding and training protocols through customized learning pathways and immersive virtual reality simulations. Additionally, AI-driven performance management strategies leverage real-time feedback mechanisms and predictive analytics to enhance performance evaluation and identify trends. Despite the potential advantages of AI in HRM, certain challenges need to be addressed to ensure its successful implementation.

ARTIFICIAL INTELLIGENCE IN HUMAN RESOURCE MANAGEMENT: APPLICATION AND BENEFITS

The integration of artificial intelligence (AI) revolutionizes Human Resource Management (HRM) by ushering in innovative tools and methodologies that optimize diverse HR functions (Rathore, 2023). AI’s impact extends across recruitment and selection processes, where sophisticated tools such as automated resume parsing and video interviews employing facial analysis facilitate precise candidate assessments (Rathore, 2023). Moreover, AI orchestrates intelligent onboarding and training protocols, offering customized learning pathways and immersive virtual reality simulations (Kaushal et al.,

2023). Real-time feedback mechanisms and predictive analytics underpin performance management strategies, enriching performance evaluation and trend identification (Stefanović, 2014).

Automated process of recruitment

Recruitment processes, a crucial step in attracting and selecting talent, traditionally require significant human resources and time. However, with the advancement of technology, organizations have begun to recognize the potential of artificial intelligence in automating these processes. By utilizing thousands of CVs and candidate profiles in a very short time, AI algorithms can identify relevant skills, experience, and characteristics necessary for a specific position, significantly easing the candidate selection process. Additionally, AI can recognize behavioral patterns indicating a candidate who best fits the organization's needs, leading to faster and more precise talent selection.

One of the most common algorithms for recruitment works are shown on Figure 1.

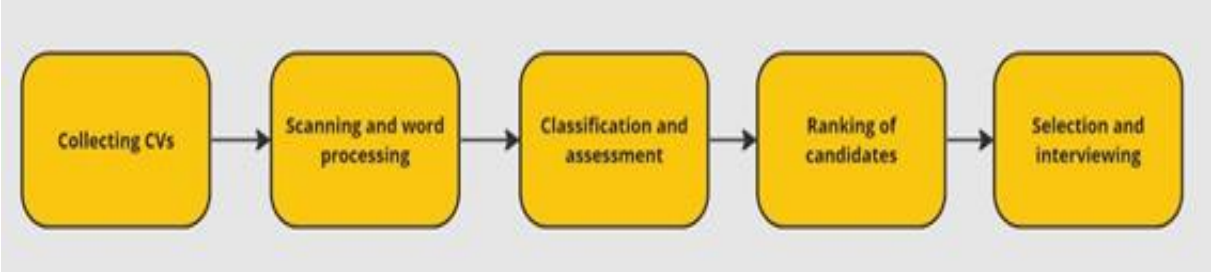

Figure. 1. Example of automated AI process of recruitment

As shown on Figure 1, CVs are initially collected from candidates, either manually through job application platforms, email submissions, or automated systems. Once the CVs are gathered, algorithms that are "powered" by Machine Learning (ML) techniques are employed to analyze and evaluate candidates based on how well their skills and experiences align with job requirements. This may involve semantic search, some deep learning methods, or examination of specific keywords. After the analysis, candidates are ranked according to their suitability for the job. Using the rankings, recruiters or systems that are automated can efficiently select candidates to invite for interview. This approach could save time, especially when dealing with many CVs that are common in large companies.

Analysis of employee satisfaction

Since the 1900s, job satisfaction has been a widely explored research area due to its significant impact on workplace atmosphere and productivity. It can be defined as the perceived relationship between one's desires from their job and what they perceive it to offer or entail. Job satisfaction is characterized by a pleasurable or positive emotional state resulting from an individual's appraisal of their job or job experiences. It reflects employees' sentiments about the organization from their diverse perspectives. Satisfied employees are crucial prerequisites for a healthy company and represents a key asset for organization (Egemen, 2024). Job satisfaction can drive employees' commitment and encourage positive managerial and financial performance (Chamberlain & Zhao, 2019).

A high level of employee satisfaction can contribute to better productivity, greater loyalty to the company and reduced labor turnover. To achieve this goal, more and more organizations are increasingly using artificial intelligence to analyze employee satisfaction. AI techniques allow organizations to efficiently analyze large amounts of data, including surveys, feedback, and social media data, to better understand employee attitudes and needs. Algorithms can identify key patterns and trends that affect employee satisfaction, allowing organizations to recognize key issues and implement appropriate strategies to improve work environment.

Some of the most known algorithms that are commonly used in analyzing employee's satisfaction are:

- Sentiment Analysis - Its primary function is to systematically identify and categorize sentiments embedded within text data, enabling the assessment of emotional tones, opinions, and attitudes conveyed through written or spoken language. Sentiment analysis techniques encompass a range of approaches, beginning with the primary classification of text into positive, negative, or neutral sentiments (Jim et al., 2024).
- Machine Learning Algorithms – One of the examples are hierarchical clustering (HC). Its technique for performing data exploratory analysis. It is an unsupervised technique (Nielsen, 2016). This helps in understanding the varying needs and preferences of different employee groups.
- Natural Language Processing - Natural Language Processing (NLP) is a field of Artificial Intelligence (AI) that aims to provide computer programs with the ability to analyses, understand, and interpret human language including oral and written language. Using text or voice as input data, NLP addresses several aspects of language including the syntax (the contextual arrangement of words and phrases) and the semantics (the meaning) and uses a combination of various techniques such as rule-based methods, statistical, machine learning (ML), and deep learning (DL) models to process human language and provide the output (Larayre et al., 2023). NLP algorithms can extract insights from unstructured text data, such as employee comments or reviews, to identify related topics to satisfaction or dissatisfaction.
- Recommender Systems – Systems that suggest personalized actions to improve employee satisfaction based on individual preferences and past behaviors.

Predictive analytics for hiring decisions

To find best candidate, companies must also think about the cost and time so that the process runs effectively. If recruiters do not pay enough attention to specific details, it may result in unrealistic job analysis and long recruitment cycles. This makes it harder to find outstanding talent and increases costs in terms of money, labor, and opportunity (Jayanti & Wasesa, 2022). To identify potential and matching it to an organization's needs, advanced algorithms can also locate team players based on core traits and personality matching, making it an effective way to avoid the need for costly and time-consuming preliminary screening (Walford-Wright & Scott-Jackson, 2018). HR analytics can be used for predictive purposes. Predictive analytics uses sophisticated methods like machine learning to forecast future events (Kumar & Garg, 2018). This approach integrates various of data, including historical candidate performance, work experience data, skills, education, as well as information on internal organizational factors. By using advanced analytics techniques, organizations can identify patterns and trends that indicate successful candidates and potential employee attrition risks.

In addition to facilitating the candidate selection process, predictive analytics for hiring decisions enables organizations to make informed decisions about investing in talent and planning for future workforce needs. Through the integration of data and analytics, organizations can create competitive advantage and achieve long-term success in the labor market.

CHALLENGES IN THE IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE IN HR

The implementation of artificial intelligence in the field of human resource management represents a key step towards optimizing the process of recruitment, employee development and performance management. These technological advances bring with them several potential benefits, including increased efficiency, accuracy, and personalization in HR processes. Applying AI in HR enables organizations to identify talent, adjust trainings and develop plans, and better understand employee need and preferences more effectively. However, along with this progress, certain challenges arise that require careful consideration and strategies for overcoming:

- AI Impact - Job Transition– The ethical discussions regarding AI technologies resolve around several issues. One significant aspect concerns the potential for job displacement. AS each innovative technology emerges, it changes the demand for certain job roles in the market.

Organizations must support emloyees during this transition to AI technology by acknowledging their concerns and assisting them in coping with the changes. It's crucial for organizations to maintain transparency regarding which jobs will be affected by AI, as well as the specific components of jobs that may be diminished or enhanced (Kaur & Gandolfi, 2023).

- Data security – It is necessary to make sure that emloyees' data is going to be in secure hands and it will not be used for any wrong purpose. It is an importan challenge. The companies should frame legal policy to make sure that their data will not be used for any illegal purpose and proper implementation of those policies should be done at right time to win the confidence of the employees towards the organization (Rani, 2019).
- Lack of "human touch" – Although AI can improve the efficiency of HR processes, it can also lead to a loss of human touch and empathy in interactions with emloyees. This can negatively affect employee engagement and their sense of belonging to the organization. HR should explore ways to integrate AI technologies with human factor and maintain a balance between efficiency and the human touch in HR processes.

PERSPECTIVES AND FUTURE RESEARCH DIRECTIONS

In addition to addressing current challenges as it was written in previous section, it is imperative to consider future research directions and perspectives to furher advance the integration of AI in HRM. The following areas represent key avanues for future exploration:

- With rise of the AI, there is a growing focus on making AI systems transparent. Transparency means being able to understand how AI makes decisions, what factors it considers, and whether it might show biases. Having transparent systems is super important. First, it helps build trust and accountability. When people can see how AI algorithms work, they are more likely to trust the decisions those algorithms make. Transparent AI systems also help with following rulse and doing things ethically. By beinge transparent, organizations can show they are following rules and doing the right thing, which can help them avoid legal trouble or damage to their reputation
- To prevent biases, it is vital to train AI systems using diverse and inclusive datasets. These datasets should ont only cover a range of demographics but also incorporate various perspectives. HR professionals should work closely with AI developers to curate datasets that encopass diverse experiences, backgrounds, and perspectives. This process aims to train AI systems to make decisions that are free fro bias and discrimination. Moreover, organizations should conduct regular audits to identify and rectify biases that may emerge as the AI systems operate within HR context (Ontop, 2023).
- One crucial aspect is to consider the promotion of continuous education among employees regarding the application of AI in HR. This involves providing ongoing learning opportunities to enhance employees' understanding of AI technologies and their implications for HR practices. Furthermore, it is essential to emphasize the need for organizations that can ensure that their workforce remains knowledgeable and prepared to leverage AI in HR effectively (Hung, 2006).

CONCLUSION

In conclusion, the integration of Artificial Intelligence (AI) in Human Resource Management (HRM) offers numerous benefits in terms of efficiency, accuracy, and personalization of HR processes. However, its implementation presents challenges that require careful consideration and strategies for overcoming. Organizations need to support employees during the transition to AI technology and maintain transparency regarding the impact of AI on job roles. Data security should also be ensured to protect employees' data from misuse. It is crucial to strike a balance between efficiency and the human touch in interactions with employees to maintain employee engagement and a sense of belonging. Continuous education and training of employees regarding AI technologies are essential to leverage AI in HR effectively. Overall, the successful interactio of AI in HRM requires the careful navigation of challenges and the exploration of future research directions and perspectives.

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THE INFLUENCE OF THE POWER OF KNOWLWDGE EXCHANGE AND THE COMMITMENT OF PROJECT MANAGERS ON INCREASING THE EFFCIENCY OF THE PROJECT

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ABSTRACT

The aim of this study is to develop an integrative understanding of the factors that support or inhibit individuals' intentions to share knowledge. Knowledge sharing is considered crucial in the project environment, therefore, the integration of knowledge management in project management becomes crucial for project success. The paper investigates the intermediary role of knowledge exchange, and the commitment of project managers and their mutual relationship increase the success of the project. We collected data from 90 team members in IT projects and analyzed the conditional process model through PROCESS after achieving model fit. The results revealed that project managers' commitment enhances project success directly and through knowledge sharing and trust in the team. As indicated by a set of statistical methods that revealed the relationship between the observed participants, age is not significant in relation to overall commitment. Regression analysis for education was highly significant $F(3,370) = 2,68$, $P < 0,05$. The set of statistical results indicated that tenure in the company was not significant $F(3,365) = 1,72$, $P = 0,16$, thus comparisons of mean values are not significant. The set of statistical results for tenure in the current job was significant, $F(3,358) = 4,411$, $P < 0,01$. The result indicates that knowledge sharing is positively associated with project success. The result shows that knowledge sharing positively mediates the relationship between project managers' commitment and project success.

Keywords: Commitment, Knowledge sharing, Power, Project managers, Efficiency.

INTRODUCTION

Knowledge becomes a basic business resource (Sajfert et al. 2007). The replacement of such an understanding with a new one, which stems from the idea: "The power is in the exchange of knowledge", cannot happen overnight, according to Sajfert et al. (2007). One of the first organizations in the world that introduced the use of the concept of project management in all its activities is the American National Aeronautic Space Administration (NASA), according to Avlijaš & Avlijaš (2022). Letić & Jevtić (2007) define a project as a series of activities that are undertaken to achieve a predetermined goal in a certain time interval, using resources and with certain costs. Letić & Jevtić (2007) state that in order to successfully implement a project from the very beginning and give the desired result, it is necessary to apply certain management actions, that is, it is necessary to manage the project. Kapusić (1989) states that there are 4 phases of project management, namely: 1) project idea, 2) project planning, 3) project realization and 4) project implementation. Sajfert et al. (2007) state that every project manager and worker is constantly learning and developing mutual relationships to ensure the development of the project, the exchange of ideas and the birth of new ideas. Sajfert et al. (2007) state that knowledge exchange requires a systemic approach and that it is a continuous process

that has many forms and that there are still unused resources in each individual to contribute their knowledge to more effective project management. Sajfert et al. (2007) state that knowledge management enables the application of information technology and helps knowledge workers to learn, collaborate, share and apply four main factors in the design process: creativity, problem solving, decision making and action taking. All these aspects: knowledge organization, knowledge exchange, learning and knowledge workers support each other in project management. Project managers are required to lead projects following organizational strategies, and recent research has focused on the key roles of project managers in the implementation of knowledge sharing strategies (Ansari et al., 2015; Sajfert et al. 2007).

LITERATURE REVIEW

Gazder & Khan (2018) state in the study that the key driver is knowledge exchange and cohesion among members as a key factor in the success of projects. Project management is a key methodology in the workplace of matrix organizations, which is also called project management that is the work of the 21st century, according to Kogon et al. (2015), PMI (2020) argues that projects have the leverage to change and complete work. Park & Lee (2014) state that knowledge sharing – a process intended to use existing knowledge – encourages project team members to sustain project performance. Hu & Randel (2014) state that in the exchange of knowledge, employees become more innovative. Huang et al. (2014) state that in the exchange of knowledge employees become more creative. Pearce (2004) states that members are more willing to share knowledge with each other when they feel that the leadership role is shared between them. Pearce & Conger (2003); Houghton, Neck, & Manz (2003) state that this is because it is not only the project manager who interacts with members more often, but each member acts as a leader and shares their knowledge and expertise. In the paper Imam & Zaheer (2021) investigated the mediating role of knowledge sharing, cohesion and trust in the team as moderators. Scott-Young et al. (2019) state that knowledge sharing, perceived cohesion and trust of team members contribute to project success. Studies on knowledge sharing by these groups of professionals (Kauffmann and Carmi, (2014); Stray, Moe and Noroozi, (2019); Wolf and Blomberg, (2020) in research show that there are challenges when it comes to technology-mediated knowledge sharing and communication within teams.

METHODOLOGY

Hypotheses

H1: Knowledge sharing will be positively related to project success.
H2: Knowledge level positively mediates the relationship between project managers' commitment and project success.

Sample

Research was conducted in the IT industry of Serbia. Based on available data, the number of employees in the ICT sector is 105,400 in 2023. By random selection, 56 companies were contacted and 500 questionnaires with a unique identifier were distributed. A total of 147 responses were received, with a response rate of 29.4%. In the second phase, out of 147 completely filled questionnaires received, 57 responses were not filled in well, which led to their exclusion from the data. The final sample was taken with 90 responses, and an overall response rate of 18%.

The sample was 70% male and 30% female. Age is categorized as follows. The sample was 25-35 years old with 40%, 35-45 years old with 33.4%, 45-55 years old with 20% and 55-65 years old with 6.6%. Experience was also categorized: 13.4% of the sample had 1 year of experience, 28.9% 1–5 years, 35.5% 6–15 years, and 15.6% 15–25 years. Only 6 respondents (6.6%) had experience of over

25 years. 68.8% were employed on an indefinite basis, while 31.2% were employed on a fixed-time basis.

Table 1. Demographic data on beneficiaries from the sample

Variables	N=90	N=90
Gender	n	%
male	63	70
female	27	30
Age		
25-35 year	36	40
35-45 year	30	33,4
45-55 year	18	20
55-65 year	6	6.6
Years of service		
Up to 1 year	12	13,4
Up to 5 year	26	28,9
5-15 year	32	35,5
15-25 year	14	15,6
More than 25 year	6	6,6
Emplopyment		
indefinetly	62	68,8
For a set amount of time	28	31,2

Instruments - Measures

The subject of the study is the relationship between supervisors and the work group. It explores the mutual relationship between supervisors and employees within the work group. The research aims to determine the level of employee commitment within the organization and to identify the levels of both commitment and disengagement among subordinates in the organization. Statistical data analysis was conducted using the SPSS program.

Becker & Billing (1993) By combining two low and two high levels of each of these groups, they came up with four profiles of commitment. First, individuals who have a low degree of commitment to work groups and supervisors as well as a low degree of commitment to management and the organization are rated as not committed. On the other hand, individuals who are highly committed to both groups are rated as committed. Between these two groups, according to Becker & Billing (1993), there are two more groups: 1. those who are highly committed to their supervisors and the work group and 2. those who are highly committed to management and the organization.

Becker & Billing (1993) propose the following profiles: (1) Locally committed (employees who are tied to their supervisor and work group), (2) Globally committed (who are tied to top management and the organization), (3) Committed (who are tied to both local and global foci) and (4) Uncommitted (not tied to either local or global focus).

RESULTS

For categorical demographic and contextual variables, x^2 tests were conducted using a modified Bonferroni error control procedure.

The ANOVA for age was significant, P (3,360 = 3,17 $p<0.05$. For pairwise comparisions, df (90) = 4,14, $p<0.03$ (where df is the least significant difference as determined by Fisher's method, differences between means greater than this value are significant at the 0,03 level).

As the top half of Table 2 shows, members of the Committment tend to be olderthan people with other profils, although this difference is not significant with respect to the Globally Committment. The ANOVA for education was also significant, F (3,370) = 2,68, p<0.05. For pairwise comparisons, df (90) = p<0.03. As Table 2 indicates, No other diferences are significant.

The ANOVA fortenure with the company was not significant F(3,365) = 1.72, p= 0.16. Therefore, mean comparisons were not conducted. However, fortenure on the job, the ANOVA was significant, F (3,358) = 4,11, p<0.01. Forpairwise comparisons, df (90) = 1.28. As Table 2 shows, members of the Locally Committment trend to have been on the job longer thanpeople with other profiles. No other differences were significant.

Table 2. Pairwise comparisons for continuous demografic variables dependent variables∗

Variables	**Committment**	**Clusters**		**Uncommittment**
		Globally Committment	**Localy Committment**	
Demographic variables				
Age	4,44a	40.66a,b	39.99b	39.93b
Education	13.46a	13.54a	14.37b	13.67a
Job tenure	3.56a,b	2.96a	5.14b	3.43a
Dependent variables				
Overall satisfaction	5.39a	4.67b	4.73b	3.75c
Overall prosocial behavior	3.68a	3.54b	3.59a,b	3.37c
Intent to quit	2.87a	3.33b	3.73b	4.53c
Local Satisfaction	5.49a	4.37b	5.22a	3.09c
Local prosocial behavior	3.17a,b	2.99b,c	3.29a	2.76c

∗ Means with diferent subscripts in the same row significantly diferent at p<0.03.
Chi-square analyses showed that membership in the clusters did vary by gender, x^2 (N = 90) = 3.51, p= 0.32.

Analytical strategy and hypothesis testing

PROCESS Macro, developed by Hayes (2013), was used in SPSS to test the hypothesized framework, PROCESS Model was used to test the hypotheses. The result shows that knowledge sharing is positively related to project success (= 0.30, p-value ≤ 0.000), supporting hypothesis 1. The second hypothesis states that knowledge sharing positively mediates the relationship between project managers' commitment and project success. The conditional indirect effect indicates that knowledge sharing mediates the relationship between leader commitment and project success (= 0.24, LLCI, ULCL = 0.15, 0.34). Hypothesis 2 is supported.

Table 3. Regression results for condition indirect effects

	Boot Indirect Effect	Boot SE	95% CI (Lower, Upper)
Shared leadership →	Cohesion →	Project success	
-1SD	0	0 . 0 8	-0.12, 021
Mean (0)	0.11	0.00	0.00, 0.22
-1SD	0.32	0.07	0.16, 045
Shared leadership →	Knowledge sharing →		Project success
Mean (0)	0.24	0.05	0.15, 0.34
- 1SD	0.17	0.07	0.02, 032

Note: N = 90. Unstandardized regression coeffcients are reported.
Bootstrap sample size = 5000. CI = confidence interval. SE = standard error.

Discussion

Hewitt & Walz (2005) their work conceptualizes the benefits of a combination of vertical and shared leadership in ISD project teams. This study examined the role that power and knowledge sharing have in enhancing the commitment of project managers. Hewitt & Walz (2005) and Pee et al. (2010) state that team members must understand the power of knowledge sharing in order to successfully complete a given project. This heavy dependence on knowledge sharing creates heavy coordination and communication burdens for both project managers and relevant domain experts at all stages of the project. The results of this study confirmed the theoretical argument of Hewitt and Walz (2005) and indicate that the power and knowledge sharing that fosters commitment significantly improves project success. From a team perspective, a shared management approach uses the power of knowledge sharing to help the project team make effective decisions, solve problems, and set goals by sharing their expertise and experiences, Muethel & Hoegl (2013) state.

CONSLUSION

It is evident from this study that shared leadership in IT teams develops different skills and sense of overall project results. Likewise, managers' knowledge sharing creates team synergy by improving professional relationships that directly contribute to overall project performance. This study concludes that implementing shared leadership in IT projects has significant benefits, both at the individual and team level.

Sundqvist (2019) suggested that in addition to the project management role, project managers must play the role of project improvement agents to align projects with strategy. In addition, recent research has suggested that project managers are potential strategists and can be involved in strategy formulation as well as strategy implementation (Lowstedt, Raisanen & Leiringer, 2018; Soderlund & Maylor, 2012). Project managers usually prefer to be focused on the day-to-day execution of the project instead of the business and strategic aspects of the projects, which can lead to disappointing business results of the project and even failure according to Patanakul & Shenhar (2012). Research has begun to encounter barriers and promoters of project manager behavior related to knowledge sharing strategy Ekrot, Kock & Gemünden (2016); Sundqvist (2019) states that it is therefore important to investigate how to improve the readiness of project managers to perform strategic tasks in knowledge exchange.

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RESEARCH OF THE DIVERSITY OF THE NATIONAL CULTURES OF SERBIA AND THE UNITED STATES OF AMERICA AND THEIR INFLUENCE ON E-BUSINESS EMPLOYEES

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ABSTRACT

The aim of the paper is to point out the importance and diversity of the national culture of Serbia and the United States of America. Participants were selected through contacts with e-business employees in Serbia and the United States of America. The findings reveal that: (1) lower power distance and lower degree of uncertainty avoidance make e-business of companies operating with foreign private capital more liquid and profitable. (2) when it comes to the attitude towards uncertainty, the employees of the e-business group of companies that operate with private capital of foreign origin showed a higher degree of uncertainty avoidance compared to the employees of companies that operate with private capital of domestic origin. (3) The results showed that in Serbia, the national culture implies a high power distance, avoidance of uncertainty, a distinct dose of collectivism, to promote moderately feminine values, with short-term orientation and high restraint. (4) The results show that in the USA the power distance is low, individualism and masculine values are in the foreground, while change and uncertainty are not avoided.

Keywords: Organizational culture, Dimensions of national culture, Value dimensions.

INTRODUCTION

Hofstede (1991) states that he sees culture as "software of the mind". According to Hofstede (2001) the collective programming of the mind that distinguishes members of one group or category of people from another. According to Janićijević (2002), national culture means a set of assumptions, beliefs and values that are shared by members of a national community and that significantly determine their understanding of the world, as well as their behavior in it.

According to Hofstede (1980), Yugoslavia and the USA were included in the research of organizational and national culture. Hofstede (1996) broke the original data on Yugoslavia, after its disintegration, into data on the national culture of Slovenia, Croatia and Serbia. According to Hofstede (2001), the work "Culture's Consequences" has been updated with new data. Janićijević (2003) states that all three cultures are positioned very close to each other. Cultures with pronounced characteristics of national cultures can be seen on the maps shown. The research shows that cultures with low power distance are individualistic. Sejfert & Vukonjanski (2008) state that this group includes Anglo-Saxon, Germanic and Romanic cultures. In contrast, there is a large group of cultures that represent high power distances, where the Yugoslav national culture also belonged. These are the orientation results in the paper. The US has the opposite results.

Figure 1 according to Hofstede (2000) illustrates when and what our mental programs are acquired. Hofstede (2000) states that we as humans are born incompletely programmed; during the first ten

years of our lives we possess an incredible capacity to absorb complex, diffuse and implicit mental programs. Hofstede (2000) states that we acquire these mental programs from our social environment, family, neighborhood and early schooling. The right column according to Hofstede (2000) in Figure 1 shows which levels of culture we acquire and in which period. The school period generally bridges puberty; The type of school we attend is related to our social class and affects our future occupation. Business culture can be placed somewhere between the occupational level and the organizational level. According to Hofstede (2000), national and organizational cultures are completely different phenomena: national cultures belong to anthropology, organizational cultures to sociology.

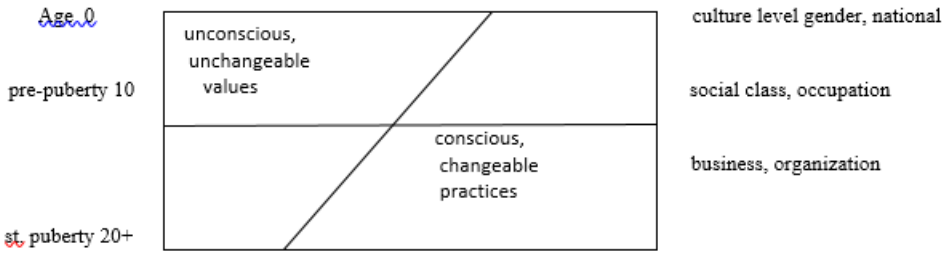
Several dimensions have been replicated in large studies by others among different types of respondents (Hofstede, Bono (1988), Hofstede, (1991), Hofstede, G., Hofstede, J. G., Minkov M. (2010), Minkov, Hofstede (2012) .Hofstede (2001) lists more than 400 significant correlations for the first five dimensions: - Power distance correlates with: income inequality, polarization and violence in national politics - Uncertainty avoidance correlates with: number of laws and rules into experts, xenophobia, faster driving.- Individualism is correlated with: national wealth, faster walking, weaker family ties.- Masculinity is correlated with: emphasis on growth as opposed to caring for the weak and the environment , and negatively with the percentage of women elected in parliaments and governments.- Long-term orientation correlates with: savings rates, economic growth of poor countries and adaptation to the changed reality, in contrast to short-term orientation which is correlated with: concern for social obligations, national pride and fundamentalisms . - Indulgence correlates with: higher birth rate, more active sports, more obesity, more private internet, smaller position.

The aim of the paper is to emphasize the importance of applying a holistic approach to the national culture of Serbia and the USA, and to introduce the dimensions of e-business. The work itself is of an exploratory nature, and aims to prepare future empirical research on the influence of the diversity of the national cultures of Serbia and the USA on e-business. The work is based on the use of older, secondary sources, analysis of cases (case studies), as well as numerous cited references.

LITERATURE REVIEW

Hofstede (1980) identified four dimensions of national cultures: Power distance, Uncertainty avoidance, Individualism-collectivism, Masculine-feminine values. Hofstede & Bond (19881), together with their colleagues, introduced a fifth dimension based on Eastern traditional teachings in research conducted among students from 23 countries in 1991. Hofstede & Bond (1988) state that it is a short-term-long-term perspective (short term–long term) characterized by the following peculiarities. The long-term orientations of society are characterized by tendencies towards savings, perseverance as a way of preparing for changing circumstances in the future, the degree to which they value long-term goals and approach the problem pragmatically, while the opposite orientation is oriented normatively and short-term. Minkov & Hofstede (2012) added another, sixth dimension of indulgence versus association (Indulgence versus Restraint IND), where indulgence depicts the dimension of free satisfaction of human needs related to life and enjoyment, and restraint refers to societies that suppress the satisfaction of needs and regulate them using strict rules.

Ivanić & Paunović (2013) investigated how the dimensions of organizational culture (power distance and uncertainty avoidance) influence the co-currentness of medium-sized enterprises in the region of a transition economy. Ivanić & Paunović (2013) tested the differences in the attitudes of managers and employees of two groups of companies, with private capital of foreign or domestic origin. Ivanić & Paunović (2013) came to the conclusion that a lower power distance and a lower level of uncertainty avoidance make the operations of companies operating with private capital of foreign origin more liquid and profitable. According to Ivanić & Paunović (2013), when it comes to the attitude towards uncertainty, managers of a group of companies operating with private capital of foreign origin showed a higher degree of uncertainty avoidance compared to managers of companies operating with private capital of domestic origin.



Source: Hofstede (2000)

Figure 1. Acquiring mental programs

METHODOLOGY

Subject and problem of research

The subject of the research is comparing national cultures in two different environments, Serbia and the United States. The research problem is to analyze uncertainty avoidance in e-business operated within the private sector. The subject of the research encompasses employees in privately owned companies. The challenge is to uncover the power distance within the surveyed population.

The theoretical framework of the work, as a basis for deriving the hypotheses of national culture in Serbia and the USA, the authors rely on Hofstede's (1980) study on national cultures. Another source is empirical studies in Serbia and the former Yugoslavia and contemporary research programs of the GLOBE (Global Leadership and Organizational Behavior Effectiveness) project.

Hypothesis:
H1 – There is no influence of national culture in Serbia on e-business employees
H2 – There is an influence of national culture in the USA on e-business employees

Sample

The sample consisted of 90 employees from three IT companies with headquarters in Belgrade, Novi Sad, and Zrenjanin. The second sample consisted of 90 employees in the USA - California

Instruments

Respondents were asked to respond on a Likert scale (1932) ranging from 1 = not at all to 5 = often, if not always.

RESULTS

According to the subject of the study and the results obtained from the research for the Republic of Serbia, they are as follows: Power distance 86, Individividualsm-collectivism 25, Mmasculuty-femininity 43, Uncertainty avoidance 92, Short term-long term 54, Indulgence versus Restraint IND 28.

Source: Domino Magazin 03. jul. 2017.

Figure 1

In the research problem, the results showed uncertainty avoidance in e-business in Serbia and the USA.

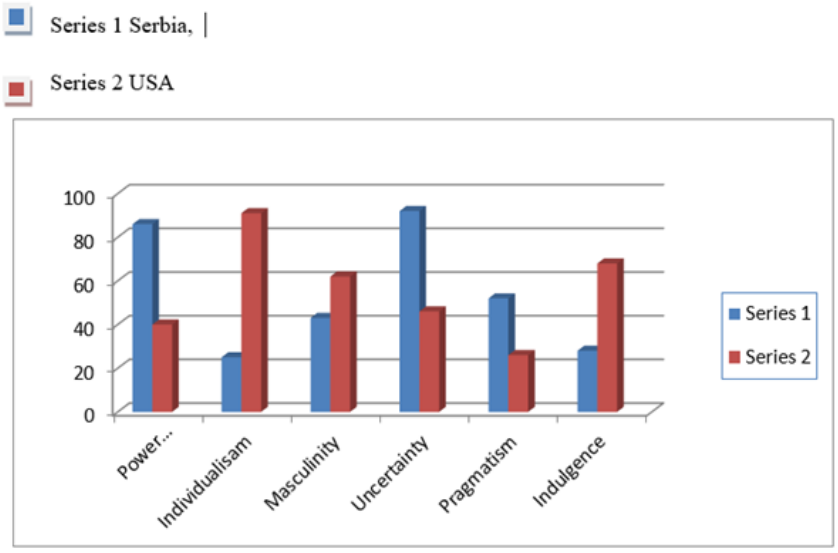


Figure 2

Source: Customized based on the data and tools available on the siteThe Hofstede Centre, Internet, https: www.hofstede-insights, 29/11/2017

Hofstede (1980) on graph 2 concluded on the basis of his research that Serbian national culture implies: high power distance 86, a strong dose of collectivism 25, to promote moderately feminine values 43, avoidance of uncertainty 92, with short-term orientation 52 and high restraint 28. Hofstede (1980) on graph 2 concluded, based on his research, that in the United States of America national culture implies: high power distance 40, a strong dose of collectivism 91, to promote moderately feminine values 62, uncertainty avoidance 46, with a short-term orientation 26 and high restraint 68. According to Hofstede (1980), America is the opposite of Serbia: power distance is low, individualism and masculine values are in the foreground, while changes and uncertainty are not avoided. Orientation is long-term until individuals feel pressure from society to release their needs.

The subject and research problem according to Figure 3 are the comparison of national cultures between Serbia and the USA, with the results displayed.

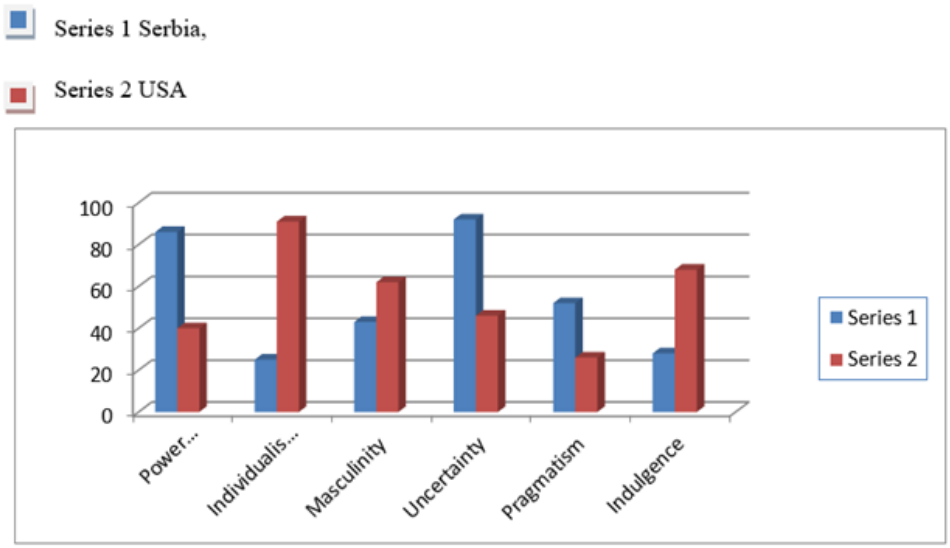


Figure 3

Research on the diversity of the national cultures of Serbia and the United States of America and their impact on e-business employees is as follows. On the graph 3, based on these researches, it was concluded that the Serbian national culture implies: high power distance 82, a strong dose of collectivism 29, to promote moderately feminine values 47, avoidance of uncertainty 88, with a short-term orientation 48 and high restraint 32. On the graph 3, on based on these researches, it was concluded that in the United States of America, national culture implies: high power distance 44, a strong dose of collectivism 87, to promote moderately feminine values 58, avoidance of uncertainty 42, with a short-term orientation 30 and high restraint 64.

DISCUSSION

The results of the aforementioned study showed that Serbian national cultures for e-business employees are characterized by high power distance, high uncertainty avoidance, pronounced collectivism and the predominance of "feminine" values, with a short-term orientation and high restraint. Based on the above scores, Serbia differs from the USA, and based on the above scores, it could be classified in a cluster of Latin American countries.

The obtained results of the study showed that e-business employees in the United States of America have a low power distance, individualism and masculine values are in the foreground while changes and uncertainty are not avoided. Orientation is long-term until individuals feel pressure from society to release their needs. The results show that there is no influence of national culture in Serbia on e-business employees. This proves hypothesis 1. The obtained results on the sample of the United States of America show that there is an influence of national culture on e-business employees. In this way, hypothesis 2 was confirmed.

CONCLUSION

The results obtained in this research confirm the influence of national culture on e-business both in Serbia and in the United States of America. Where the influence of national culture and the use of information technologies is particularly pronounced. The use of the national culture of information technologies, increased training and motivation affect the improvement of employee performance through increased responsibility, creativity and teamwork, which positively affects their organizational commitment**.**

The findings reveal that: (1) lower power distance and lower degree of uncertainty avoidance make e-business of companies operating with foreign private capital more liquid and profitable. (2) when it comes to the attitude towards uncertainty, the employees of the e-business group of companies that operate with private capital of foreign origin showed a higher degree of uncertainty avoidance compared to the employees of companies that operate with private capital of domestic origin. (3) The results showed that in Serbia, the national culture implies a high power distance, avoidance of uncertainty, a distinct dose of collectivism, to promote moderately feminine values, with short-term orientation and high restraint. (4) The results show that in the USA the power distance is low, individualism and masculine values are in the foreground, while change and uncertainty are not avoided.

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DIGITAL LITERACY OF EMPLOYEES AS AN IMPORTANT FACTOR IN THE PROCESS OF BUSINESS DIGITALIZATION

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ABSTRACT

Employee digital literacy is critical to the success of businesses pursuing digital transformation in today's quickly changing digital environment. Examining the role that digital literacy plays in driving businesses toward digitalization and determining the discrepancy between the skills that employees now possess and those that are required are the primary concerns. A variety of skills are included in digital literacy, such as the capacity to use digital technologies, assess digital content critically, and interact with others in digital settings. Strong digital abilities enable employees to contribute to creative solutions, communicate effectively in digital workspaces, and adjust to technology developments. Digital literacy is becoming more and more important, yet many companies still struggle to match their workforce's current skill set with the digital capabilities needed for successful digitalization programs. This disparity presents difficulties like lower production and lost chances for innovation, among other things. The study presents how this gap is addressed. Businesses may fully realize the benefits of digitalization projects and stay competitive in the present digital economy by bridging the skills gap between current personnel and the digital skills required.

Keywords: Digital literacy, Digitalization, Employees, Business, Transformation.

INTRODUCTION

Digital transformation makes people's lives easier and modernizes businesses, but before this can happen, individuals and organizations need to be prepared to rethink how they operate and how they view digital transformation in general. Because of the astonishing speed at which digitalization has accelerated society, digital transformation is now essential for all businesses, public or private. Consequently, many organizations have not yet adapted to digital transformation (Arnaud et al., 2024). Many businesses need to drastically alter their operational procedures to gain a competitive edge. They also need to put IT solutions in place to transform digital customer interactions and, in certain situations, even the current business model. Businesses that are using those cutting-edge tools to the fullest extent possible may be further along in the stages of digital transformation (Krajčík et al., 2023).

Among the main concerns of digitalization are the workforce's digital literacy, businesses' efforts to help people become digitally literate, and the stages at which businesses are digitally transforming (Krajčík et al., 2023). The ability to use digital devices, including computers, tablets, and smartphones, is known as digital literacy. Technical proficiency with mobile applications, information and communication proficiency with technologies, and teamwork proficiency with social media are other components of digital literacy (Krajčík et al., 2023).

The paper aims to explore how the digital literacy of employees may impact the process of business digitalization.

ROLE OF EMPLOYEES

It is shown that in the context of digitization, human capital is becoming an increasingly valuable resource since people transmit both digital information and the techniques for employing it (Blanka et al., 2022). Employee responsibilities are altered when they are recognized as vital players, and it is emphasized that they need to be significantly more knowledgeable about computers than just the fundamentals. Digital literacy and the capacity to use it in particular situations are becoming essential since digital transformation demands "different mindsets and skill sets than previous waves of transformative technology." To move toward digitization, particular talents must be acquired at the employee level. These competencies include computer skills as well as a combination of entrepreneurial and digital competencies (Kohtamäki et al., 2020; Gekara & Thanh Nguyen, 2018).

Merely possessing digital information is insufficient; one must also be able to utilize it and recognize potential opportunities. Because employees need a diverse range of talents in the form of "technical competence, analytical ability, and work experience," developing human resources is crucial. Employee responsibilities and the necessary human capital have evolved as a result of the dissemination of digital knowledge and the empowerment of employees to contribute ideas for realizing digital potential (Vial, 2019; Blanka et al., 2022).

Between enterprise digitalization and enterprise R&D collaboration, employees' digital literacy acts as a bridge. The favorable correlation between enterprise digitization and the extent and level of enterprise R&D cooperation is undermined by the inferior qualities of firms. The positive correlation between firm R&D cooperation intensity and digitalization is strengthened by state-owned enterprises' shareholding (Lei et al., 2023).

The importance of the workforce's digital literacy is noted by Huu (2023). The degree of workforce digital literacy significantly influences an organization's level of preparedness for such unexpected events and changes. The impact of cutting-edge digital technology on the training that employees need to get to succeed in this changing workplace (Huu, 2023).

Employees' favorable expectations for performance and well-being in the future workplace—which mostly depend on interpersonal relationships—have an impact on their desire to support change initiatives. In addition to encouraging digital fluency and skills, managers should also foster employee engagement, teamwork, and connections among staff members to support them in doing their jobs. Interpersonal engagement has a significant impact on a higher degree of employee happiness (Huu, 2023). People who are proficient in digital skills typically outperform those who are not in the workplace in terms of productivity. Businesses are also conscious of the difference between current and required digital competencies. To make sure that their employees have the necessary digital skills for the increasingly digital world, many companies are holding workshops and training sessions in digital technology (Reddy et al., 2023).

Some studies narrow down to specific aspects. A study by Yoganathan et al. (2021) examined the connection between employee social media proficiency and online social capital outcomes. But little is known about how social media-savvy employees from different cultural backgrounds are. It can be used as an example of the variety of digital literacy skills that may be of importance.

METHODOLOGY

To address this topic, existing literature will be collected and critically analyzed. The focus will be on the recent academic sources. Focusing mainly on the role of employees in the process of digital transformation, the research will determine if there is a gap between the skills that employees have and the needs presented in the market. The findings will show some of the potential solutions based on which future actions can be made.

DIGITAL LITERACY GAP

The ability to use digital tools is essential for job readiness in the future. To work on location-based labor platforms like ride-hailing or delivery services, or to make efficient use of digital services like banking services or online tools for farmers, one must possess a rudimentary degree of "digital literacy". Workers can only effectively participate in digital industries or online labor platforms, which are utilized to provide and offer online and distant tasks if they possess advanced digital skill levels. As a result, there is a wide range in demand for digital abilities. It varies between industries and professions, as well as between nations with various starting technical and talent endowments (Fietz & Lay, 2023). Assessing "digital skills" is a serious task. Digital skills are defined as foundational (basic digital literacy), meta-cognitive (transversal ICT skills, e.g., software use), and technical/hard skills (intermediate/advanced digital skills, e.g., programming), as supported by a thorough analysis of the literature. The application of these talents is influenced by socio-emotional abilities, which may become more significant as machines take on more and more technical duties. Thus, in a "digitalized labor market," a set of abilities known as "digital skills" is important (Fietz & Lay, 2023).

In the twenty-first century, the idea of digital literacy is becoming more and more common. Education has responded with focused interventions and innovations to instill digital skills in the next generation of workers, in response to the work sector's growing needs for digital literacy. But despite attempts, there is still a glaring digital skills gap on a worldwide scale (Reddy et al., 2023).

Of course, this skill set is dynamic which makes the gap more evident. It is likely that some hard technical skills, like programming, may become less necessary than some may have thought not too long ago, given the recent advent of extremely powerful AI chatbots. Despite these complications, the ensuing analysis of a few chosen indicators nevertheless identifies some significant trends regarding digital skills globally and in developing nations. Comparable data on digital skills are generally available, yet there is a glaring bias in favor of higher-income nations.

CURRENT RESPONSES TO THE GAP

The education sector has employed several tactics throughout the years to enhance students' learning and digital abilities and get them ready for jobs that rely heavily on technology. The idealized picture of the present and future workforce has been achieved through the application of several 21st-century educational frameworks and models. Generally referred to as 21st-century learning models or 21st-century learning frameworks, some well-known examples of 21st-century education frameworks and models are the Partnership for 21st Century Skills (P21) framework, the E3 learning model, the Organization for Economic Co-operation and Development (OECD) learning framework, and many more (Reddy et al., 2023).

These models and frameworks describe the necessary competencies and serve as "signposts" for learning in the twenty-first century. Additionally, the Substitution, Augmentation, Modification, and Redefinition (SAMR) and Technological Pedagogical Content Knowledge (TPACK) frameworks have been essential in assisting teachers in effectively incorporating technology into the teaching and learning process (Reddy et al., 2023).

Enhancing the digital competencies of the global labor force makes sense, especially for emerging nations. Adult digital skills training is widely available. The needs for digital training are very variable, context-specific, and conditional. These needs range from basic training in digital skills—such as how to use basic digital tools to participate in location-based labor platforms or increase productivity on an individual, business, or farm level—to intermediate or advanced courses in digital skills that equip participants for work on online labor platforms and other ICT-related jobs (Fietz & Lay, 2023).

Fietz and Lay (2023) empathize that millions of individuals have taken advantage of these training opportunities globally, or are currently doing so. Although many of these training programs are free, "big tech" is crucial to the planning and execution of these initiatives. Numerous smaller-scale programs are also available. In addition to supporting some of these private-sector initiatives, the public sector—which includes national governments, international organizations, and development cooperation initiatives—also participates in different independent projects.

CONCLUSION

In summary, an essential component of a company's successful digital transformation is its workforce's digital literacy. Employee adaptability and utilization of digital tools and platforms are becoming more and more important as technology continues to transform industries and redefine work processes.

The current disparity between the digital capabilities that employers want and what employees possess emphasizes how vital it is to make coordinated efforts to close this gap. Businesses can enable their staff to embrace digital transformation and maintain competitiveness in a constantly changing digital landscape by funding training and development programs focused on digital literacy.

Employees who are part of an environment that values digital fluency and lifelong learning are better equipped to face the challenges that lie ahead.

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THE IMPACT OF COVID-19 ON PR IN THE ONLINE ENVIRONMENT

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ABSTRACT

The age of information technology has brought a strong transformation in many sectors, and it has become especially pronounced in the field of communications. Traditional ways of communication are increasingly giving way to digital ones, adapting to the newly emerging needs and dynamics of modern society. Precisely in this context, public relations as a key segment of corporate communication is experiencing significant changes in its way of functioning. In the beginning, public relations relied on direct communication, press releases and classic PR events. However, with the expansion of the Internet and social networks, this discipline has expanded to a much wider range of channels and tools. Social networks, blogs, podcasts and various digital platforms have become not only a supplement, but also a central part of PR strategies. In addition, the global health crisis caused by the COVID-19 pandemic has further emphasized the importance of digital communication. Rapid adaptation and changes in communication strategies became imperative, while ethical dilemmas and responsibility in communication came to the fore.

Key words: PR, On line environment, Covid-19, Ethics.

INTRODUCTION

The modern era is marked by rapid technological innovations and the constant evolution of communication channels and practices. Through an analysis of public relations in the digital environment, it is clear that these changes have become deeply integrated into the essence and practices of the field. The digital era has not only brought new tools and platforms for communication, but has changed the very foundations on which public relations are built. The key characteristic of digital public relations is undoubtedly dynamism and adaptability. In today's digital landscape, where technology and social media are constantly advancing and changing, organizations cannot rely solely on traditional methods of communication. Instead, there is an imperative to keep up with the fast pace and uncertainty of this dynamic environment. PR people intuitively understand the value of relationship marketing, with social media simply being another way to build relationships. PR pros have flocked to social media because it plays so naturally to their strengths as relationships managers. (Gillin, 2007, p. 125).

There is a numebr of studies that have examined various aspects of organizational communication and COVID-19 (Guzzo et al., 2021; Sanders et al., 2020). In this work, the central attention is devoted to the study of public relations in the context of the digital age. The impact of the COVID-19 pandemic on public relations in the online environment was analyzed. The changes in communication strategies that followed in response to the global crisis, the introduction of new tools and technologies in light of the pandemic, as well as ethical dilemmas and responsibilities in communication during this period are

presented. The paper also analyzes the future of public relations in the digital environment. Here, the integration of advanced technologies into communication strategies and the need for greater transparency and ethical approach in the digital age are reviewed.

The aim of this paper is to provide a comprehensive analysis of public relations in a digital environment, considering how traditional practices evolve in light of digital innovations and how these changes shape the way organizations connect with target groups. The paper will focus in particular on various digital tools and platforms that have become necessary in modern communication strategies, as well as on specific challenges and opportunities brought by the digital space. The importance of this topic lies in the increasing integration of digital tools and technologies in public relations. In a world where technology is constantly changing and where digital communication has become the norm, understanding how this field adapts and innovates is crucial for all organizations striving to stay relevant and communicate effectively with the public in the digital age.

QUICK ADAPTATION TO DIGITAL COMMUNICATION

With the emergence of the global pandemic of COVID-19, the world faced numerous challenges, both in everyday life and in business. In particular, the public relations sector experienced significant changes, as communication strategies and approaches had to be rapidly redefined in order to successfully respond to new circumstances. The speed of the spread of the virus, the unpredictability of the situation and the global concern demanded innovation, flexibility and clarity in communication. The online environment has become a central place for interaction, and digital tools and platforms have become not only desirable, but necessary for effective communication. This segment analyzes key aspects of the changes that have taken place in the field of PR in response to the challenges brought about by the COVID-19 pandemic.

The COVID-19 pandemic has caused serious disruptions in all sectors around the world, and has particularly affected the way companies and organizations communicate with their target groups. One of the most impressive changes was the rapid transition towards a digital environment, especially when talking about working from home and holding virtual conferences (Santoso et al., 2021, p. 299). The transition to working from home, which for many companies was sudden and unplanned, caused the need for new methods of communication. Traditional meetings were replaced by video calls, and work routines had to adapt to the new digital environment. This adaptation required effective digital tools to ensure smooth communication and collaboration among employees. Platforms like Zoom, Teams and Slack have become key components of everyday communication for many professionals.

Parallel to this transition, virtual conferences experienced an expansion. While traditional events and conferences have been canceled or postponed, the need to communicate and share information has not stopped. That's why many PR professionals have turned to digital platforms to organize webinars, online panel discussions and virtual trade shows. These platforms have allowed companies to maintain a connection with their customers, partners and the general public, even in these unforeseen circumstances (Santoso et al., 2021, p. 301). In this whole process, digital tools have become not only a necessity, but also a key factor for successful adaptation. Digital communication, more than ever, has become a central part of public relations strategy, enabling organizations to remain relevant, visible and engaged despite the physical limitations imposed by the pandemic. In this context, the ability to quickly adapt to digital communication channels and tools has become crucial for survival and success in the new normal situation defined by COVID-19.

CHANGES IN COMMUNICATION STRATEGIES

Capriotti et al. (2021) have came to a conclusin that the internet has affected communication between organizations and individuals. According to Capriotti et al. (2021) corporations have to be active with ongoing presence in social media, which can lead to better communication that demonstrates their

wish to communicate with their stakeholders. The COVID-19 pandemic not only brought operational challenges, but also profoundly affected the tone and content of communications that organizations sent to their target groups. This period of uncertainty and global crisis led to a review and adaptation of communication strategies in order to adequately respond to the changed circumstances and expectations of the audience (Santoso et al., 2021, p. 302). One of the key changes was the increased importance of empathy and humanity in messages. In times of crisis, people seek understanding, support and a sense of community. Companies that have recognized this need and adapted their communications to be more people-centric and less product- and service-centric have achieved greater success in maintaining the trust and loyalty of their customers and users. Emotional intelligence and an honest understanding of the audience's needs and fears have become central elements of any effective communication strategy.

In addition, many companies have faced the need to recalibrate their marketing and PR campaigns. Campaigns that were planned before the pandemic often became inappropriate or even insensitive in light of the new circumstances. As a result, companies have had to quickly revise their plans, adapting them to the current moment and placing human experience and well-being at the center of their narrative. This meant delaying some campaigns, redirecting funds to humanitarian efforts, or completely reformulating messages to be relevant and responsive (Yue, 2021, p. 112). The changes brought about by the COVID-19 pandemic have highlighted the need for flexibility, empathy and accountability in communication strategies. More than ever, organizations have been called upon to show their human side, adapt to new realities and communicate with their target groups in a way that reflects a deep understanding of their needs and feelings.

NEW TOOLS AND TECHNOLOGIES IN LIGHT OF THE PANDEMIC

The COVID-19 pandemic, among other things, served as a catalyst for the development and application of new technological tools and innovations. Faced with the challenges of limited physical interactions and the need for rapid adaptation, companies and institutions were forced to explore new ways of communicating and interacting with their users and employees (Santoso et al., 2021, p. 303). One of the key trends that emerged in response to COVID-19 was accelerated innovation in digital technologies. A number of platforms for virtual meetings, webinars and online conferences have experienced expansive growth, enabling companies to maintain connectivity with their teams and target groups regardless of physical barriers. In addition, various contact tracing and pandemic information applications have appeared, providing people with the necessary information in real time.

The increased use of artificial intelligence, chatbots and other digital tools has become even more pronounced during the pandemic. Chatbots, for example, have enabled organizations to provide quick answers to frequently asked questions related to COVID-19, thus easing the pressure on customer services. In addition, artificial intelligence was used to analyze data and predict trends related to the spread of the virus, giving decision makers valuable insight into the situation (Santoso et al., 2021, p. 303). Additionally, many companies have seen the benefits of automating and digitizing their processes, leading to greater reliance on digital tools. This has also resulted in greater investment in the technology sector, which is likely to have long-term consequences for the way companies communicate and do business.

The era of COVID-19 has brought with it a number of ethical challenges in the field of communications, especially in the context of information dissemination. At a time when accurate and timely information is critical to public health and safety, the role of communication professionals becomes extremely important, but also complex (Yue, 2021, p. 115). One of the biggest challenges the world faced during the pandemic was the fight against misinformation and "fake news". Misinformation about the virus, its origin, methods of treatment and preventive measures spread like wildfire through social networks, creating an atmosphere of fear, confusion and mistrust. Such information is not only potentially dangerous for individuals, but can also lead to wider social unrest.

In this chaotic information landscape, the role of PR professionals has become essential. These professionals are not only responsible for creating and distributing company and customer information, but also for promoting accurate and responsible information that serves the public good. This responsibility requires a high level of ethical awareness and professional integrity. Public relations professionals were also on hand to educate the public about the importance of vetting information sources and distinguishing fact from misinformation. Through various campaigns and initiatives, many organizations have dedicated themselves to informing the public about the importance of critical thinking in the digital age and the dangers of misinformation (Yue, 2021, p. 113).

The era of COVID-19 has emphasized not only the importance of ethical communication, but also the role that PR professionals play in shaping the information space and fighting misinformation. Their role in promoting transparency, integrity and accountability becomes crucial for building trust and an informed public in the future.

THE FUTURE OF PUBLIC RELATIONS IN THE ONLINE ENVIRONMENT

Digitization has undoubtedly revolutionized the world of public relations, introducing dynamism, interactivity and immediacy in communication with target groups. As technology advances, the PR landscape is constantly changing, setting new standards, challenges, and opportunities. Understanding those changes and anticipating future trends is key to adapting and succeeding in the digital age. In the modern era of digitization, the integration of advanced technologies into public relations strategies is becoming imperative. Developments in technology are not only transforming the way we communicate, but also shaping the public's expectations of how companies and institutions should communicate with them.

Algorithm changes on social networks, for example, can significantly affect the visibility and reach of posts overnight, forcing organizations to adapt their strategies to remain relevant and effective. At the same time, the emergence of new digital platforms and communication channels requires PR professionals to be flexible and open to learning, so that they can successfully integrate these new tools into their communication plans. Unexpected global events, such as the COVID-19 pandemic, further complicate the digital communications arena. The pandemic has shown how important it is to be ready for rapid change and how organizations must be equipped for real-time crisis communication, using digital channels to inform, reassure and engage their target groups. An essential element in crisis communication is the content of messages, particularly empathy in building a positive reputation of the organization. (Schoofs et al., 2019)

The first and most fundamental transformation comes with the use of artificial intelligence (AI) in data analysis. Through the application of AI, PR professionals can more precisely segment their target audience, tailoring messages to resonate in the strongest possible way. In addition, machine learning-based algorithms enable real-time trend and sentiment recognition, enabling organizations to proactively respond to changes in public opinion (Seidenglanz & Baier, 2023, p. 6). New technologies such as augmented reality (AR) and virtual reality (VR) open new horizons for creating immersive experiences in communication with the public. These technologies allow companies to create virtual spaces where they can engage their audiences in a completely new way, whether it's virtual booths at trade shows, educational sessions, or interactive product presentations. (Seidenglanz & Baier, 2023, p. 7)

The potential of blockchain technology should not be overlooked either. Although often associated with cryptocurrencies, its application in the sphere of public relations can bring a new level of transparency and trust. Through verified and unalterable records, companies can prove their responsibility and integrity, providing added value to their stakeholders. In the future, as technology continues to advance, the integration of these advanced tools will become not only advisable, but

necessary. PR professionals will need to align with these technological trends, adapting their strategies to remain relevant in a digitally transformed environment.

ETHICAL IMPERATIVES AND TRANSPARENCY IN THE DIGITAL AGE

In the digital age, where information circulates at the speed of light and where every action can be scrutinized by the public, ethical behavior and transparency become key components of any communication strategy. Given that digital platforms enable greater reach and interaction with different audiences, public relations must be oriented toward integrity, authenticity, and accountability (Hagelstein et al., 2021, p. 108).

Socially responsible practices and transparency in business are becoming central aspects of reputation management. The public expects organizations to be open about their decisions, actions and values. Whether it's about transparency of funding sources, environmental initiatives or corporate social responsibility, authentic communication helps build trust and credibility. In addition, the era of "fake news" and disinformation additionally reinforces the need for ethical behavior in digital communication. PR professionals have an imperative to provide accurate and verified information, countering the spread of unverified facts and narratives. In situations of crisis or controversy, transparency and rapid response can significantly reduce negative consequences and restore public trust (Hagelstein et al., 2021, p. 112). There is a high importance of ethical narratives when communicating with an audience in order to enhance connections, trustworthiness, and positive attitudes toward the communicator (Clementson, 2020).

Digital tools, such as analytics and metrics, allow organizations to track public reactions and sentiment in real time. This information should be used to improve communication strategies, but always with respect for user privacy and integrity (Hagelstein et al., 2021, p. 113). The era of digitization offers many opportunities, but it also brings with it certain challenges in the sphere of public relations. At the center of these transformations is an ethical obligation. Transparency and responsibility in digital communication are not only a recommendation, but become key to success in the modern media environment.

CONCLUSION

The digital environment has opened the door to many new opportunities and innovative approaches in public relations. Now, relationships can be built and nurtured through social media, blogs, podcasts and many other online platforms. This digital expansion allows organizations to communicate with their audience in a much more direct, personalized and interactive way. At the same time, the need for fast, transparent and authentic communication has become imperative. While the tools have evolved, the core principles of public relations, such as trust, integrity and transparency, remain at the center of any successful communications strategy. The future of public relations in the digital environment certainly represents a fascinating field that will be filled with continuous technological innovation. Technologies such as artificial intelligence, augmented and virtual reality, and automation are expected to play a major role in shaping the way organizations communicate with target audiences. These technologies bring the potential to create even deeper, personalized and interactive experiences with the public, enabling PR professionals to deliver communications that are both innovative and effective.

PR professionals are expected not only to develop technical skills, but also strategic thinking, in order to anticipate potential changes and trends. Also, the importance of continuing education and professional development has never been greater. PR professionals must now be at the forefront of digital transformation, constantly acquiring new competencies to remain relevant and effective in an ever-changing digital world. In addition to technological changes, the need for greater ethical responsibility and transparency in the digital environment was highlighted. In an era of fake news and

manipulation, public relations must be based on trust and truthfulness. This not only strengthens the integrity of organizations, but also increases their credibility and reputation in the eyes of the public. For centuries, public relations has been the foundation of communication between organizations and their target groups. At the core of this profession has always been the desire to connect and create meaningful connections. Traditional methods of communication, such as press releases, live events and press conferences, have dominated the PR landscape for decades. However, while these classic tools are still relevant, the digital revolution has introduced complexity to the way these relationships are shaped.

Yet despite these technological advances, the essence of public relations remains unchanged. The basic principles of transparency, ethics and building trust will continue to be the foundation of any successful communication strategy. Therefore, the challenge for future PR professionals will be how to make the best use of new technologies, but at the same time remain true to the core values of the profession. Preserving the human touch and authenticity, despite the ubiquity of technology, will be key to maintaining strong and long-lasting public relations.

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KEY FACTORS OF HUMAN CAPITAL ALLOCATION IN RUSSIA

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ABSTRACT

The paper provides a quantitative assessment of the contribution of various factors to the dynamics of human capital allocation in Russia based on Rosen-Roback model of labor-housing market equilibrium. Based on Rosstat data for the period 2017-2022 in industry-regional context, the paper study the impact of these factors on equilibrium employment, including in different time periods (the period of "normal life", the pandemic and the sanctions period) and for different professional groups. In particular, the results show positive effect on allocation from availability of employment support policies in the region; significant influence of informal sector, the prevailing type of economic behavior (propensity towards hedonism), crime and environmental quality. Results of the study suggest paying special attention in the regions to the problem of informal employment, as well as stimulating the productivity growth, introduction of advanced technologies and the creation of highly productive jobs. In addition, it is advisable to increase the elasticity of housing supply in the most productive regions in order to minimize the negative effects created by limited housing supply. An alternative to this is the active development of interregional transport, connecting local labor markets with high productivity and nominal wages, with local labor markets with low nominal wages.

Keywords: Human capital, Factors of production, Effective allocation, Productivity, Local labor markets.

INTRODUCTION

Many studies note that the characteristics of institutions and economic policies in a country can influence economic growth through the channel of resource allocation, including human capital allocation. In conditions of free allocation, people choose occupations that will allow them to get the greatest return (and corresponding reward) from their abilities. It is assumed that in this way the highest efficiency of human capital allocation is achieved – total output and social welfare are maximized. However, in reality, the allocation of human capital is influenced by a number of factors, including geographical, cultural, social, trade, technological, institutional, territorial and other barriers. Potentially, these factors can change the real returns to skills for different people, leading to their allocation to occupations in which they do not have a comparative advantage.

In recent years, under the influence of the pandemic and then sanctions restrictions, the role of various barriers in the process of human capital allocation in the Russian economy could most likely have increased, which could potentially have long-term consequences not only for the labor market, but also for the whole economy, including total output. All this emphasizes the importance of studying the mechanisms of human capital allocation and identifying its key determinants. In this regard, the main goal of the study is to quantify the contribution of individual drivers and barriers to the dynamics of human capital allocation in Russia.

A significant amount of economic literature is devoted to the study of human capital allocation. Theoretical and empirical works propose various models of worker allocation between regions and sectors, in particular, between the productive and unproductive sectors (Baumol, 1990; Murphy et al., 1991; Levine, Rubinstein, 2019, Bai et al., 2021), general equilibrium models in local labor markets (Moretti, 2011, Hsieh, Moretti, 2014), various models of occupational choice (Hsieh et al., 2019; Barros et al., 2023), models of the relationship between the allocation of human capital and productivity of the economy, influence on the allocation of various drivers and barriers.

A study of the influence of individual barriers to the rational allocation of human capital was carried out, for example, in the works of Hnatkovska et al., 2012 (the impact of barriers of the caste system in India), Lockwood et al., 2017 (the impact of non-linear taxation in the USA), Burstein et al., 2019 (the impact of the development of technology trade and the corresponding change in the demand for skills in the US), Li, 2020 (the impact of increased technology imports in China on the process of human capital allocation). Ebeke et al., 2015 assessed the influence of institutions on talent allocation in the context of the resource curse. The impact of structural technological changes on the allocation of human capital in the context of different countries was studied in the works of Krusell et al., 2000, Autor et al., 2003, Parro, 2013. The allocation of human capital in a regional context was considered, for example, in Arntz, 2022.

RESEARCH METHODOLOGY

The process of human capital allocation can be represented by the Rosen-Roback general equilibrium model in local labor markets, generalized in Moretti, 2011 and further in Hsieh, Moretti, 2014. In the model supply of human capital is formed by maximizing the total utility of workers, which depends on wages, housing costs and "local amenities". The demand for human capital comes from the firms that produce the final product from the resources - labor and capital. Local labor markets may offer different amenities, have different costs of living, and consist of workers with different skills; workers may differ in their preferences for allocation; in addition, there may be barriers to allocation: migration and trade costs; housing market costs, etc. In simplified form, the equilibrium allocation of workers between regions and sectors is determined by differences in total factor productivity (TFP), local amenities, and elasticity of housing supply, which can be expressed as (1):

$$dL_{srt} \propto d\left(\frac{A_{srt}Z_{srt}}{P_r}\right)^{\frac{1}{\gamma_r}} \qquad (1)$$

Where L – is the equilibrium number of workers in sector s, region r and year t, A – is TFP level of sector s in region r and year t; Z – is a certain measure of "local amenities" of working in sector s and region r in year t; P – is the housing prices in region r, γ – is the elasticity of housing supply in the region r.

According to the model, TFP growth will increase industry/regional equilibrium employment, endogenous housing prices and wages, with the elasticity of supply in the housing market determining whether TFP growth is reflected more strongly in employment growth or housing price growth. Similar logic applies to changes in local amenities.

The equation for empirical assessment of the selected model in basic specification can be represented in logarithmic form by (2):

$$lnL_{srt} = \beta_0 + \beta_1 lnA_{srt} + \beta_2 \gamma_r + \beta_3 lnZ_{srt} \qquad (2)$$

In the second stage, the local advantage parameter is divided into a number of variables that influence both the labor supply side (the attractiveness of local markets for workers) and the demand side (the need for labor resources to ensure the optimal level of output, c. p.). In a context of Russian economy the list of such variables included indicators characterizing the labor market itself (migration activity, informal employment, availability of high-productivity jobs), infrastructure and social amenities (road density, provision of hospitals, kindergartens, educational institutions, theaters), technological potential (development of advanced technologies, investment potential, economic diversification of region) and general living conditions (environmental quality, crime, prevailing type of economic behavior: propensity for hedonism or saving). In addition, an indicator of availability of employment support programs in the region was included.

The empirical basis for the assessment was Rosstat data at the regional, industry-regional and professional-industry-regional level for the period of 2017-2022. During the analysis, the necessary model variables were calculated: TFP (as the residual of the Cobb-Douglas production function of labor and capital at the region-industry level), elasticity of housing supply (sensitivity of housing prices to changes in construction volumes for each region) and local amenities (the ratio of the normalized cost of housing in the region to the average wage).

It was found that in a number of the most productive regions (for example, in Moscow, the Republic of Sakha) the elasticity of housing supply was very low, which, according to the theoretical model, can restrain the allocation of additional workers. Potential increase in productivity or local amenities of such regions will be reflected primarily in the growth of housing prices and nominal wages, not in employment growth. On the other hand, the highest elasticity of housing supply was observed in Tatarstan, Buryatia (since 2019 included in the list of regions prioritized for attracting personnel), the Volgograd region – in these regions, growth in productivity or local advantages will be reflected to a greater extent in employment growth, rather than in rising housing prices and wages.

FINDINGS AND DISCUSSION

The results of the empirical assessment in basic specification showed that, on average, an increase in the local advantages by 1% led to an increase in the deployment of human capital in the region-industry by 1.2%, an increase in TFP – by 0.7-0.9%, and an increase in the elasticity of housing supply – by about 0.2%. At the same time, the higher elasticity of housing supply did increase the impact of local advantages on employment growth by 0.02%, and the impact of TFP – by 0.15% (Table 1).

Table 1: Estimated regression results for equilibrium labor allocation by region-industry, basic specifications

	(1)	(2)
Local amenities	1.255*** (0.047)	1.230*** (0.048)
TFP	0.869*** (0.029)	0.728*** (0.043)
Elasticity of housing supply in the region	0.184*** (0.021)	
Local amenities * elasticity of housing supply in the region		0.020** (0.008)
TFP * elasticity of housing supply in the region		0.155*** (0.035)
Year, industry, const.	+	+
N of obs.	4072	4072
R2	0.451	0.432

The table presents the results of OLS regression with standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1***.

As for the additional determinants of allocation, first of all, the availability of employment support programs in the region, according to the results, had a small but positive effect on stimulating the allocation of human capital to the region (+0.03%). The greatest effect on equilibrium labor allocation was exerted by the share of informal sector in the region and industry (-0.66%), the prevailing type of economic behavior (with an increase in the propensity for hedonism – an increase in the share of consumption and lending and a decrease in the share of savings – by 1% allocation decreased by 0.2%), crime (-0.2%) and air quality (+0.2%). The availability of social infrastructure and technologies had a smaller but still positive effect – with an increase in availability of kindergartens, hospitals, theaters, and education institutions, as well as advanced technologies equipment by 1%, the allocation of human capital to the region grew by an average of 0.1-0.18%. Factors such as the diversification of

the region's economy, the share of high-productivity vacations, migration activity, road density and the investment potential of the region also had a certain effect on allocation (Table 2).

Table 2: Estimated regression results for equilibrium labor allocation by region-industry, specifications with the extended indicators of local amenities, including within subperiods

	All period	Subperiods		
		"Normal life" 2017-2019	Covid-19 2020-2021	Sanctions 2022
Local amenities	0.005	-	-	-
TFP	0.789***	0.626***	0.781***	0.825***
Elasticity of housing supply in the region	0.172***	0.106***	0.257***	0.117***
Employment support (treatment eff.)	0.029**	0.019*	-0.015	-
Diversification of region	0.063***	-	-	-
Share of high-productivity jobs	0.039***	0.030**	0.052***	0.141***
Share of informal sector	-0.658**	-0.378***	-0.529***	-0.892**
Type of economic behavior (propensity for hedonism)	-0.209***	-0.452***	-0.140***	-0.145**
Migration	0.063***	0.088***	0.057***	0.036
Kindergartens	0.121**	0.070**	0.084**	0.142***
Hospitals	0.185**	0.102*	0.175***	0.285***
Theatres	0.106***	0.136***	0.058*	0.066
Air quality	0.235***	0.241***	0.264***	0.223***
Higher education institutions	0.111***	0.101**	0.183***	0.251***
Crime share	-0.190***	-0.151***	-0.188***	-0.185***
Road density	0.070***	0.074***	0.080***	0.063***
Technological equipment	0.146***	0.124**	0.236***	0.294***
Investment potential	-0.029***			
Year, industry, const.	+	+	+	+
N of obs.	3808	1904	1270	634
R2	0.889	0.761	0.777	0.792

The table presents the results of the OLS regression. *** p<0.01, ** p<0.05, * p<0.1***.

The selected time period covered three sharply different subperiods: the period of "normal life" – from 2017 to 2019, the period of pandemic – from 2020 to 2021, and the period of sanctions – from 2022. The assessment results showed that in recent years the contribution of TFP to the dynamics of human capital allocation has increased: in a "normal" period with TFP growth of 1%, equilibrium employment in the region-industry increased by 0.6%, during the pandemic it increased by 0.78%, and in the sanctions period – by 0.82%. Thus, in times of crisis, it become more important to prioritize productivity growth. The impact of housing supply elasticity was highest during the pandemic, likely due to the widespread shift to remote work. During crises, the influence on the allocation of human capital from of the informal sector, the demand for highly productive labor and the technological equipment of the region has also increased. On the contrary, the influence of the type of economic behavior in the region and the availability of social infrastructure has decreased.

The study also assessed the impact of various factors on equilibrium employment in the context of different occupational groups. In particular, TFP was most important for attracting managers, professionals (including technicians and associate professionals), as well as plant and machine operators, and assemblers. The informal sector factor was most important for the majority of groups, but especially for managers, clerical workers, and craft related trades workers. In contrast, the elasticity of housing supply turned out to be more significant for the allocation of clerical workers and unskilled workers (Table 3). On average, for the majority of professional groups the following factors turned out to be relatively more significant: the propensity to hedonism (but especially among managers), coverage of kindergartens (among managers and highly qualified specialists), air quality (among highly qualified specialists), technological equipment (among managers and industrial workers), crimes (among industrial and agricultural workers).

Table 3: Estimated regression results for equilibrium labor allocation in the context of different professional groups

	Managers	Profes-sionals	Clerical Support Workers	Service and Sales Workers	Skilled Agricul-tural Workers	Craft Workers, Operators, Assemblers	Elementa-ry Occupa-tions
TFP	0.764***	1.299***	0.277***	0.238*	0.597***	0.640***	0.265*
Elasticity of housing supply	0.047 (0.081)	0.035	0.247***	0.114*	0.185***	0.071**	0.357***
Employment support (treatment eff.)	0.056*	0.056*	0.054	0.036**	0.026*	0.029*	0.018
High product. jobs	0.050**	0.099***	0.020*	0.055**	0.074**	0.054	0.074**
Informal sector	-3.753***	-0.689**	-2.025***	-1.015	-0.132	-0.977**	-0.691
Propensity for hedonism	-0.845***	-0.615***	-0.432***	-0.602**	-0.110**	-0.180***	-0.170***
Migration	0.060*	0.053**	0.100***	0.063*	0.071***	0.123***	0.078*
Kindergartens	0.373***	0.170***	0.101*	0.081**	0.066*	0.316***	0.114**
Hospitals	0.225**	0.206**	0.121	0.132	0.174*	0.161**	0.149
Theatres	0.111*	0.216**	0.135*	0.069	0.071	-0.037	0.168
Air quality	0.189***	0.263***	0.234***	0.137*	-0.064	0.127	0.135*
Higher education	0.177**	0.206***	0.147**	0.129**	0.057	0.125***	0.009
Crime share	-0.175***	-0.153***	-0.126***	-0.171***	-0.210***	-0.190***	-0.149***
Road density	0.030	0.089**	0.147***	0.055	0.087**	0.158**	0.119**
Technological equipment	0.277***	0.175**	0.130**	0.181**	0.112*	0.217***	0.175
Year, industry, const.	+	+	+	+	+	+	+
N of obs.	3808	7616	3808	3808	3808	3808	3808
R2	0.773	0.753	0.791	0.750	0.797	0.759	0.764

The table presents the results of the OLS regression. *** p<0.01, ** p<0.05, * p<0.1***.

CONCLUSIONS AND IMPLICATIONS

Policies aimed at improving the efficiency of human capital allocation or attracting human capital to specific regions should consider all the noted factors – since they determine the achievement of target indicators. Currently, in the regions, special attention should be paid to the problem of informal employment – since it, along with productivity growth, most largely determines the allocation of workers across sectors and regions. The next important areas of development – stimulating the introduction of advanced technologies and the creation of high productivity jobs. In addition, it is advisable to increase the elasticity of housing supply in the most productive regions to minimize the negative effects of housing supply restrictions. An alternative to this can be active development of interregional transport, connecting local labor markets with high productivity and nominal wages, with local labor markets with low nominal wages.

The structural transformation of the Russian economy under conditions of severe economic and technological restrictions has caused changes in the existing mechanism for the allocation of human capital across industries and regions. Against the background of low internal mobility of the population and historically minimal levels of unemployment, the systemic problem of personnel shortage has worsened. The shortage of highly qualified personnel in critical industries, the demand for which has grown in the context of the deployment of import substitution programs after 2022 has

become especially acute. Given the existing restrictions, increasing the required level of competencies without attracting foreign specialists in a short time seems hardly feasible. It should be understood that this is a long-term process that requires the creation of prestige, including at the state level, for certain professions that are in demand in new priority industries. In this regard, active revision and creation of new training programs is required – and first of all, in high productivity regions. It is advisable to maximize the synergy between science and business: universities, research centers and the education system should focus on solving priority problems and training relevant specialists for the most productive companies and industries.

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Session C: MARKETING MANAGEMENT

Papers (pp. 159-176):

THE USE OF MARKETING MIX MODELING AS A DECISION-MAKING TECHNIQUE

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ABSTRACT

In today's business surroundings, it is very difficult for marketers to make decisions. One of the reasons relates to a large number of factors that should be considered before defining and implementing any strategic or tactical action. Besides the impact of macro factors, which are beyond the company's control, attention should be paid to different market participants. On one side, there are customers, who, with the development of informational technology, are becoming more demanding, while on the other, there are competitors who would try to take advantage of the smallest opportunity that comes their way. Hence, to minimize risk and make the most optimal decisions, marketers can use different analytical tools and techniques. Among them is the marketing mix modeling (MMM), which is the subject of this paper. In addition to the explanation of this term, the emphasis is on its phases and analysis types. Hereby, the attention is dedicated to the Bayesian model as well.

Keywords: Marketing mix modeling, Variables, Phases, Regression.

INTRODUCTION

There are many factors that marketers should take into account when making decisions regarding marketing strategy and tactics. Therefore, any activity related to the marketing mix (product, price, promotion, and distribution) should be approached with particular attention, especially considering their mutual relationships and effects on profitability. For this purpose, marketers may rely on different statistical tools and techniques, operationalized through software that can process a large amount of data.

The focus of this paper is on marketing mix modeling (MMM), the technique that through statistical analysis and quantification, provides marketers with information necessary for making predictions and optimizing marketing activities. After presenting some definitions and explanations regarding this term, two approaches related to MMM phases were discussed. The emphasis was also on the main regression techniques used in marketing mix modeling, as well as on Bayesian statistics, as a more flexible, simulation-based approach.

THE DEFINITION OF MARKETING MIX MODELING

Due to the corporate world's interest in increasing revenue and the proliferation of new media, there is growing attention towards marketing mix modeling (Thomas, 2006). Various explanations and definitions are related to MMM. Following Thomas (2006, p. 1), "this term is widely used and applied indiscriminately to a broad range of marketing models used to evaluate different components of marketing plans, such as advertising, promotion, packaging, media weight levels, sales force numbers,

etc." According to Pandey et al. (2021), for a long time, MMM has been considered a significant technique needed by advertisers seeking answers to questions related to:

- the quantification of the effect of a marketing plan (or strategy) on business sales;
- the way in which their current marketing tactics affect future sales.

As stated by the same authors (2021, p. 784), marketing mix modeling refers to the use of "advanced econometrics and marketing science to objectively measure the relative efficacy and effectiveness of an entire set of marketing and advertising investments, competitive steal, or initiatives to produce sales and growth in the both short and long term". In accordance with the Nielsen Company (2014), the MMM can be associated with the use of statistical analysis towards the estimation of the past effect and the prediction of the future effect of different marketing tactics on sales. It has an important role in closing the loop and connecting marketing expenditures and results; moreover, it reveals the path to higher return on marketing investment (Figure 1).

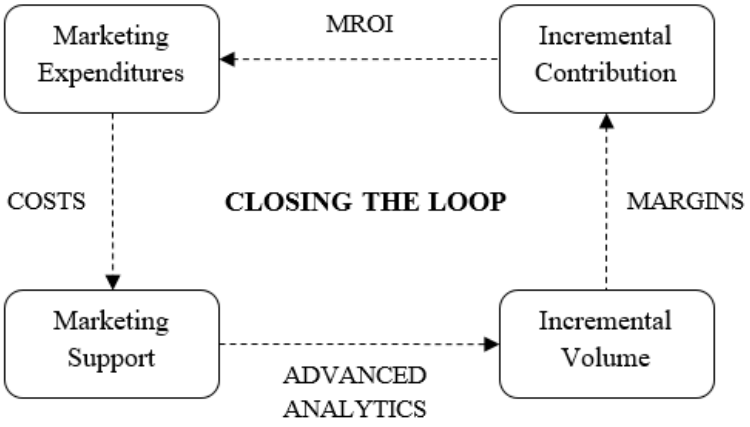

Figure. 1. MMM – Closing the loop

Marketing mix modeling can also be defined as a statistical technique that marketers can use to quantify the marketing and non-marketing influences on sales (Meta, 2022, p. 4), i.e. it helps them to understand how various initiatives reflect on their product metric, especially on the return on investment (Latent view, 2019). Hereby, when it comes to business metrics, there is a difference between "incremental" and "base drivers" – while the former refers to business results (outcomes) of marketing activities (such as promotion and price discounts), the latter relates to an outcome generated without any advertisements, as the result of brand equity (Latent view, 2019). In addition, as stated in the Latent view's guide to MMM (2019), there are "other drivers" that represent a sub-component of base factors and are associated with the brand value obtained as a result of the long-term effect of marketing activities.

As a statistical and analytical tool that can be used for quantifying the effect of past marketing decisions and predicting the effect of future sales taking into account different marketing scenarios, marketing mix modeling can be of strategic importance – it can provide numerous benefits reflected in quantifying effects of marketing variables on both the base and incremental revenue; optimizing marketing spend through the maximization of MROI; understanding short vs. long-term influence of marketing activities; etc. (Perceptive Analytics, 2015).

MARKETING MIX MODELING PHASES

Marketing mix modeling should be included in any marketing plan, bearing in mind that it enables measuring past performance and charting the way to success (The Nielsen Company, 2014). As a project, MMM consists of several phases. Hereby, as suggested by the Nielsen Company (2014), in the beginning, an adequate checklist of business questions needs to be designed (for example which

campaign has the highest marketing return on investment), after which, the attention should be dedicated to the following phases:

- Data collection and integrity – in collaboration with the MMM vendor it should be decided what data should be applied in a statistical model (for example, data related to products, the timeframe, the granularity of the time dimension, markets, sales performance, as well as data necessary for calculating marketing return on investment);
- Modeling – models should be tested against the checklist by involving the analytics team; when using a statistical method, there is a need for a deep and detailed analysis; in addition, brand managers should also take part in this phase;
- Model-based business measures – after the interpretation of the model-based outputs (including the analysis of the campaign's effectiveness, efficiency, and marketing return on investment), incrementality by campaign should be measured for all tactics, so the incremental profit drivers could be better understood;
- Optimization and simulation – performing an optimization or simulation to obtain insights that can be used for planning future marketing campaigns; in other words, in this (final) phase of the MMM project, outputs are turned into inputs for future planning.

Following Meta (2022), marketing mix modeling consists of six stages: data ingestion, data quality review, building statistical models, reporting, marketing optimization, and business planning. They are presented in Figure 2.

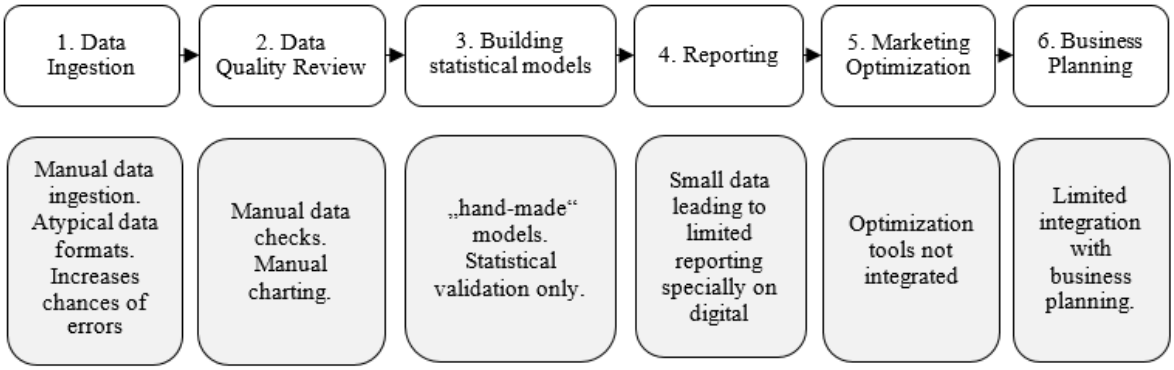

Figure 2. MMM stages

The typical time for this type of project is about six months. Besides requiring high time and investment, two more things are important when considering the MMM project: 1) depending on its complexity, the validation of results is based on analysts or, in the case of in-house models, on business intuition; and 2) because of high expenses, its application is usually episodical, in the form of annual exercises (Meta, 2022).

MARKETING MIX MODELING TECHNIQUES

In marketing mix modeling, the central place belongs to regression techniques, which can be used for predicting the most efficient combination of all marketing variables (Latent view, 2019). According to Uyanik and Güler (2013, p. 234), „regression analysis is a statistical technique for estimating the relationship among variables which have reason and result relation“.

In regression, there are two categories of variables – independent and dependent – where the former impacts the outcome of the latter (Latent view, 2019). In other words, regression analysis is undertaken to determine the cause-effect relations and to predict the outcomes based on the examined relation (Uyanik and Güler, 2013). In the case of MMM, the most common regression types are linear and multiplicative regression (Latent view, 2019).

Linear regression is used when the dependent variable is continuous with the assumption that the relationships between independent variables and the dependent variable are linear (Latent view, 2019). If there is only one single independent variable, the regression analysis is called univariate, and if there are more independent variables, it is called multivariate (Uyanik and Güler, 2013). Multivariate regression analysis can be presented through the following equation (Uyanik and Güler, 2013):

$$y = \beta_0 + \beta_1 x_1 + ... + \beta_n x_n + \varepsilon \quad (1)$$

where:
y – dependent variable,
x_i – independent variables,
β_i – parameter,
ε – error.

In a marketing context, it can be presented as (adjusted to Pandey et al. 2021):

$$S_t = \beta_0 + \beta_1 A_t + \beta_2 P_t + \beta_3 R_t + \beta_4 Q_t + \varepsilon_t \,, \quad (2)$$

where:
S – sales,
β – coefficient
t – periods,
A – advertising,
P – price,
R – promotion,
Q – quality,
ε – error.

Multiplicative regression models are usually applied to overcome the shortcomings of linear models; contrary to additive models, where independent variables are added, in multiplicative models independent variables are multiplied together (Latent view, 2019). There are several advantages of multiplicative models – „they readily accommodate percentage adjustments and efficiently calibrate nonlinearities; also, because the models are in logarithmic format, the range of the dependent variable is considerably reduced, meaning that more equal weight is given to each property and the influence of outliers is reduced“ (Gloudemans, 2002, p. 28).

Two types of multiplicative models are semi-logarithmic (log-linear) models and logarithmic (log-log) models (Latent view, 2019). In semi-logarithmic regressions, the dependent variable represents the natural logarithm of the variable of interest (Giles, 2011). In logarithmic models, both dependent and independent variables are transformed (Latent view, 2019).

Log-linear and log-log models differ in the way the response coefficients are interpreted (Latent view, 2019). In log-log models, there is a constant elasticity, i.e. the coefficients present the percentage change in business outcome, which resulted from a 1 percent change in the independent variable. On the other hand, in log-linear models, there is no possibility of determining the elasticity directly, but it can be obtained from the coefficient as $\beta \bullet X$ for every period.

When it comes to MMM techniques, the attention should be dedicated to Bayesian statistics, which has been particularly relevant in the last few years. It is based on running simulations with the possibility of controlling how they are run; it enables the encoding of actual assumptions into the analysis, after which simulation-based methods are used to find the combinations of parameters from which the outcome variable could be obtained (Kaminsky, 2024). This approach is more flexible, and by including prior knowledge and estimates, the Bayesian MMM can adjust and improve over time (Keen, 2023).

CONCLUSION

For making decisions, marketers may use various tools and techniques. Among them, a special place belongs to marketing mix modeling. By applying the MMM technique, intended for quantifying marketing and non-marketing effects on sales, marketers can have deeper insights into different initiatives and, thus, an adequate basis for choosing the right tactics. Its implementation can be of strategic importance, providing many benefits, primarily aimed at maximizing MROI.

Depending on the approach, the marketing mix modeling procedure may consist of four (data collection and integrity, modeling, model-based business measures, and optimization and simulation) or six phases (data ingestion, data quality review, building statistical models, reporting, marketing optimization, and business planning). Hereby, regardless of the number of phases, the main statistical technique used in MMM refers to regression. With its implementation, marketers can analyze the cause-effect relations and predict the outcomes concerning different combinations of marketing variables. Two main regression types, used in MMM, are linear and multiplicative regressions. In addition, it is important to mention that in recent years, there has been growing attention dedicated to the application of Bayesian statistics, which offers a more flexible approach that can improve over time.

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OPTIMIZING SUPPLY CHAIN RESILIENCE: JUST-IN-TIME STRATEGIES AND BUFFER STOCK APPROACHES IN UNCERTAIN MARKET CONDITIONS

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ABSTRACT

In the wake of recent market disruptions, optimizing supply chain resilience has become crucial. This paper reviews the literature to compare and analyze two contrasting inventory management strategies: Just-in-Time (JIT) and buffer stock approaches. JIT, traditionally favored for minimizing inventory costs and reducing waste, has shown vulnerabilities in unpredictable market conditions due to its reliance on lean stock levels. Meanwhile, buffer stock approaches emphasize maintaining extra inventory to absorb supply chain shocks. By synthesizing current research findings, this paper provides insights into the effectiveness of both strategies in managing supply chain uncertainties. Key considerations include the role of technology in predictive analytics, supplier relationship management, and the strategic balance between efficiency and responsiveness. The comparative analysis underscores that while JIT offers significant cost efficiencies under stable conditions, buffer stock provides a safety net when market volatility is high. Ultimately, this review highlights the need for a hybrid strategy tailored to individual supply chain characteristics, ensuring resilience without sacrificing operational efficiency. Further research is recommended to refine these hybrid models and integrate them with emerging technologies for enhanced decision-making.

Key words: Supply Chain Resilience, Inventory Management, Just-in-Time, Buffer Stock, Uncertainty

INTRODUCTION

Just-in-Time (JIT) inventory management emerged as a revolutionary strategy within supply chain management, rooted in its historical success at reducing waste and improving efficiency. Initially pioneered by Toyota in post-war Japan, JIT sought to minimize inventory levels by aligning production closely with demand. This lean manufacturing approach helped firms significantly cut storage costs, improve quality control, and eliminate surplus production. As a result, JIT gained global acclaim in the latter half of the 20th century, becoming a foundational practice for businesses across industries seeking to streamline operations and remain competitive.

However, in recent years, the weaknesses of JIT have become more apparent, particularly due to global supply chain disruptions. The COVID-19 pandemic served as a pivotal point, where widespread lockdowns, fluctuating consumer demands, and logistical hurdles led to significant challenges for businesses employing JIT. The system's reliance on low stock levels and a tightly interconnected supply network left many companies unprepared for sudden disruptions. Stockouts, production delays,

and mounting backlogs became frequent as supply chains struggled to recover. Even industries that traditionally embraced JIT for its efficiencies found themselves rethinking their reliance on lean inventories.

In response to these challenges, businesses have begun to adapt their inventory strategies by incorporating buffer stocks or "just-in-case" approaches to hedge against the risks associated with JIT. These buffer strategies involve maintaining extra inventory as a cushion against unexpected disruptions, ensuring that production can continue even if supply chains falter. While buffer stocks increase carrying costs, many organizations have recognized them as necessary to safeguard against future uncertainties and maintain customer satisfaction.

Moreover, technological advancements provide promising solutions to enhance JIT systems. Predictive analytics, machine learning, and other data-driven tools enable more accurate demand forecasting, helping businesses better anticipate fluctuations and adapt inventory levels accordingly. These technologies can significantly reduce the risks of stockouts or overstocking by providing real-time insights into consumer trends and supply chain performance.

METHODOLOGY

The subject and the problem of research

This paper focuses on the analysis of inventory management strategies in supply chain systems, particularly contrasting Just-in-Time (JIT) and buffer stock (or "just-in-case") approaches. The study aims to understand the interplay between these strategies and how they impact supply chain resilience, especially in light of recent disruptions like the COVID-19 pandemic. Supply chain management practices are at a critical juncture where balancing lean and flexible operations is vital for maintaining business continuity amid market uncertainties.

Research goal

The primary goal of this paper is to investigate and analyze the effectiveness of different inventory management strategies in enhancing supply chain resilience. Specifically, it aims to:

Compare and contrast Just-in-Time (JIT) and buffer stock ("just-in-case") inventory strategies, focusing on their advantages and limitations in mitigating risks and disruptions.

Research questions

How do Just-in-Time (JIT) and buffer stock strategies compare in their ability to enhance supply chain resilience and manage disruptions?

Research method

This research constitutes a theoretical approach wherein conclusions are derived from the examination of previously conducted studies. It involves considering various methodologies employed by other researchers and analyzing their findings to establish overarching conclusions.

RESULTS AND DISSCUSION

In the realm of supply chain management, JIT requires a highly coordinated approach involving all elements of the supply chain, from suppliers through to the end customer. At its core, JIT necessitates exceptional communication and collaboration with suppliers to ensure that components and materials

arrive just in time for assembly or manufacture. This not only minimizes the need for large storage facilities but also reduces the capital tied up in unused stock (Hamadneh et al., 2022).

Critical to the success of a JIT strategy is the reliability of suppliers and the stability of the supply chain. Suppliers must be able to deliver materials of consistent quality on a predictable schedule. Any delay or defect in the supply chain can halt the entire production process, leading to potential losses. Therefore, risk management becomes an essential aspect of the JIT system, requiring companies to develop robust contingency plans, including maintaining relationships with multiple suppliers or keeping limited buffer stocks for critical components (Mishra, 2016).

Furthermore, JIT can significantly enhance production efficiency and reduce waste, contributing to improved overall profitability and customer satisfaction. By reducing the incidence of overproduction, JIT aligns production schedules closer to consumer demand, thereby also reducing the cost of unsold good(Khusairy Azim, 2018)

However, the effectiveness of JIT is heavily dependent on the predictability of demand and the absence of disruptions in the supply chain. Economic uncertainties, natural disasters, or even labor disputes can disrupt the delicate balance of JIT systems, highlighting the need for a flexible approach to inventory management. As such, many firms that implement JIT systems also invest heavily in advanced forecasting techniques and supply chain analytics to better predict and respond to potential disruptions(D. K. Singh, 2013).

Buffer stock, often referred to as "safety stock" or "just-in-case" inventory, is a strategic inventory management approach that involves holding extra quantities of raw materials, components, or finished goods to protect against uncertainties and supply chain disruptions. This strategy serves as a counterbalance to the Just-in-Time (JIT) approach, offering a safety net that cushions production lines from unexpected supply chain issues, demand fluctuations, or production delays(Bradley, 2015).

The concept of buffer stock gained prominence in supply chain management as businesses began recognizing the risks associated with running lean inventory models, particularly following global disruptions such as the COVID-19 pandemic. Companies operating with minimal inventories under JIT principles were caught unprepared for sudden supply chain interruptions, resulting in stockouts and production stoppages. The adoption of buffer stock strategies allowed businesses to mitigate these risks by maintaining a reserve that could be tapped into during supply chain disturbances(Soares et al., 2021).

Buffer stock provides a cushion to absorb unpredictable spikes in demand, preventing potential lost sales or customer dissatisfaction. By maintaining a reserve of inventory, companies can quickly respond to sudden increases in customer orders without needing to wait for new supplies from their vendors(Mangal & Gupta, 2015).

Maintaining buffer stocks can protect production lines from supplier delays or logistical bottlenecks. This is particularly valuable in industries where a reliable and continuous flow of inputs is necessary to sustain production processes. The additional inventory ensures that production can continue even if supplier shipments are delayed or disrupted(Lu et al., 2021).

Lead time variability, caused by fluctuating shipping times or inconsistent supplier performance, can create significant challenges for inventory planning. Buffer stock accommodates these variations, reducing the impact of delivery delays on production schedules(Saoud et al., 2021).
Buffer stocks are often allocated for critical components that have a long lead time or limited supplier base. In some industries, the absence of a single component can halt entire production lines, making it crucial to have strategic reserves of such items(Andry et al., 2023).

While buffer stock provides risk mitigation, it also leads to increased carrying costs, warehousing expenses, and potential obsolescence. Therefore, careful analysis is needed to determine the

appropriate levels of buffer stock that balance supply chain risk with cost-efficiency(Lapinskaitė & Kuckailytė, 2014).

Technological advancements enable dynamic optimization of buffer stocks, ensuring that reserves are adjusted based on real-time demand data and supply chain conditions. Predictive analytics and machine learning are increasingly used to determine optimal safety stock levels that reflect current market conditions(Dziri et al., 2019).

Just-in-Time (JIT) and buffer stock are two contrasting approaches to inventory management that represent different philosophies and strategic priorities in the supply chain. JIT, with its origins in the post-war Japanese automotive industry, focuses on minimizing waste and reducing costs by aligning production schedules closely with demand. Buffer stock, on the other hand, represents a more conservative approach that seeks to build a safety net against unpredictable demand spikes, supply chain disruptions, or production delays.

GUIDELINES AND RECOMMENDATIONS

Adopt a Hybrid Inventory Strategy. A one-size-fits-all approach rarely provides optimal results in today's volatile market environment. Companies should consider adopting hybrid inventory strategies that blend Just-in-Time (JIT) principles with buffer stock practices. This hybrid approach can help achieve operational efficiency while maintaining resilience. For instance, JIT principles can be applied to regular production operations, while a limited buffer stock can be maintained for critical components or during high-risk periods.

Strengthen Supplier Relationships and Diversify Supply Sources-Businesses should cultivate close partnerships with their key suppliers to ensure reliable, high-quality inputs and improve supply chain visibility. Additionally, diversifying the supplier base by incorporating multiple sources for critical components can reduce dependency on single suppliers and help mitigate supply chain risks. Nearshoring or regionalizing supply chains could further enhance flexibility and reduce lead times.

Invest in Advanced Forecasting and Data Analytics-Predictive analytics, machine learning, and other advanced data analysis techniques should be leveraged to improve demand forecasting and inventory management. By utilizing real-time data on market trends, consumer behavior, and supplier performance, businesses can better anticipate demand fluctuations and adjust inventory levels accordingly. These insights enable companies to fine-tune their hybrid models and optimize safety stock levels.

Incorporate Risk Management Practices-Organizations should incorporate comprehensive risk management strategies into their supply chain planning processes. Scenario planning, risk assessments, and contingency planning can help identify potential disruptions and establish protocols to minimize their impact. Maintaining emergency buffer stock and alternate supplier contracts are practical ways to prepare for unexpected challenges.

Continuously Monitor and Adapt Inventory Strategies- The effectiveness of inventory strategies depends on how well they align with evolving market conditions and organizational needs. Regular reviews and performance assessments can reveal areas for improvement. Businesses should establish key performance indicators (KPIs) that monitor efficiency, cost-effectiveness, and supply chain resilience, and use these metrics to refine inventory policies.

Integrate Technology and Automation- echnological advancements such as Internet of Things (IoT) devices, robotics, and supply chain management software can automate processes and provide real-time visibility into inventory flows. These tools help streamline ordering, monitor inventory levels, and quickly respond to supply chain fluctuations. Automation also reduces errors and improves efficiency in JIT systems.

Consider Regulatory and Environmental Factors-Companies should ensure that their inventory practices are aligned with existing regulations and environmental considerations. Waste reduction, ethical sourcing, and reverse logistics should be integral parts of inventory management strategies. This not only ensures compliance but can also enhance the company's brand reputation and customer loyalty.

CONCLUSION

The evolving landscape of supply chain management has underscored the need for strategic and adaptive inventory practices. Just-in-Time (JIT) and buffer stock represent two distinct approaches to inventory management, each offering unique benefits and facing inherent challenges. JIT, with its roots in the lean manufacturing movement, prioritizes efficiency and waste reduction by aligning production closely with demand. However, its reliance on streamlined inventory levels leaves it vulnerable to supply chain disruptions and unexpected demand shifts. Conversely, buffer stock provides a safeguard against these disruptions by maintaining a safety net of extra inventory but introduces higher carrying costs and potential obsolescence.

The recent global disruptions, such as the COVID-19 pandemic, highlighted the vulnerabilities of purely JIT systems, resulting in significant production delays and stockouts. Consequently, businesses have begun adopting hybrid models that incorporate buffer stocks for critical components while maintaining lean inventory principles for regular operations. These hybrid approaches seek to balance operational efficiency with supply chain resilience, recognizing the importance of maintaining flexibility in an unpredictable global market.

Moreover, the adoption of advanced technologies, such as predictive analytics and machine learning, has proven instrumental in optimizing inventory strategies. These technologies provide organizations with real-time data insights, enabling more accurate demand forecasting and enhanced risk management. Supplier diversification, nearshoring, and alternative sourcing strategies also emerged as practical measures to strengthen supply chain resilience.

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CONSUMER BEHAVIOR IN ONLINE SHOPPING DURING CORONAVIRUS PANDEMIC

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ABSTRACT

The Covid - 19 pandemic, which completely changed our lives, further accelerated the process of online shopping. The pandemic had a strong impact on the purchasing behaviour of consumers, especially during the first wave of the pandemic. During the pandemic, older and less digitally savvy consumers began to discover online shopping. The main goal of our research was to find out the attitude of consumers towards online shopping and their satisfaction with online shopping, and to study the impact of the coronavirus pandemic on online shopping. We want to check whether the coronavirus pandemic has increased the volume of online shopping and changed the attitude and satisfaction of customers towards online shopping compared to the time before the pandemic. Research has shown that the most consumers have a positive attitude towards online shopping, and most of them are also satisfied with online shopping.

Keywords: Online shopping, Customer satisfaction, Coronavirus pandemic, Consumer behaviour.

INTRODUCTION

The coronavirus pandemic has deeply affected our lives over the past two years and in a way started a new chapter in human history. It has changed our way of living and acting and interfered with interpersonal relationships. It has changed our habits, which until now were deeply rooted and changed only slowly and gradually. One of these habits, which the pandemic has deeply affected, concerns the purchasing habits of customers, which is also pointed out by researchers Pantano, Pizzi, Scarpi and Dennis (2020), who say that during the pandemic, customers have shown purchasing behaviour that significantly deviates from normal purchasing behaviour.

Customer satisfaction was strongly influenced by the spatial arrangement of the store, the availability of products and the waiting time. The impact of the introduced political measures to curb the coronavirus on customer satisfaction also proved to be significant.

ONLINE SHOPPING

One of the basic instruments of electronic business is the online store. An online store is a store that operates in the Internet or online environment (Bucko, Lukáš, & Ferencová, 2018).

Online shopping can be defined as a form of electronic commerce that allows customers to purchase products or services over the Internet, using a web browser or mobile application (Al-Hattami, 2021). Already at the beginning of the use of the World Wide Web about 30 years ago, it was clear that eventually online shopping would become an alternative way of buying goods. Since then, online shopping has evolved in terms of range of services, efficiency, security and popularity, as online marketing needs continuous improvement if it is to meet the changing and evolving needs and expectations of customers (Laohapensang, 2009).

Internet penetration and the wide availability of 3G and 4G mobile networks have provided a huge boost to online stores in recent years. Over the past few years, online retail platforms have expanded from a few websites such as Amazon and eBay to a variety of alternative models such as social networking platforms, independent retailer websites, and shopping mobile apps. With the adoption of the 5G network, exponential growth is still expected (Nanda, Xu & Zhang, 2021).

Online shopping has been around since 1995, but it wasn't until recent years that the number of digital shoppers exceeded those who shopped exclusively at physical stores.

Ecommerce, in its current form, is not intended to completely replace in-store shopping. Some retailers are even moving towards a model where you can try things in-store and then get the same product shipped to you (Fakina, 2024).

THE IMPACT OF THE CORONAVIRUS PANDEMIC ON ONLINE SHOPPING

Consumer behaviour is necessarily a reflection of external factors, so it is quite clear that the coronavirus pandemic also had a strong impact on consumer behaviour.

The Covid-19 pandemic has generated dramatic changes in the social and financial lives of human beings and continues to spread all around the world uncontrollably (Kim 2020).

Since the beginning of the COVID-19 outbreak (early 2020), consumers displayed stockpiling behaviours that significantly deviate from their usual shopping behaviour. A further consequence of the lower accessibility of store premises, combined with consumers' higher health concerns, has been an immediate increase in demand for alternative distribution channels.

In 2020, online store trends were strongly influenced by store closures and restrictions on social movement due to covid-19. Experts predict that the impact of the coronavirus will not only be a short-term launch of e-commerce, but will also remain after the covid, as people will feel the benefits offered by online providers. The ability to shop from the couch, pay with a variety of contactless payments, and growing confidence in online business could lead to a lasting behavioural shift toward digital shopping. The positive impact of covid-19 on e-commerce, on the other hand, unfortunately represents a large loss and closure of many physical stores (Oberlo, 2021).

The development of online shopping as a way of coping with the coronavirus crisis involved not only new technologies, but also consumer training. As with all shopping, buyers must acquire the competencies and knowledge necessary to properly carry out this way of shopping, and it requires a specific set of competencies. Both general digital competencies and competencies specific to online shopping are required. While some consumers had experience with online shopping before the coronavirus crisis, others had to learn this new way of shopping during the pandemic. There are two ways to gain competencies; by interacting with others and with the technology itself. These two ways of acquiring purchasing competences are not mutually exclusive and are often combined. For consumers who had no prior knowledge of online shopping, interaction with others, usually family, was crucial. Those who did not shop online before the pandemic, usually the elderly, needed the support of more experienced and usually younger family and friends in the initial phase. Without their support in the initial phase, online shopping would probably not be possible, which shows the vulnerability of this way of shopping (Fuentes, Samsioe & Backe, 2022).

EMPIRICAL FINDINGS

The purpose of the empirical research is to gain insight into the attitude of customers towards online shopping, customer satisfaction with online shopping and the impact of the coronavirus pandemic on customer satisfaction with online shopping.

A questionnaire was made in 1KA - a one-click survey. There have been 14 questions. We collected respondents' answers by sending a link to the website and through social media platforms.

The total number of respondents for carrying out a market survey was 108 of this, 64 were women and 44 were men.

We first obtained data on the age structure of the respondents. Most respondents are from the 18-30 age group, as 65% of respondents belong to this group. It is followed by the 31-45 age group, represented by 25% of respondents. 8% of respondents are from the age group of 46-60 years, and 2% of respondents belong to the age group of over 60 years. (Table 1).

Table 1: Age of the respondents

Age (Years)	**Frequency**	**Percent**
18 - 30	70	65%
31 - 45	26	25%
46 - 60	9	8%
Over 60	3	2%
Total	108	100%

The next question was about employment status. According to the obtained results, 39% of respondents are students, 49% of respondents are employed, 5% of respondents are self-employed, 4% of respondents are unemployed, and 4% of respondents are retired.

With the following question, we wanted to check the attitude of the respondents to online shopping. As shown in Figure 1, 23% of respondents indicated that they have a very positive attitude towards online shopping, 60% said that they have a positive attitude, 14% have neither a positive nor a negative attitude, 3% of respondents have a negative attitude, and none of the respondents he did not say that he has a very negative attitude towards online shopping.

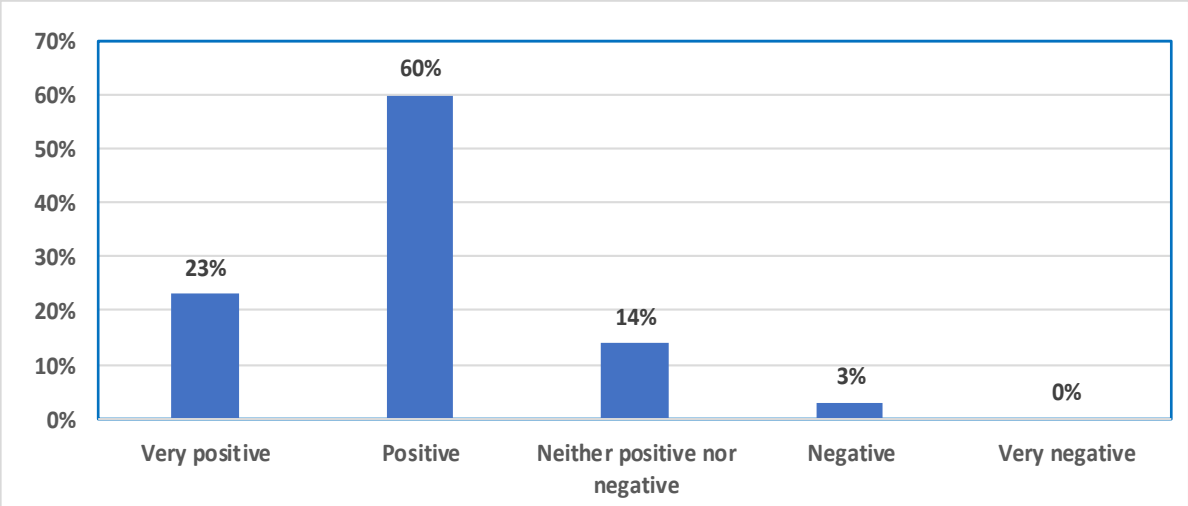

Figure 1: Attitude towards online shopping

In the next question, we wanted to reinforce the answers from the previous question, so we asked the respondents 10 individual statements that indicate satisfaction or respondents' dissatisfaction with online shopping. Respondents had to evaluate individual statements with grades 1 to 5, where grade 1 means that they do not agree with the statement at all, grade 2 means that they do not agree with the statement, grade 3 means that they neither agree nor agree with the statement, grade 4, that they agree with the statement and score 5, that they completely agree with the statement. The statements and the arithmetic mean of the respondents' answers are shown in figure 2 below.

As we can see, all 10 statements that check various aspects of satisfaction with online shopping exceeded the average score of 3.5, so we can say that most customers are satisfied with online shopping.

Figure 2: Arithmetic mean of answers to individual statements

We also wanted to know when respondents started using online shopping. As can be seen in Figure 3, 30% of respondents started using online shopping during the coronavirus pandemic, and 70% of respondents started using online shopping before the start of the pandemic.

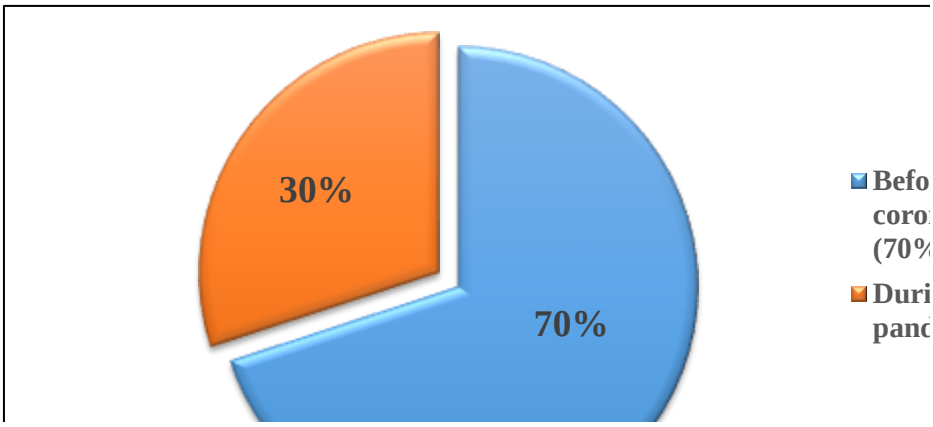

Figure 3: Getting started with online shopping

Respondents who started using online shopping before the start of the pandemic were also asked a question with which we wanted to check whether they were more satisfied with online shopping since the beginning of the pandemic compared to the time before the pandemic. Respondents who only started using online shopping during the pandemic were excluded from this question, as they could not give us relevant answers. There were 76 respondents included in this question. We asked them the following statement: "Since the beginning of the coronavirus pandemic, I have been more satisfied with online shopping compared to the time before the pandemic." and asked them to indicate to what extent they agree with this claim. The respondents had the following possible answers: "I completely agree", "I agree", "I neither agree nor disagree", "I disagree" and "I do not agree at all".

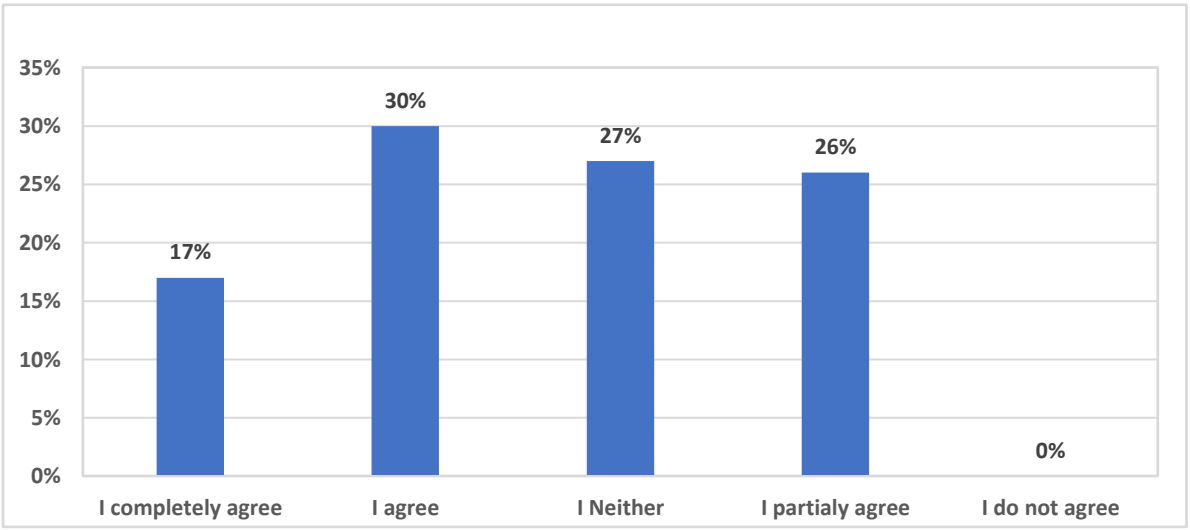

Figure 4: Respondents' satisfaction with online shopping since the beginning of the coronavirus pandemic compared to the time before the pandemic

As we can see in Figure 4, 17% of the respondents said that they completely agree with the statement, 30% of them said that they agree with the statement, 27% of the respondents neither agreed nor disagreed with the statement, 26% of the respondents disagreed with the statement agreed, but none of the respondents agreed with the statement at all, so this answer received 0%.

We can conclude that the majority of respondents were not more satisfied with online shopping due to the coronavirus pandemic. In the last question, we were interested in whether customers have a more positive attitude towards online shopping since the beginning of the coronavirus pandemic compared to the time before the pandemic. We included all 108 respondents in this question, including those who only started shopping online during the pandemic, as we believe that they can also make a relevant assessment of the comparison of attitudes towards online shopping.

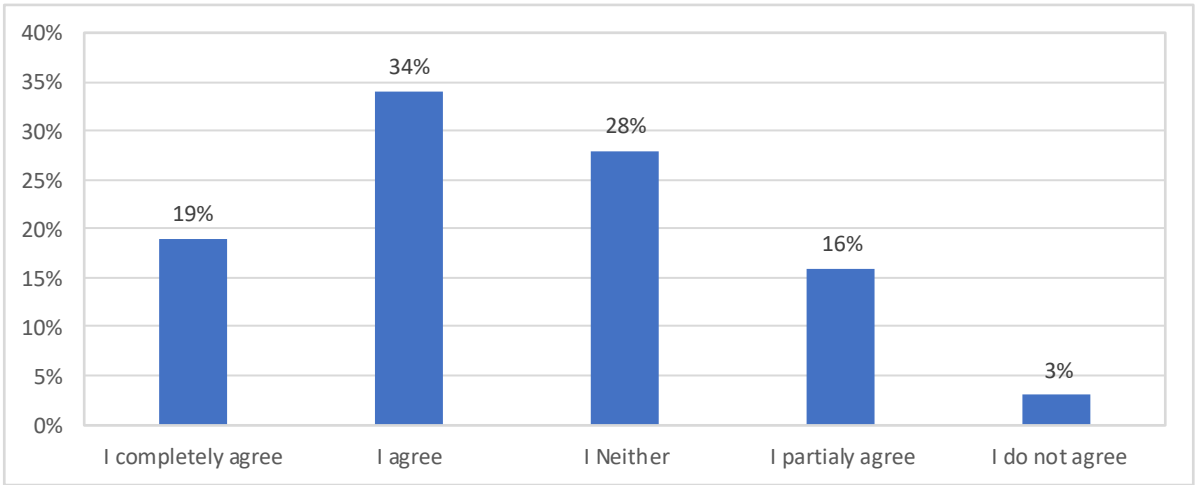

Figure 5: Respondents' satisfaction with online shopping since the beginning of the coronavirus pandemic compared to the time before the pandemic

As can be seen in Figure 5, 19% of the respondents said that they completely agree with the statement, 34% of them said that they agree with the statement, 28% of the respondents neither agreed nor disagreed with the statement, 16% of the respondents disagreed with the statement agreed, while 3% of respondents did not agree with the statement at all.

We can conclude that there were a total of 53% of respondents who answered yes to the statement and confirmed a more positive attitude towards online shopping since the beginning of the pandemic compared to the time before the pandemic, which is more than half, which consequently means that the majority of respondents have since the start of the coronavirus pandemic, a more positive attitude towards online shopping compared to the time before the pandemic.

CONCLUSION

We realized that the essential factors that influence customers' intentions to continue using online shopping are customers' attitudes towards online shopping and customer satisfaction with online shopping. Those customers who have a positive attitude towards online shopping are more likely to shop online. Over the years, it has also been found that attitudes toward online shopping are influenced by, among other things, experience with online shopping, level of Internet literacy, personal innovativeness, and computer self-efficacy. But the social aspect is also important, as customers feel pressure from their family and friends regarding online shopping, which means that online shopping is also influenced by social norms. Higher levels of customer satisfaction with online shopping were also found to influence increased online shopping volume. Satisfaction is a key factor that helps maintain a competitive advantage and usually stems from prior experience. This is influenced by the following factors: convenience of online shopping, appearance of websites, financial security, product range and product information, reliability of online shopping and customer service.

Since the start of the coronavirus pandemic, most respondents have not been more satisfied with online shopping compared to the time before the pandemic. Nevertheless, since the beginning of the coronavirus pandemic, they have a more positive attitude towards online shopping compared to the time before the pandemic. This is probably the result of the fact that during the pandemic, due to closed national borders and other anti-coronavirus measures, the delivery time for online purchases was often extended, which affected customer satisfaction, but despite this, customers perceived the usefulness of online shopping during the pandemic, so they have mostly developed a more positive attitude towards online shopping compared to the time before the pandemic.

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Session D: ECONOMY

Papers (pp. 179-230):

COST OF CAPITAL OF A CORPORATION

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ABSTRACT

Cost of capital serves as a basic indicator of successful composing of capital structure in any corporation. The fixing of cost of capital is important because it enables maximizing the value of corporation and making numerous financial decisions in the corporation. The data of financing costs concerning the existing capital structure are not authoritative for fixing cost of capital, but the date of the costs of additional out of which a corporation intends to be financed. That means it is necessary to determine the cost of own capital, the cost of borrowed capital and the cost of hybrid capital. For this reason, composing adequate capital structure in a corporation presents a very complex problem. This complexity implies not only the need of knowing the cost of every single financing source, but also knowing of the average cost of capital. The aim of this paper is to point to the complexity of certain aspects of fixing the cost of capital process as a criterion for making strategic financial decisions at the corporation level.

Keywords: Cost of capital, Capital structure, Corporation.

INTRODUCTION

From the standpoint of financial decision making in a corporation, the cost of capital is given great significance today, since the cost of capital is used as the main indicator of successful composing of the capital structure of each specific company. In fact, in modern business conditions, it is difficult to assume that any company has at any given moment an optimal capital structure that provides optimal financing costs. In pursuit of such an optimum, determining the cost of capital, which is conditioned by a combination of existing and potential sources of financing, is almost an inevitable path to establishing economically rational criteria for financial decision making at a company level. Bearing in mind the fact that there are no free sources of financing in the market economy, it follows that composing a good capital structure of a company is a rather complex problem. This complexity necessitates knowledge of not only the cost of each individual source of financing, but also the knowledge of the average cost of capital of a company. Consequently, in the following presentation, we will try to briefly explain the main set of issues related to both the costs of individual sources of financing and the average cost of capital of a company. In this context, attention will be focused on the consideration of the following set of issues:

1. Cost of capital from the issue of ordinary shares,
2. Cost of accumulated income,
3. Cost of long-term debt,
4. Cost of capital from the issue of preference shares,
5. Average cost of capital.

COST OF CAPITAL FROM THE ISSUE OF ORDINARY SHARES

Theoretically, the cost of capital from the issue of ordinary shares can be defined as the minimum rate of return that a company needs to realize by investing into business in order to prevent a decrease in the market price of shares. From the standpoint of investors in shares, the cost of capital from the issue

of ordinary shares could be defined as the return that they expect to obtain by investing in the shares of the company. If we start from the logical assumption that shareholders expect the dividends to grow steadily in the future (model of constant dividend growth), then the rate of return for potential investors, which from the standpoint of the company represents the cost of capital from that source, can be quantified as follows:

$$r_e = (D_1 / P_0) + g, \quad \text{where: } D_1 = D_0 (1 + g) \tag{1}$$

r_e - cost of capital from the issue of ordinary shares
D_1 - expected dividend in the following year
P_0 - current price of shares
g - dividend growth rate

Based on the given formulae, it is clear that by applying the model of constant dividend growth, the cost of capital from the issue of ordinary shares is estimated according to the current price of shares, dividends per share and dividend growth rate. For companies whose shares are traded on the market, information on the current price of shares and dividends per share can be obtained directly, while the dividend growth rate must be estimated. In addition, it can be estimated based on the dividend growth rate realized in the previous period or based on estimates of the future dividend growth rate. According to this model, the cost of capital from the new issue of ordinary shares is equal to the discount rate (internal rate of return) that equates the present value of the expected dividend per share with the current price of share, assuming that a steady growth in net profit and dividends is expected.

However, it should be noted that the model for determining the cost of capital from the issue of ordinary shares described here has its advantages and disadvantages. The advantages of this model are reflected, on the one hand, in it being simple and understandable, since the return in the form of dividend can be easily estimated, and on the other hand, not all future dividends have to be directly estimated, but it is necessary to estimate the dividend growth rate. However, there are several important disadvantages of this model, namely: (a) the model can be applied only to companies that pay dividends, (b) the model assumes that dividends grow at a constant rate, which is not the case in practice, (c) the model is very sensitive to the estimated dividend growth rate, and (d) the model does not take into account the risk, i.e. there is no direct adjustment to the investment risk, since the current price of shares is used (Besley & Brigham, 2015).

COST OF ACCUMULATED INCOME

For many companies a significant percentage of long-term financing sources come from the accumulated net income. That part of the net income cannot be considered a free source of financial assets due to the presence of the opportunity costs of financing. The level of these costs is in fact determined by the dividend which had to be sacrificed by shareholders since the proportionate share of the net income is not distributed but is retained and invested in the company's operations. Similarly, the cost of capital resulting from the accumulation of net income could be defined as the rate of return the shareholders expect to obtain from the ordinary shares of the company (Todorovic & Ivanisevic, 2021). However, the cost of accumulated income is quite difficult to quantify. In addition, there are two basic criteria or approaches as possible solutions to this problem, namely: (a) the criterion of the sacrificed income, and (b) the criterion of external income.

(a) According to the criterion of sacrificed income – the cost of the accumulated income is in the functional dependence with the dividend sacrificed by shareholders, since the net income is not paid in full, but is reinvested in the company's operations. In addition, the boundary of the justification of income accumulation is seen in the equal rates of return that can be achieved on such assets in the company and the rate of return that would be received by shareholders by investing individually in other market alternatives with equivalent risk. If we disregard here the effect of taxation of dividends, then the cost of accumulated income (r_a) in this context is equal to the required rate of return on external sources of owned capital (ordinary shares), which can be expressed in the following formula:

$$r_a = (D_1 / P_0) + g \tag{2}$$

In the previous part, we saw that the cost of capital from the issue of ordinary shares was determined according to the given formula, which means that the same formula can be used to determine the cost of accumulated income. In this regard, it is considered that at such a cost of accumulated income, the market price of shares would remain unchanged. In other words, the market price of shares will remain unchanged if the rate of return equal to the cost of share capital is realized for the invested accumulated income. Consequently, the income which is lower or higher than the cost of capital will result in a decrease, i.e. an increase in the market price of the shares. However, opponents of such considerations point to the fact that the cost of accumulated income (ra) as determined in the previous way is high, because the income of shareholders from dividends is lower for the amount of tax they have to pay to the dividend received, as well as for the amount of any intermediary commission which they have to pay in the event that the received dividend is reinvested outside the company. Accordingly, shareholders will realize a lower rate of return than (ra) which at the same time means that those moments will have to be included in the formula we have previously given. After the inclusion of these facts in the mathematical form, we get the following quantitative expression:

$$ra = (D1 / P0 + g) \times (1 - T) \times (1 - B) = re \times (1 - T) \times (1 - B) \quad (3)$$

ra - cost of accumulated income
re - cost of share capital
T - marginal tax rate paid by the shareholders to the total income
B - percentage of intermediary commission

(b) According to the criterion of external income - in determining the cost of accumulated income, a company is based on the criteria of external income. According to this criterion, in determining the cost of accumulated income, a company must consider investment opportunities into available market alternatives with identical risk outside the company. The logic of this approach is that the potential income of the best available external alternative, according to the principle of opportunity cost, must be added to accumulated incomes as the cost of capital. Unlike the previous approach which insists on the income that the shareholders could achieve by excluding the distributed profit and placing it somewhere else, the criterion of external income assumes that the assessment is done by the company itself, leaving the income within the business. Therefore, it is considered that the criterion of external income reflects economically reasonable opportunity costs from the standpoint of the company and, consequently, can be consistently applied in determining the cost of the accumulated income.

COST OF LONG-TERM DEBT

The borrowed capital is characterized by precise time of maturity, as well as the predetermined amount and time schedule of the interest expenses. Consequently, identifying the cost of debt is based on the two cash flows that occur as a result of debt assumption, namely: (a) the net income from debt (sale price of bonds P_0), and (b) periodic expenses for interest and repayment of principal at the maturity of debt. Consequently, finding of the discount rate which equates the present value of these two flows is assumed. For a potential buyer, this rate is the expected rate of return on a bond, or alternatively, the profit up to the maturity. In addition, the accounting treatment of interest as the expense and coverage of its operating profit (profit before taxation) reduces the taxable result of the company, which results in lower tax expenditures. For its part, this causes the cost of debt to be determined in two levels: before and after taxation (Malinic et al., 2019).

Cost of debt before taxation is the contracted interest rate for assets acquired through long-term loan arrangements. For the assets procured through the sale of bonds, the cost of debt is equal to the nominal interest rate, provided that the nominal interest rate and the market rate are the same. If we assume that the company is financed only by debt and share capital, then the cost of debt can be defined as the minimum rate of return that must be achieved on the investment from debt in order to avoid a decrease on the rate of return on the share capital (Brealey et al., 2017). Otherwise, theoretically speaking, the cost of debt (borrowed long-term sources) is the rate of return that must be earned on investments financed with borrowed capital in order to enable the return of debt principal with the agreed interest. In addition,

mathematically, it is possible to calculate the cost of capital from this source by adapting the model of the market value of bonds. Namely, it is well known that the market value of bonds can be calculated by the following formula:

$$V_0 = \sum_{i=1}^{n} \frac{In + Vn}{(1+i)^n} \tag{4}$$

Mathematically, the price of bond as a form of debt can be calculated by adapting the model for the determination of the market value of bonds. In addition, adaptation of the model of market value of bonds is realized by replacing the market value (V_0) with the net income from the sale of bonds (P_0) as the known value (Antony & Biggs, 2016). Consequently, we have the formula:

$$P_0 = \sum_{i=1}^{n} \frac{It}{(1+i)^t} + \frac{Vn}{(1+i)^n} \tag{5}$$

I_t - annual (periodic) amount of interest
V_n - amount of the principal at maturity
n - maturity
i - cost of bond as a form of debt, before taxation
P_0 - sale price of bond

Determining the cost of debt after taxation requires adjusting the cost of debt before taxation for the expected effect of the income tax. Business income represents the total effect of business with the total business assets, regardless of the source from which it is financed. This means that in the accounting sense, if the company in the capital structure has borrowed sources, expenditures for interest are in fact a part of business income. In addition, tax legislation treats interest expenses as expense for the period and determines the tax as the difference between operating income and interest expenses. Consequently, with the same amount of business income, the amount of tax base (income before taxation) is directly determined by the amount of expenditures for interest, i.e. capital structure of the company. Logically, this means that at the same level of business profit, a company with a high share of foreign capital in the financing structure and high interest expenses will have a lower taxable base compared to a company that has no expenses for interest, i.e. is funded only by own capital. This effect is known as the tax savings and it de facto favors financing companies from borrowed sources. In the context of the cost of debt, the tax savings result in a higher cost of debt before taxation than after taxation. However, the effect of the tax savings is only possible if the company operates profitably, i.e. realizes operating profit. Companies operating with losses or at the breakeven point of profitability cannot count on the effect of the tax savings, since for them the tax rate is zero, and the cost of debt is equal to the interest rate (Veselinovic & Vunjak, 2014).

Regardless of the methods of obtaining long-term borrowed capital (loan arrangements or bond issue), the cost of debt can be determined as the discount rate that equates the current net cash income from specific sources of financing with the present value of future expenditures on behalf of the interest and principal as adjusted for the expected effect of taxation (Zhong et al., 2018). In this context, and in accordance with notes listed here, it is clear that the cost of debt before taxation must be corrected for the effect of income taxes to the profit. This correction is performed by the model which can be represented in the following formula:

$$k = k_d (1 - t) \tag{6}$$

k_d - cost of debt before taxation (internal rate of return)
k - cost of debt after taxation
t - income tax rate

COST OF CAPITAL FROM THE ISSUE OF PREFERENCE SHARES

Preference shares are a hybrid source of financing for a company that bears the characteristics of debt and share capital. Namely, preference shares are similar to debt in that they cause fixed periodic expenses such as dividends for the company and that privileged shareholders in the event of liquidation of the company have a pre-emption right to the company's assets in relation to the ordinary shareholders. In accordance with the fact that the preference shares are hybrid sources of financing, determining costs so obtained capital is quite similar to determining the cost of debt. Accordingly, identifying the cost of this source of financing starts from two cash flows that occur as a result of the sale of preference shares, namely: (a) one-time cash receipts from the sale of shares in the amount of the price which shares reach on the market, minus any flotation costs, and (b) a permanent issue based on preferred dividends, which by its characteristics represents a perpetual annuity (Ivanis, 2019). In addition, the problem of determining the cost of this source of financing comes down to finding the discount rate at which the present values of the aforementioned flows are equalized. In addition, mathematically, the cost of capital from the emission of preference shares can be reached by adapting the model of the market value of preference shares. Namely, it is well known that the market value of preference shares can be calculated by the following formula:

$$\text{Vpa} = \sum_{t=1} \frac{D_t}{(1+k)^t} = \frac{D}{k} \qquad (7)$$

Mathematically, we can calculate the cost of capital from the issue of preference shares by adapting the model for determination of the market value of preference shares. In addition, the adaptation of the model of the market value of preference shares is realized by replacing the market value of preference shares (V_{pa}) with the market price of preference shares (P_{pa}), i.e. income from the issue of preference shares. Consequently, we will have the following formula: $P_{pa} = D / k_{pa}$ where the P_{pa} is the market price of preference shares, D is the annual amount of preferred dividend, while k_{pa} is the cost of capital from the issue of preference shares. Solving the above formula according to k_{pa}, it follows that the cost of capital from the emission of preference shares can be expressed as the ratio of the annual preferred dividend (D) and their market price (P_{pa}), i.e. cash income from the sale of preference shares. This can be represented by the following form: $k_{pa} = D / P_{pa}$ where we have already explained the meaning of the given symbols.

AVERAGE COST OF CAPITAL

Bearing in mind the fact that the capital of the company is, as a rule, composed of multiple sources of different costs, determining its average cost is not an easy task. Due to the different relative share of individual sources in the capital structure, the average cost of capital of a company cannot be established as a simple mathematical mean of costs of individual sources. Similarly, for finding the average cost of capital of a company, a system of weighing the individual cost of individual sources is usually used, the most commonly used weights being the relative shares of individual sources in the capital structure of the company. As a result of this process, the weighted average cost of capital (*WACC*) is obtained, which expresses the expected average future costs of capital of a company in the long run.

Observing the abovementioned, it can be said that the weighted average cost of capital (WACC) is a standard methodology for calculation of the average cost of capital. In addition, the process of calculating the weighted average cost of capital of the company is reduced to multiplication of the cost of capital from each individual source of financing with appropriate weights. However, the specific calculation of the average cost of capital can be estimated only when the cost of capital obtained from each individual source of financing is known. Similarly, assuming that the company is funded from various sources, the weighted average cost of capital (WACC) could be calculated using the following formula:

$$\text{WACC} = k_1 w_1 + k_2 w_2 + k_3 w_3 + k_4 w_4 + \ldots\ldots k_n w_n \qquad (8)$$

In the mentioned formula, $k_1, k_2, k_3, k_4 \ldots\ldots k_n$ are costs of individual sources of financing (after taxation) included in the capital structure of the company, while $w_1, w_2, w_3, w_4 \ldots\ldots w_n$ represent the respective weights, i.e. the relative participation of individual sources in the capital structure. In

addition, it does not need to be specially noted that $w_1 + w_2 + w_3 + w_4 + ... w_n = 1,0$. However, the process of quantifying the weighted average cost of capital of a company necessarily requires addressing two key issues, namely: (1) determining the costs of individual sources of financing (after taxation) that are involved in the given capital structure of the company, and (2) specifying the basis for weighting (Ivanis, 2019).

CONCLUSION

The previous discussion has shown that in most cases the corporation can choose any capital structure it wants. Accordingly, modern research has shown that companies with similar activities tend to have a similar capital structure, which indicates that the nature of their assets and operations is essentially determined by the structure of their capital. It has also been noted that the companies include in the capital structure larger amounts of debt when marginal tax rates rise and when the management function is clearly separated from the ownership function. On the other hand, companies are going to reduce the share of debt when they have unstable and variable cash flows, when there is no ability to control the company and when there is a need for flexibility in terms of decision-making in the future. In addition, research has shown that financial managers in the choice of capital structure prefer the accumulated income and capital from the issue of pure and convertible bonds. In fact, only when they cannot be financed from these sources, do they include the capital obtained by issuing ordinary and preference shares in the capital structure. In addition, whenever it is possible, financial managers will turn to financing from the so-called clean sources (issuing bonds and shares), i.e. only if they have no other option will they resort to obtaining capital by issuing hybrid securities (convertible bonds and preference shares). Consequently, the main reason for a greater inclusion of debt in the capital structure is the need to maximize share prices. At the same time, the main reason given for avoiding financing by issue of shares is to avoid the dilution of the company's capital.

Composing an adequate capital structure is a very complex problem. A traditional financial rule was that the ratio of owned and borrowed capital is 1:1. However, in conditions of modern corporation operations, the practice has simply refuted this rule and it has been abandoned. Similarly, it is considered that the modern corporation should decide on such a ratio of debt and share capital which maximizes the value of ordinary shares, i.e. which maximizes the value of the entire company. In addition, it is important to note that changes in the value of a company are the same as the net effect for shareholders and, consequently, financial managers must always strive to find such a capital structure that maximizes the value of the company.

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STRATEGY OF MANAGING FINANCIAL RESOURCES

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ABSTRACT

Managing financial resources (cash) in a company represents especially significant and sensitive task of financial managers. In the process, the sensitivity and complexity of managing financial resources is conditioned by the need of constant balancing between two basic financing principles – profit priciple and liquidity principle. This balancing, as a matter of fact, comes to the requirement for establishing and maintaining optimal balance of cash at any moment. Contemporary economic practice shows that even the most liquid and the most profitable companies are short of financial resources. In such situations, the management of the company has to find new sources of financial resources and also at the most favourable conditions. On the contrary, in the conditions of financial resources surplus, the task of the management is to find out opportunities for a short-term investment of cash at satisfactory profit and maximal security of return of financial resources. The aim of this paper is to point to the complexity of some aspects of the financial resources management process in company.

Keywords: Strategy, Managing, Resources, Cash, Company.

INTRODUCTION

From the aspect of management of financial resources or cash management, a company has an urgent need to adhere to two basic principles, namely: the principle of profitability and the principle of liquidity. Respecting the principle of profitability, the main concern of the company is to achieve maximum results with minimal investment, which is the main motive of business. On the other hand, a successful performance of the company and keeping the company in its environment, imposes the obligation to provide continuous liquidity, i.e. the performance of obligations in a timely and complete manner. Bearing in mind that management of financial resources is a very dynamic process, it is not surprising that the company is often tempted to give an advantage to one financial principle over another, especially as the principle of profitability and the principle of liquidity are in mutual conflict. Thus, the effective management of financial resources or cash becomes extremely important and sensitive task of managing the company's finances, given that it puts into the focus the balancing between the two basic principles of finance - the principles of profitability and the princliple of liquidity of the company. This balancing, as a matter of fact, comes to the requirement for establishing and maintaining an optimal balance of cash at any moment. In addition, any surplus cash above the level of requirement has an impact on reducing profitability, while any cash deficit below the level of requirement, directly threatens the solvency of the company, i.e. the ability to pay due obligations.

Previous practice shows that even the most liquid and the most profitable companies are often short of financial resources. In such situations, the management of the company has an obligation to find new sources of financing, in the shortest possible time and also under the most favourable price (interest rate). However, one should bear in mind that it is very difficult to find short-term financial resources for the maintenance of liquidity in the moment when the company needs them. Also, it is very risky to withdraw the excess of short-term invested cash within the situation of general insolvency. Hence, theoretical and practical experience suggests that it is possible to find a solution to the liquidity that will not threaten the profitability of the company, only provided that there are stable partners, the company and the bank.

More precisely, the movement of interests of the principle of profitability and the principle of liquidity could be implemented according to a model that would enable the company and a commercial bank to slove together the difference between the daily inflows and outflows. In fact, at a time when the inflow of financial resources is smaller than outflow, the difference wuld be covered from the financial resources of a commercial bank. Conversely, at a time when the inflow is bigger than the outflow of financial resources, the company would pay the difference to an account of a commercial bank. In this way, the company would open with a business bank the so-called open account (business operations on the principle of the current account), which would be in the red or in the black, depending on whether the company pays the excess funds to their commercial bank or the commercial bank has to intervene in the area of coverage of liabilities of the company. In addition, the financial activity of enterprises and commercial banks would be measured through active and passive balance on the open accounts and calculated lending and deposit interests at an agreed interest rate, which would be paid by a net debtor at the end of the year (Vapa & Ivanis, 2023).

CASH CYCLE

Cash management requires knowledge of some important features of cash. In fact, a good knowledge and understanding of all the important features of cash allows, taking into account their impact on decisions within the scope of cash management, to better contribute to the success of business operations of a company, in terms of the maximum profitability within its continuous current solvency i.e. liquidity (Chandra, 2022).

Similar to other forms of working capital, the circulation of cash through the process of business operations of an enterprise can be measured and expressed by the average duration of one turnover called the cash cycle. In addition, the cash cycle is generally defined as the number of days in a year that have elapsed since the issuance of cash for the purchase of raw materials to the point of receiving cash as payment of proceeds from the sale of finished products in which the purchase value of raw materials is realistically contained. More precisely, the cash cycle indicates the length of time from issuance of financial resources for the purchase of raw materials, to the payment of sold goods or services. In addition, there are significant differences in the length of the cycle from the time of acquisition of assets to the time of collection of receivables from sold goods or services, when the fixed assets or working capital are in question (Todorovic & Ivanisevic, 2021).

Duration of the cash cycle for the purchase of *fixed assets* begins with payment for their purchases, and ends after the collection of revenue, and at the end of useful life of the asset. Thus, the cycle of engagement of financial resources in fixed assets last as long as depreciation of the said business asset. Therefore, engaging cash for the purchase of fixed assets is less common, while the collection of thus engaged financial resources is long lasting and successive.

Duration of the cash cycle for the supply of *working capital* begins with their purchase and ends with the sale and collection of finished goods and merchandise. In addition, in order to calculate a cash cycle it is necessary to have good quality information on stocks, clients and suppliers. Stocks as part of the real assets of the company change in the physical form, while investing in the stocks, observed financially, is continuous and relatively constant. Financial investment in accounts receivable is a reality due to the time interval between the act of sale and the act of collection of receivables. Financial investments of this type would not be present if the company paid raw materials and supplies at the takeover, and charged the finished products at the time of sale. Practical experience shows that it is not so, but that the supplier (seller) credits his customers. Hence, the company is often in the role of the buyer (debtor) and the seller (creditor). In cases where a company purchases raw materials and supplies, it is the client who is credited by his suppliers. In cases where the company sells the finished products, it is the seller (supplier) who credits his clients (Ivanis, 2019).

Based on the above, it can be concluded that the company is in two basic positions. Firstly, when purchasing raw materials, then it is the buyer and as such is credited by the supplier. Secondly, when it sells finished products then it changes its role to the seller (supplier) and finds itself in the position of the client's

creditor. Accordingly, in the cash cycle from the sale and payment of raw materials to the sale and collection of finished products, there are three main factors which are essential: stocks, clients and suppliers, which may be graphically illustrated as shown in Figure 1.

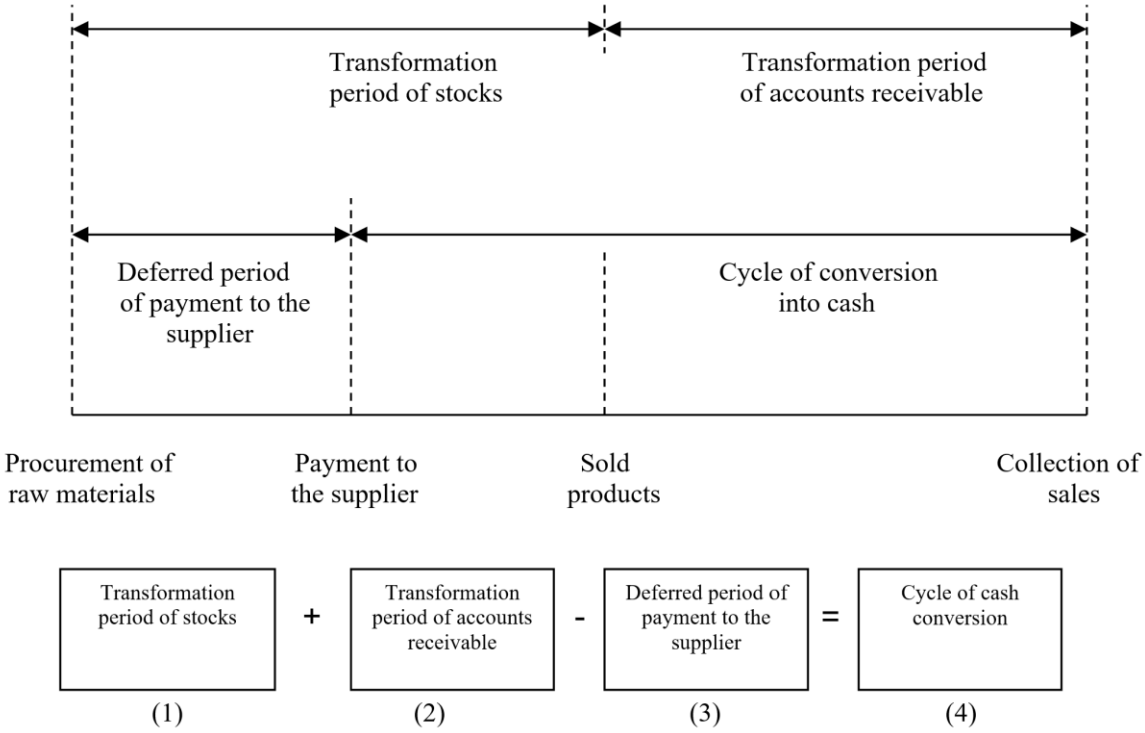

Figure 1: Cycle of financial resources (cash cycle)

From the aspect of cash management, the pursuit of each company is focused in the direction of shortening of the cash cycle. In this way, less financial stress is achieved related to financially finest form of property, which is undoubtedly the cash. At the same time it means shorter total turnover of working capital, and therefore less investment in total current assets. In other words, the sense of financial management of cash should be sought in the shortening of the average time of turnover, since this inherently assumes the company's operates with a correspondingly smaller cash balance. However, it is not advisable to go so far so that the cash balance falls below the minimum required level to avoid compromising the current liquidity of the company.

On the other hand, *indirect reduction* of the duration of the cash cycle can be achieved by faster turnover of stock, both materials and finished products, as well as reducing production time, which certainly falls within the scope of consideration of management of the mentioned forms of property. However, *direct shortening* of the cash cycle implies contracting the biggest possible postponement of payments to suppliers of purchased materials and services used (Brealey, et al., 2017). Also, another possibility for this may be contracting as short period of collection receivables for the sold products as possible or stimulating faster payment of goods sold and services by granting cash discounts etc. Although it is very difficult to precisely delineate what falls within the scope of cash management, and what falls within the scope of management of receivables and liabilities, the fact remains that we should not go beyond consideration of the issues of cash.

Cash turnover ratio = Total annual cash outflows / Average cash balance

from which it follows that:

Average cash balance = Total annual cash outflows / Cash turnover ratio

On the basis of the above relations, it is evident that the minimum cash balance is in fact equal to the average annual balance which is conditioned by the size of the payments within a given period of time and

the cash turnover ratio. Thus established minimum cash balance implies full harmonization of cash inflows and outflows, which is conditioned by the state of financial stability, but also the coincidence of the short period of immobilization deadlines of short-term assets and due dates for payment of current liabilities. When the financial stability of the company is good, and the mobilization of short-term assets corresponds to the time and scope of the maturity date to pay current liabilities, then there is a risk that the mobilization of short-term assets will not be made in time and scope that fits within the scope and maturity date of payment of current liabilities. This discrepancy can only be partially remedied with the previously determined minimum cash balance.

However, it should be noted that the practical application of the above method of determining minimum cash balances should be treated with care. Consequently, in companies that are characterized by relatively homogeneous volume of procurement, production and sales, it can provide a satisfactory calculation of the required cash balances without any corrections, while in companies where this is not the case this method has to be adjusted.

Bearing in mind what has been mentioned here in connection to the required cash balance, there is a need to point to another important category of which on the liquidity of the company may depend, and it is what is known as *the liquid reserve*. The liquid reserve actually means keeping cash above the minimum cash balance level, with the help of which the company's liquidity will be maintained at a time when the inflow of cash increased by the minimum cash balance is not sufficient for the payment of liabilities due for payment. However, the liquid reserve is not easy to determine, because it is affected by a number of complex factors, among which we should mention the following:

Firstly, the amount of liquid reserves depends on the synchronization of cash inflows and outflows in a short period of time and the degree of probability that the synchronization will be maintained. In this regard, if the synchronization of cash inflows and outflows in the short time is completed and if there is a high degree of probability that it will be maintained, then a relatively small liquid reserves is sufficient. On the other hand, if there is a high degree of risk of claim settlement or if a higher outflow than inflow is expected in a short period of time, a relatively large liquid reserve is required.

Secondly, the amount of liquid reserves also depends on the severity of sanctions in the event of illiquidity of the company. These sanctions may be legal or connected to the market. *Legal sanctions* are those prescribed by the law and they are reflected in the fact that the acquisition is prohibited or limited for the insolvent company, as well as the investment and use of resources for certain purposes or it is required that the insolvent company goes into recovery procedure, i.e. the elimination of insolvency, and if it is not successful then the insolvent company usually goes into bankruptcy. On the other hand, *sanctions connected to market* are those undertaken by creditors towards an insolvent debtor. These sanctions may also be different, but usually consist of the following: calculation of default interest, suspension of further deliveries of goods, suspension of further lending, demanding the payment of accounts payable performed under unfavorable conditions, the requirement that payment obligations are guaranteed by a third party and so on. Similarly to the above, in terms of the need for a certain amount of the liquid reserve it should be said that the rule is: the higher the degree of severity of sanctions, the greater liquid reserve is required, and vice versa.

Thirdly, the amount of liquid reserves depends on whether the company financial transactions are carried out through a current account or a bank account. If business is done through the current account, the required liquid reserves will be lower because in such circumstances the company can count on maintaining liquidity by using current bank loans. However, business through bank accounts does not include the right to use a current bank loan, which also means that in this case we need greater liquid reserves.

Based on what has been said, it is clear that in determining the level of liquid reserves there is no universal and generally accepted method. This means that the level of liquid reserves must be determined by each company in accordance with its needs, relying on previous empirical evidence and taking into account the above-mentioned basic factors that determine the liquidity reserve.

CASH MANAGEMENT STRATEGY

In establishing the financial policy of the company, the choice of cash management strategies can be based on three key factors, namely: (1) extending payment deadlines to suppliers, (2) reduction of stocks, and (3) accelerating the collection of receivables from clients (Zhong et al., 2018). Each of these alternative strategies for cash management has its own features, as well as its advantages and disadvantages. Hence, in their choice what must be taken into account are all the relevant factors affecting the shortening of the time of cash cycle and the increase of the income of the company. The above mentioned strategies will be briefly clarified.

1. *Extension of deadline for payment to suppliers* - means reducing the level of financial resources through the greater participation of suppliers in the financing of companies. This source of financing is an important source of short-term external financing. In this regard, the strategy of the above mentioned source of financing can be applied provided there is no loss in rebates from suppliers, in the quality of producers, and that the selling price of purchased raw materials or goods is nor increased. Similarly to the above, the company which experiences the scarcity of cash, logically, tends to postpone paying liabilities to suppliers as much as possible without compromising their own credit worthiness.

Although the prolongation of liabilities to suppliers can be considered as an attractive financial cash management strategy, the fact remains that the actual possibility for their use is rather limited. In fact, only when the suppliers are largely dependent on the clients' companies, there is a relatively wide area of application of the cash management strategy, although it is an indisputable fact that the delay of liabilities to suppliers may arise on the basis of an agreement on long-term cooperation between suppliers and clients. However, the implementation of this strategy in terms of the general scarcity of cash becomes too expensive. Hence, in such circumstances, suppliers typically charge customers default interest on daily basis on all outstanding receivables after the expiry of the loan period, at the same time offering them *cash discounts* for all payments during the discount period to achieve the inflow of cash as quickly as possible (Ivanis, 2019).

2. *Reduction of stocks* - means reducing the cash cycle by increasing the ratio of total stock turnover, creating considerable opportunities for improving the company's economy. However, there is a significant difference in the possibility of increasing the efficiency of working capital management that is in stocks and working capital which is in receivables from clients or the use of funds from the suppliers. Namely, the improvement of the economy through asset management with clients or suppliers, apart from the successful combination of the company's management, largely depends on the consent of the other party, i.e. client or supplier. However, this is not the case with stocks, since the implementation of the strategy of cash management by reducing stocks does not require any approval of business partners (clients and suppliers). This means that the economy of stocks is directly dependent on the business moves made by the management.

While seeking the most suitable solutions, the company can use those which suit it best. For example, based on relevant analysis, the financial function of the company may, in cooperation with procurement, production and sales functions, seek the best solutions that reduce investment in stocks, i.e. which increase their turnover in any part of the work process: stocks of raw materials, stocks of unfinished production or stocks of finished products on the market. Similarly, it follows that the efficiency of the financial management of the total stocks with the aim of shortening the cash cycle can be improved only through the efficient management of individual types of stocks, which necessarily presupposes success in performing basic business functions and on the basis of respecting the financial way of thinking in making business decisions. According to these criteria, *the procurement function* of the company should seek to increase stock (raw materials) turnover ratio using modern techniques of the production process. *The production function* must focus on the application of appropriate methods of organization and planning of production in order to enable greater shortening of the production cycle, i.e. increase of the turnover ratio of unfinished production, regardless of the regularity of supply of finished products in the required quantity and range. Finally, *the sales function* has the primary task to, by analyzing and stimulating demand, i.e. planning and improving sales by individual segments and sales channels increase the turnover ratio of finished products. Consequently, effective management of each of these types of stocks also affects the shortening of the cash cycle, i.e. reducing the minimum required cash balance. In this regard, practical experience shows that any

acceleration of stocks turnover directly affects the shortening of the cash cycle and reduction of the operating costs of the company. These effects are especially pronounced if the company has well connected core business functions: procurement, production, sales and financial function (Ivanis, 2019).

3. *Accelerating the collection of accounts receivable from clients* - means reducing the cash cycle by accelerating the collection of accounts receivable from clients, i.e. by increasing the receivable turnover ratio. However, accounts receivable from clients also present a significant investment of companies, because of the necessity to credit clients. In addition, time of loaning to customers depends on various different factors: the ratio of supply and demand for products, the market position of buyers and suppliers, the quality and price of products, the introduction of a variety of discounts, terms given by the competition, the liquidity of companies, etc.

Accordingly, accounts receivable from clients restrict cash which, if released, can be invested in other productive assets or investments. This restriction is necessary, because lending to customers allows the company to achieve a significantly higher volume and profit from sales, than if sales were done using cash only. In addition, credit conditions necessarily determine credit standards and policies of the collection of accounts receivable. Credit standards refer to the strictness of the criteria which apply to providing credit to certain groups of clients, while the collection policy includes a variety of measures that the company applies so that accounts receivable collected from clients are converted into cash as quickly as possible. Similarly, under conditions of lending all changes and adjustments to credit standards and debt collection policy should be used not only individually but also in a complementary way, in order to shorten the time of the average restriction of cash in accounts receivable from clients and to reduce the minimum of required cash balance (Pandey, 2021). In this regard, the current practice of collection of accounts receivable proved to be very good and flexible through the application of factoring which includes the sale of accounts receivable before the expiry of the loan period.

CONCLUSION

Management of company's financial resources is a particularly difficult task for financial managers. Any surplus money above required is a guarantee of liquidity but adversely affects profitability. Conversely, any cash deficit threatens the liquidity and the ability to settle due liabilities of the company. In addition, lack of cash means the loss of creditworthiness of the company and influences a decrease in its market competitiveness. Therefore, effective cash management requires the company's management to be at any moment aware of the needs of the company for cash, the amount of cash and the place where the cash is located. In this way, it is possible to identify in a period of time the excess cash to be invested or lack of funds to be obtained so that the company can operate normally. In turn, this requires planned management of the expected cash inflows and outflows, as well as ensuring maximum profitability in business operations involving financial resources.

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TRADE-OFF BETWEEN LIQUIDITY AND PROFITABILITY: THE CASE OF BANKING SECTOR IN SERBIA

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ABSTRACT

Bank liquidity-profitability relation represents one of the most essential issues for every bank management. The subject of this study is to identify the relationship between liquidity and profitability in the banking sector of Serbia for the period 2008-2022. The obtained results of the conducted correlation analysis confirmed the significant and negative relationship between bank liquidity indicators such as liquid assets to total assets, liquid assets to short-term liabilities, liquidity ratio and profitability, as well as a positive relationship between loan-to-deposit ratio and profitability. It implies that a higher liquidity level reduces the profitability of the banking sector in Serbia for the analyzed period. These findings support the inverse relationship between these two components in the banking business. Bank management should enable optimal liquidity-profitability level to ensure necessary stability, but also growth through greater returns on investments.

Keywords: Bank, Liquidity, Profitability, Correlation, Serbia.

INTRODUCTION

Banks play a crucial role in the financial systems of numerous countries, particularly in developing economies where the financial markets are predominantly focused on banking. The banking sector is a critical financial intermediary in the development of any country (Adelopo et al. 2022). A well-structured banking sector brings about beneficial impacts for businesses and individuals. Based on Batrancea et al. (2021) commercial banks play an important role in mobilizing and distributing funds by loans and deposits to their clients. Liquidity management stands out as a critical concern in the banking sector, given that these institutions primarily function by borrowing funds. However, liquidity should not be observed without profitability issue. The trade-off between bank liquidity and profitability involves the delicate equilibrium that banks must achieve by ensuring they have sufficient liquid assets to fulfil immediate financial commitments, while also striving to optimize profits through investments and lending operations. On one hand, maintaining ample liquidity, such as holding cash or easily marketable securities, can assist banks in navigating financial crises or sudden withdrawals by depositors. However, an excessive amount of liquid assets may diminish profitability as these assets typically yield lower returns compared to riskier investments. Conversely, striving for increased profitability through investments and lending activities can heighten the risk of illiquidity if these assets cannot be readily converted to cash when necessary. Hence, banks must prudently manage their liquidity and profitability goals to ensure they can fulfil short-term obligations while also generating sustainable profits in the long run.

Banks are required to maintain a specific level of liquid resources, such as cash, reserves, and easily marketable securities, to address deposit withdrawals, loan disbursements, and other short-term liabilities. Inadequate liquidity may precipitate liquidity crises, while an excess of liquidity could impede profitability. Additionally, banks accrue profits primarily through interest income derived

from loans and investments, as well as fees and commissions from a variety of financial services. The aim of this research is to analyze the potential relationship between liquidity and profitability in the banking sector of Serbia for the period 2008-2022. The structure of the paper includes five parts. The first and second parts imply an introduction and literature review with previous empirical studies that have analyzed trade-off between liquidity and profitability in the banking sector. The third part includes methodology and data, while the fourth part enables empirical findings. Finally, the last part presents conclusions and summarizes the obtained results with policy recommendations.

LITERATURE REVIEW

Many empirical studies have confirmed significant positive or negative correlations, as well as insignificant relationships between liquidity and profitability. For example, Doan and Bui (2021) investigated the effect of liquidity on the profitability of 26 Vietnamese commercial banks for the period 2013-2018 and found that ROA was negatively influenced by the liquid asset ratio and positively correlated to the loan to deposit ratio. Davis et al. (2022) analyzed macroprudential policy effects on profitability of 7250 global banks for the period 1990-2018 and found that the loan-to-deposit ratio positively influenced the ROA and ROE. When it comes to the negative implications of bank liquidity on profitability, Olagunju et al. (2011) highlighted that excessive liquidity can harmful bank profitability which is in line with Tran et al. (2016) indicated that banks which create more liquidity achieve lower profitability. Stevcevska-Srbinoska and Gjelevska (2024) confirmed that liquidity measures such as liquid assets to total assets and liquid assets to short-term liabilities negatively correlated with ROA in the banking sector of Serbia for the period 2012-2021. Contrary, Lartey et al. (2013) identified a positive relationship between the liquidity and profitability of banks in Ghana for the period 2005-2010. Likewise, Olalere et al. (2017) confirmed the positive impact of liquidity on the profitability of commercial banks in Nigeria for the period 2010-2015. Vodova (2016) investigated liquidity and profitability in the Polish banking sector for the period 2007-2013. Using the Pearson correlation coefficient, this study confirmed that banks with high values of loan-to-deposit ratio have greater interest margin. These findings are in line with the study of Almaqtari et al. (2019) which identified a significant and positive effect of liquidity ratio on profitability of the Indian commercial banks from 2008 to 2017. Finally, Mwizarubi et al. (2015) analyzed banks in Tanzania for the period 2006-2013 and confirmed that there is no statistically significant relationship between banks' profitability and liquidity. Similar findings were identified in an analysis of Akter and Mahmud (2014) in Bangladesh, as well as Nishanthini and Meerajancy (2015) where this study did not find a significant correlation between these variables in Sri Lanka.

METHODOLOGY AND DATA

The main goal of this research is to identify potential nexus between liquidity and profitability in the banking sector of Serbia for the period 2008-2022. The study used secondary data on the annual level collected from the National Bank of Serbia. Taking into consideration the research objective, we developed the following hypotheses:

H_1: There is a trade-off between liquidity and profitability in the banking sector of Serbia.
H_2: Liquidity negatively influences profitability in the banking sector of Serbia.

EMPIRICAL RESULTS

Within this segment of the research, we presented a descriptive analysis of bank liquidity and profitability for the period 2008-2022, as well as their correlation matrix using the Pearson coefficient.

Table 1: Liquidity and profitability indicators in the banking sector of Serbia

Year	Liquidity				Profitability	
	LA/TA	LA/STL	LDR	LIQ	ROA	ROE
2008	47.8	75.7	104	1.8	2.1	9
2009	49	75.1	100	1.9	1	4.6
2010	43.7	70.1	111	2	1.1	5.3
2011	42.3	70.6	127	2.2	0.1	0.2
2012	38.9	65	119.9	2.1	0.4	2
2013	41	66.4	74	2.4	-0.1	-0.4
2014	42.2	66.7	100.4	2.2	0.1	0.6
2015	40.5	61.3	97.45	2.1	0.3	1.5
2016	38.9	56.6	92.74	2.1	0.7	3.3
2017	35.1	50.9	92.96	2	2.1	10.5
2018	35.7	50.5	88.34	2	2.2	11.3
2019	36	50.5	88.3	2.2	1.8	9.8
2020	37.3	50.9	82.61	2.2	1.1	6.5
2021	37.7	49.6	79.3	2.1	1.2	7.8
2022	35	45.4	82.8	2	1.5	10.9

Note: LA/TA – liquid assets to total assets; LA/STL – liquid assets to short-term liabilities; D; LDR – loans to deposits; LIQ – liquidity ratio; ROA – return on assets; ROE – return on equity
Source: NBS (2022)

When it comes to banks' liquidity data in the Republic of Serbia by the end of 2022, it can be manifested from four indicators values. Analyzing banks' liquidity structure, liquid assets consists 35% of total assets and covers 45.4% of short-term liabilities. The value of the loan-to-deposit ratio was 82.8%, while the average monthly liquidity ratio was 2 which is significantly higher than the reference value of 1. When it comes to bank profitability, average ROA and ROE were 1.04% and 5.53% for the observed period. Nevertheless, banks registered higher values of these indicators in 2022, when ROA was 1.5% and ROE 10.9%. Based on mentioned above, it can be noticed that the banking sector in the Republic of Serbia has a substantial level of liquid assets which contributes to greater stability. This is a precondition to allocate liquid funds to loans and investments in order to provide adequate returns.

Table 2: Correlation analysis – liquidity with ROA

Variable	LATA	LTS	LDR	LIQ	ROA
LATA	1				
LTS	0.933	1			
LDR	0.451	0.628	1		
LIQ	0.3372	0.169	0.245	1	
ROA	-0.264**	-0.415**	0.256*	-0.647***	1

Note: significance level: 1% ***, 5%** and 10%*

Based on correlation analysis, we can notice that liquidity indicators such as liquid assets to total assets, liquid assets to short-term liabilities and liquidity ratio are negatively correlated to ROA, while the relationship between loan-to-deposit ratio and ROA is positive. The highest correlation was between liquidity ratio and ROA (-0.647) for the observed period.

Table 3: Correlation analysis – liquidity with ROE

Variable	LATA	LTS	LDR	LIQ	ROE
LATA	1				
LTS	0.933	1			
LDR	0.451	0.628	1		
LIQ	0.337	0.169	0.245	1	
ROE	-0.422**	-0.591***	0.381**	-0.553***	1

Note: significance level: 1% ***, 5%** and 10%*

Similar results were found in Table 3, where coefficients of correlation were highest in the relationship between liquid assets to short-term liabilities and ROE (-0.591), as well as liquidity ratio and ROE (-0.553). Statistical significant correlation at 1% level was confirmed at variables such as liquid assets to short-term liabilities, loan-to-deposit ratio and liquidity ratio.

CONCLUSION

The correlation between bank liquidity and profitability is a fundamental aspect of financial management within the banking sector. Banks must strike a harmonious equilibrium between liquidity and profitability to keep their financial stability and enable permanent growth. When it comes to the banking sector in Serbia, it is necessary to point out that this sector plays an important role in the country's economy. Therefore, the liquidity-profitability issue is crucial when identifying the banking sector performance, liquidity implies safety and stability, while profitability reflects potential and growth. Based on the obtained findings, we can conclude that there is a trade-off between liquidity and profitability in the banking sector of Serbia for the period 2008-2022. It implies that hypothesis H_1 can be accepted. Analyzing the character of their relationship, it can be noticed that liquidity indicators such as liquid assets to total assets, liquid assets to short-term liabilities, and liquidity ratio are negatively correlated to bank profitability measured by ROA and ROE at different significant levels for the observed period. However, the loan-to-deposit ratio positively affects ROA and ROE, thus hypothesis H_2 can be partially accepted. The obtained results can be significant for bank managers, shareholders, clients and other stakeholders whose are interested in the successful banking business (Radovanov et al., 2023). The empirical research enables a better understanding of the relationship between liquidity and profitability in the banking sector and provides lucrative information for bank managers when planning and designing optimal nexus between these components in business. Furthermore, the paper specifies which liquidity and profitability determinants are crucial for banks' management in terms of their interdependence.

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SPATIAL-FUNCTIONAL LOCALIZATION OF SUSTAINABLE DEVELOPMENT PARAMETERS IN THE REGIONS OF THE RUSSIAN FEDERATION

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ABSTRACT

The aim of the research is to determine the spatial-functional localization of parameters for the sustainable development of Russian regions and categorize regions into groups based on the degree of their economic, social and environmental development. It was found out that Russian regions fall into six virtual clusters that exhibit significant disparities in overall socio-ecological-economic sustainability levels and structural compositions. Cluster "A" exhibits the best indicators in the social subsystem: the proportion of students enrolled in universities, average life expectancy, income levels, and deposits. Weak environmental indicators are observed there. Cluster "B" encompassing geographically extensive regions with low population density and traditional industrial production, showcasing high economic and environmental characteristics. Its weak point is low proportion of university students in the total population. Cluster "C" achieves stability through a high level of innovation, a significant proportion of students enrolled in universities, and good environmental characteristics. Cluster "D" demonstrates the strongest position in the environmental sphere, with other aspects being weak. Cluster "E" lacks any strong position in inter-cluster comparison. The least stable cluster "F", is inert in economic and innovative aspects, with a high level of natural resource utilization for sustaining the population, and a high life expectancy.

Keywords: Region, Sustainability, Socio-ecological-economic system, Cluster analysis, Virtual cluster.

INTRODUCTION

The sustainability of socio-economic systems has been a focal point of attention for both Russian and international scholars for several decades. Particularly concerning regions, V.V. Nasonov (2013) has noted this aspect. Despite scholars unanimously agreeing on the necessity of such assessments, their perspectives on the composition of indicators reflecting regional sustainability vary significantly. Let's examine the viewpoints of some Russian researchers that have gained widespread recognition in the literature.

G.M. Kopeeva (2009) considers it essential to use three groups of indicators for these purposes: 1) the level of actual employment of the population; 2) the Human Development Index (HDI), which includes three standard components: Gross Domestic Product (GDP) per capita, educational attainment, and population health status; 3) monetary and financial criteria. While not entirely objecting to this configuration of criteria, it's worth noting the absence of environmental indicators within its composition. Furthermore, the necessity of using HDI specifically, rather than its components, for assessing sustainability is not justified. Essentially, the author proposes using a rather conditional indicator, necessitating the recalculation of initial data, inevitably leading to an increase in the degree of conditionality of the obtained assessments. It is also essential to note that GDP and Gross Regional Product (GRP) are not entirely comparable due to the specificity of their calculations for the purposes of national and regional statistics.

L.V. Rodionova (2020) proposes using the following for this purpose: Gross Regional Product (GRP), population size, natural and migration growth rates, and real monetary incomes of the population.

E.A. Osipova (2016) employs a wide range of indicators for analysis: the industrial production index applied to the forestry complex; the dynamics of production volumes in natural terms; the dynamics and structure of investments; the ratio of areas under artificial reforestation to those subjected to clear-cutting on forest lands; the area of forest lands covered with vegetation, lost to pests and diseases; the dynamics of wages at forestry enterprises. While this set of indicators can effectively assess the sustainability of the forestry sector, considering Russia's highly diverse natural conditions, utilizing the entire list of indicators may not be practical.

N.A. Shibaeva & M.A. Katalnikova (2023) believe that in rural areas, it is important to create an institutional environment that ensures the comprehensive development thereof. The significance of establishing an institutional framework aligned with the objectives of sustainable development is evident not only for rural areas but also for any other territories. However, the challenge lies in determining indicators that reflect the actual and desired state of the institutional environment. This presents a substantial independent issue.

M.I. Gusenok (2017) also addresses the assessment of the sustainability of rural areas. His methodology involves determining the position of each specific rural area within the regional space. Undoubtedly, this is an important aspect of assessing the sustainability of any socio-ecological-economic system. It is necessary to evaluate its parameters in comparison with other functionally similar ones. The problematic aspect of the methodology is the use of an extremely broad set of indicators. There are 33 indicators characterizing the production aspect of rural area development. With such a significant number of indicators, there is a lack of an ecological component. It is important to note that the methodology assumes the use of indicators absent in municipal statistics.

E.O. Vegner-Kozlova (2021), based on theoretical and empirical analysis, proposed the use of six "eco-intensity" indicators to assess the dynamics of regional sustainability (the Sverdlovsk region): emissions of pollutants into the air; freshwater use; discharge of polluted wastewater; generation of production and consumption waste; expenditures on environmental protection; operational expenses for environmental protection; investments in fix capital directed towards environmental protection and rational use of natural resources. The challenge for practical implementation of the author's proposed approach is the combination of natural and cost-based indicators. Individually, each is justified, but to include them in a comprehensive assessment, methodological techniques are required to ensure their comparability not only statically but also dynamically.

V.E. Vasenko (2013) proposed an elaborate system for evaluating the level of socio-ecological-economic development. Following classical concepts of sustainability, the author suggested assessing three of its components: economic, social, and environmental. Unfortunately, like in most studies, the number of indicators is exceedingly broad. Additionally, the author employed a significant number of dynamic indicators: growth rates, production indices, etc., which reflect not so much sustainability as the dynamics of systems, inevitably varying in the face of rapid changes in the socio-economic environment. The ambiguity in the connection between growth rates / increases and sustainability necessitates the application of methodological approaches that allow for distinguishing these phenomena. Therefore, it is preferable to use absolute or relative indicators in static assessments. The dynamic aspect should be presented separately to characterize changes in sustainability over time.

RESEARCH METHODS

In light of the aforementioned considerations, we have adopted a limited number of indicators for assessing the stability of regions, comprising the economic, social, and environmental categories:

- Economic indicators: GDP per capita, rubles (var 1); the share of innovative goods, works, and services in the total volume of shipped goods and services, % (var 2); employment rate, % (var 3); collateralization of loans by value created, rubles GRP / 1 ruble of loan provided (var 4);
- Social indicators: average income per capita per month, rubles (var 5); deposits in rubles and foreign currency per capita, rubles (var 6); the proportion of university students in the total population, % (var 7); average life expectancy, years (var 8);
- Environmental indicators: the share of captured and neutralized air pollutants in the total amount of emitted pollutants from stationary sources, % (var 9); expenditure on environmental protection per capita, rubles (var 10).

- All indicators in the calculations are normalized, allowing their values to be compared regardless of the units of measurement.
- The calculations were conducted for the year 2022, characterized by a high level of structural changes in the socio-economic systems at the federal and regional levels.
- To establish the localization patterns of various indicators of socio-ecological-economic sustainability, cluster analysis was employed. This allowed us to form relatively homogeneous groups of regions, distinguished by the values of each indicator.

The theoretical foundation of this method is presented in the works of I.D. Mandel (1988), M.S. Aldenderfer & R.K. Blashfield (1984), and J.A. Hartigan & M.A. Wong (1979), Y.Fang & J.Wang (2012). The study of regional socio-economic systems using this method was initiated by the works of O. Golichenko & I. Shchepina (2009). This method has been utilized for the formation of homogeneous groups of regions in the works of E.M. Isaeva, L.M. Nikitina & Yu.I. Treschevsky (2013), Yu.I. Treschevsky & V.M. Kruglyakova (2011), and a number of other authors.

In our calculations, we considered variants of dividing the socio-economic space into five, six, and seven clusters. The most favorable statistical characteristics were achieved with six clusters.

RESULTS AND DISCUSSION

The analysis of variance revealed high significance in the calculated mean values of the indicators: the F-criterion ranged from 7.50 to 41.18, and the p-criterion approached zero up to the sixth decimal place. The composition of the clusters is presented in Table 1.

Table 1: Composition of Regions in Clusters

Cluster	Regions
«A» (2 regions)	Moscow, St. Petersburg
«B» (7 regions)	Tyumen Oblast, Krasnoyarsk Krai, Sakha Republic (Yakutia), Kamchatka Krai, Magadan Oblast, Sakhalin Oblast, Chukotka Autonomous Okrug
«C» (11 regions)	Belgorod Oblast, Tula Oblast, Murmansk Oblast, Rostov Oblast, Mordovia Republic, Tatarstan Republic, Nizhny Novgorod Oblast, Samara Oblast, Ulyanovsk Oblast, Chelyabinsk Oblast, Khabarovsk Krai
«D» (30 regions)	Bryansk Oblast, Kaluga Oblast, Lipetsk Oblast, Moscow Oblast, Ryazan Oblast, Smolensk Oblast, Tver Oblast, Arkhangelsk Oblast, Vologda Oblast, Kaliningrad Oblast, Leningrad Oblast, Novgorod Oblast, Crimea Republic, Krasnodar Krai, Karachay-Cherkess Republic, Perm Krai, Penza Oblast, Saratov Oblast, Sverdlovsk Oblast, Khakassia Republic, Altai Krai, Irkutsk Oblast, Kemerovo Oblast, Novosibirsk Oblast, Omsk Oblast, Buryatia Republic, Zabaykalsky Krai, Primorsky Krai, Amur Oblast, Jewish Autonomous Oblast
«E» (22 regions)	Vladimir Oblast, Voronezh Oblast, Ivanovo Oblast, Kostroma Oblast, Kursk Oblast, Oryol Oblast, Tambov Oblast, Yaroslavl Oblast, Karelia Republic, Komi Republic, Pskov Oblast, Volgograd Oblast, Stavropol Krai, Bashkortostan Republic, Mari El Republic, Udmurt Republic, Chuvash Republic, Kirov Oblast, Orenburg Oblast, Kurgan Oblast, Altai Republic, Tomsk Oblast
«F» (10 regions)	Adygea Republic, Kalmykia Republic, Astrakhan Oblast, Sevastopol city, Dagestan Republic, Ingushetia Republic, Kabardino-Balkar Republic, North Ossetia-Alania Republic, Chechnya Republic, Tuva Republic

As can be seen, the distribution of regions across clusters is quite uneven. The most stable cluster, considering all parameters collectively, includes two large, developed regions in terms of socio-economic terms. Cluster "B" comprises seven major, industrially developed regions in Siberia and the Far East. Cluster "C" includes 11 socially and economically developed regions, primarily in the European part of the country. The largest clusters, "D" and "E," consist of regions varying in levels of socio-economic development and geographical location. Cluster "F" comprises 10 smaller-scale economic regions, primarily in the southern part of the country.

The average normalized indicators for clusters are presented in Figure 1.

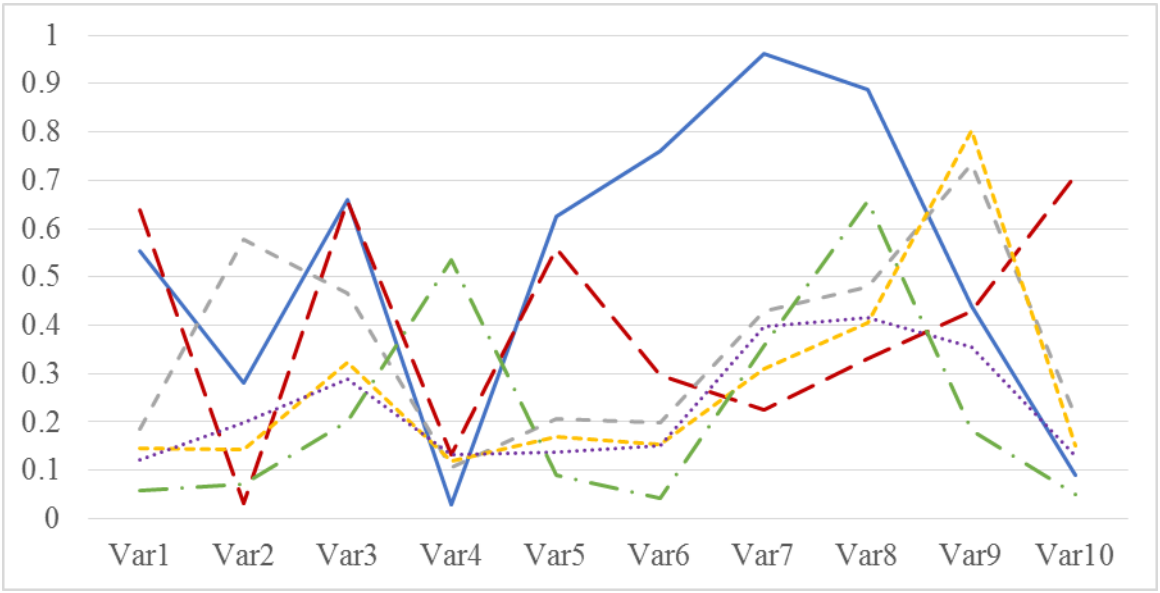

Figure 1: Average normalized values of variables by clusters

Designations:

Cluster "A"
Cluster "B"
Cluster "C"
Cluster "D"
Cluster "E"
Cluster "F"

Calculated by the authors based on Rosstat (2023), Rosstat (2024).

As can be seen from the data presented in Table 2 and Figure 1, each cluster has its own unique peculiarities.

Cluster "A" has the following features. The proportion of university students in the total population is the highest relative to other clusters and own parameters of the cluster (var7). The value of the indicator is 2-4 times higher than in other clusters. The next strong position is the average life expectancy (var8). The third strong position is deposits in rubles and foreign currency per capita, rubles (var 6). The level of average monetary income per capita is also quite high (var5). That is, cluster "A" demonstrates the highest positions in the social block. All four indicators are higher than in other clusters. Cluster "A" occupies a lower position (although higher than that of other clusters) in terms of employment (var 3), although the gap with cluster "B" is not significant. The cluster has average positions (lower than that of any one cluster) in the following indicators: GRP per capita, rubles (var 1); the share of innovative goods, works, and services in the total volume of shipped goods, completed works, and services, % (var 2). Weak positions (values of indicators are lower than in two or more clusters) are occupied by cluster "A" according to the following indicators: collateralization of loans by value created (var 2); the share of captured and neutralized air pollutants in the total amount of waste pollutants from stationary sources, % (var 9); environmental protection costs per capita, rubles (var 10). Paradoxically enough, the two largest cities in the country have weak positions on the environmental component of sustainable development.

Cluster "B" has several notable features. The strongest feature of the cluster is its environmental protection costs per capita, which are significantly higher than the average of other clusters. Another strong feature is the level of gross regional product (GRP) per capita, which is also above the average. On average, Cluster "B" performs slightly below other clusters in terms of employment, average per capita income, and deposits in rubles and foreign currency. Cluster "B" also has weaker positions (below second place in the inter-cluster ranking) in several indicators, including the proportion of university students in the population. The overall layout of the positions is quite logical. Cluster "B" includes large, industrialized areas with traditional production, higher wages, lower population density, and higher costs for businesses to protect the environment, due to the legal requirements.

Cluster "C" is characterized by the following features. The strongest position is the share of innovative goods, works, and services in the total volume of shipped goods, completed works, and services - the first place among all clusters. The value of this indicator is twice that of cluster "A". Cluster "C" also occupies high positions (second place) according to the proportion of university students in the total population, and the

proportion of captured and neutralized air pollutants in the total amount of emitted air pollutants from stationary sources. These three positions of the cluster are fully justified by the presence of regions that are characterized by a high concentration of industrial enterprises, educational and scientific institutions, and population. Most of the indicators should be considered as average values, which correspond to the overall third position of cluster "C" in the inter-cluster space. The weakest position, below the third overall position, is the collateralization of loans by value created. Enterprises tend to take risks or do not have sufficient funds of their own. The second seems to be the case, since there are a significant number of industrial enterprises in the region that are actively engaged in innovative activities.

Cluster "D" has the following characteristics. The proportion of trapped and neutralized air pollutants in the total amount of waste pollutants emitted by stationary sources is higher than in other clusters. Without an in-depth analysis of the intra-cluster variations in the indicator values between regions, it is difficult to determine the cause of this phenomenon, especially since cluster "D" includes 30 regions of different levels of socio-economic development, including industrial. The remaining features are weak, but at the same time, but the cluster is not last in any of these areas. This is justified by the significant number of regions with different levels of development included in the cluster.

Cluster "E" is characterized by the following features. In the inter-cluster comparison, no strong or medium positions can be identified, as all positions are weak. Only relatively strong or relatively weak positions can be established within the intra-cluster context. Relatively strong positions are observed in the following indicators: average life expectancy, the proportion of university students in the total population, and the proportion of trapped and neutralized air pollutants in the total amount of waste pollutants from stationary sources. The weakest positions are GRP per capita, the collateralization of loans by value created, and average income per capita. In general, the cluster can be described as socio-environmentally oriented, with a low level of economic development.

Cluster "F" has the following characteristics. The highest position is the collateralization of loans by value created. This is reflected in the highest normalized value among all clusters. Businesses in this cluster are less likely to borrow. A high position is observed in terms of average life expectancy, ranking second after cluster A. However, when compared between clusters, the remaining positions are relatively weak. In intra-cluster comparisons, in addition to the above, a relatively high proportion of students in universities in the total population can be noted. The weakest positions in both inter-cluster and intra-cluster comparisons include GDP per capita, the proportion of innovative goods, works, and services in the total volume of goods shipped, works performed, and services rendered, deposits in both rubles and foreign currency per capita, and expenditures on environmental protection per capita.

In summary, the cluster can be characterized as economically inert, with a high level of reliance on natural resources to sustain the population's livelihoods. Consequently, there is less demand for material investments to mitigate pollution from stationary sources.

CONCLUSIONS

The analysis above allows us to draw the following conclusions:

- The most stable cluster "A", which includes Moscow and St. Petersburg, stands out for its high proportions of citizens enrolled in higher education, its average life expectancy, its per capita deposit sums, and its disposable income levels. In terms of employment rates, GDP per capita, and the share of innovative goods, works and services, this cluster exhibits a moderate level of development. However, it shows weaknesses in environmental metrics, and there's a notable vulnerability due to low credit accessibility for value-added creation.
- The second most stable cluster "B", comprises territorially large regions with low population density and a dominance of traditional industrial sectors. It excels in wage levels, enterprise expenditures on environmental protection, and GDP per capita. However, it lags behind in the proportion of university students relative to the total population.
- The third most stable cluster "C" has the strongest positions in the share of innovative goods, works, and services in the total volume of shipped goods, performed works, and services; proportion of students enrolled in higher education institutions relative to the total population; and effec-

tively captured and neutralized air pollutants. Most indicators align with the cluster's overall third-place ranking, and there are no glaring weaknesses present.

- The cluster of the fourth level of stability, labeled "D", exhibits a dominant position in effectively capturing and neutralizing air pollutants emitted from stationary sources. However, its other aspects are relatively weak.
- Cluster "E", at the fifth level of stability, lacks any significant strengths compared to other clusters. Internally, it shows moderate strengths in average life expectancy, the proportion of students enrolled in higher education institutions relative to the total population, and the efficient capture and neutralization of air pollutants from stationary sources. Its weaknesses include GDP per capita, adequacy of credit provision in terms of value created, and per capita disposable income. Overall, this cluster can be characterized as socio-ecologically oriented with a modest level of economic development.
- Cluster "F" is the least stable cluster, demonstrating economic inertness with a heavy reliance on natural resources for sustaining livelihoods. It boasts high average life expectancy but lacks vigor in attracting credit resources. Additionally, it requires minimal material investment to mitigate air pollution from stationary sources.

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GLOBALIZATION IN THE REPUBLIC OF SERBIA

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ABSTRACT

Globalization is a process that is inevitable in modern societies and is based on technological elements. It strengthens the various relations in the fields of economy, politics, society and culture, which exist between people originating from different countries and parts of the world. The basis of globalization is represented by its economic elements and the effects it has on the process of integration of national economies into a single global economy, which should enable more efficient performance of economic transactions and all other segments of the functioning of human societies. If viewed from the perspective of economics, globalization has enabled the liberalization of trade activities and capital flows between individual countries.

Key words: Globalization, Globalization in the Republic of Serbia, Digital entrepreneurship

INTRODUCTION

Globalization of the market, i.e. its economic aspect, represent the most important element of globalization, which is given maximum attention during its study. Seen from the perspective of its impact on the world as a whole, globalization is accompanied by a large number of different trends, of which the most significant can be singled out (Đurić et al, 2016):

- growing differences between rich and poor countries,
- significant changes in the way economic activities are perceived, primarily in the areas of international trade,
- reduction of differences between national cultures, as well as ethnic and religious differences,
- increasingly emphasized migrations of the working-age population,
- emphasized differences in natural growth between the most developed and poor countries,
- increasing concern for the environment and sustainable development.

Globalization in modern societies creates the need for the inclusion of all countries in international business activities (Delloite Touche, 2019). This inclusion is especially important for small countries, which are not economically developed. As one of the consequences of globalization and the development of modern technologies, changes in the sources of competitive advantages, which enable successful business on the world market, are becoming increasingly apparent. Digital entrepreneurship is the source of a large number of ideas that experience extremely significant success at the global level, despite the fact that the initiators of these ventures did not have significant financial resources and that they come from countries with small national markets and weak purchasing power.

Seen from the perspective of its impacts on the level of the entire planet, the most significant economic consequences of globalization stand out (Đurić et al, 2016):

- creation of effective international economic integrations,
- the emergence of the international financial market, on which the circulation of capital is largely liberalized,
- creating opportunities for much more efficient development of entrepreneurship in all parts of the world, especially those segments of it that are connected with modern technologies,
- global mobility of resources needed for production,

- the dominant influence of large multinational companies, which operate and invest on a global level and which often have extremely large political influence, especially in smaller countries, and
- reducing the influence of states and their autonomy in conducting policies

GLOBALIZED COMPETITIVE RELATIONS

In modern business conditions, which are characterized by the objective liberalization and globalization of almost all markets in the world, global competitiveness is not a preference or choice of companies. If they want to sustain on the markets in the era of globalization, companies must make constant efforts to strengthen their competitive advantages. Cranes are also forced to emphasize their competitiveness and to continuously develop in order to maintain their positions in the global market.

Competitiveness, in modern markets, is a complex concept, which is characterized by a greater number of dimensions and levels. During the last three decades, it has become a central element of an increasingly open, interconnected and integrated global economy. Despite the fact that its importance in modern business conditions is undoubted and widely recognized, the concept of competitiveness and its nature are often associated with certain controversies, at all levels of its application (global, national, activities and individual companies) (Garelli, 2008). In search of competitive advantages, companies are constantly searching for more unique and sophisticated sources of sustainable competitive advantages. They emphasize competitive advantages that they can use over a long period of time, which is why the activities they carry out are evaluated and measured in different ways.

When analyzing globalized competitive relations, two segments of competitiveness, which are related to countries and companies, must be taken into account. The competitiveness of countries is a concept that is significantly more difficult to define than the competitiveness of companies and is significantly more difficult to analyze. The concept on which the competitiveness of companies is based is basically very simple, if the company is not able to pay its obligations in a timely manner over a long period of time, it will cease to operate, because it was not competitive in the markets where it operated (World Economic Forum, 2019).

When it is said that it ist he company is uncompetitive, it is considered that its market position is unstable and that, if it does not improve the results it achieves during its operations, it will cease to exist.
Countries, on the other hand, can never cease to exist, that is, they cannot experience bankruptcy. They can be satisfied or dissatisfied with the results they achieve in the field of economy, while there is no precisely defined result that would indicate that they are unable to meet their obligations, as is the case with companies. Precisely because of the mentioned fact, the concept of competitiveness is not often applied to countries, whose position on international markets is assessed on the basis of other indicators.

Competitiveness can be defined as the ability to create wealth in different ways. Her research, in the context of globalization, is carried out on (Aiginger, 2006):

- at the level of companies, where emphasis is placed on the factors that lead to the emergence of competitive advantages and on the ability of companies to achieve these advantages, based on the resources they have, and to maintain them in the long term,
- at the regional level, emphasis is placed on the analysis of institutions that provide support and different types of connections that enable the competitiveness of the observed regions,
- at the national level, where economists analyze innovation systems, the quality of education, lifelong learning of the population, physical and intangible infrastructure intended for business, as well as numerous other factors, which can, in a direct or indirect way, affect the global competitiveness of countries.

Global competitiveness research, regardless of whether it is conducted at the level of companies, regions or countries, always aims to enable the identification of factors and processes that will increase incomes and ensure employment over a long period of time. Michael Porter, one of the most famous experts in the field of competitiveness studies, points out that there is a clear difference between companies and countries in the ways of creating competitiveness. Companies, in their attempts to ensure their competitiveness in the markets, compete in achieving market share and profitability, while states compete in enabling preconditions for business characterized by high levels of productivity and in attracting as many investments as possible in activities that enable high rates of return on invested capital and high wage values (Snowdon and Stonehouse, 2006).

Companies' returns on invested capital can be used as indicators of competitiveness. In the case of regions or countries, productivity is used as an indicator of competitiveness viewed from the perspective of value, and not from its narrower perspective, which implies the volume of production. The productivity of companies operating within its national economy has a direct impact on the productivity of the state (Snowdon and Stonehouse, 2006). The national economy cannot be competitive on the global market, if the companies operating within it are not competitive, regardless of whether they are domestic companies or entities owned by foreign companies. The business environment within the state represents one of the basic factors that affect the competitiveness of companies and states on the global market.

In the conditions of globalization, companies that operate within the framework of the national economy must make the efforts necessary to achieve its goals in the field of economic development. They must change the concept of their business from emphasizing the image they have acquired during their business or their comparative advantages (such as low labor costs or the possibility of using natural resources), to building competitive advantages that are based on superior or recognizable products and processes (Snowdon and Stonehouse, 2006).

When analyzing the relationship between globalization and competitiveness, there are certain elements that must be taken into account, in order to appropriately identify ways of creating global competitive relationships. The way of identifying these relationships allows understanding the reasons why the concept of competitiveness is complex to express with the help of a single expression. The concepts on which competitiveness is based differ greatly depending on the level at which it is observed.

Global competitiveness analysis represents the most comprehensive and complex form of analysis, with the help of which various dynamic events that occur in time and space are studied. Competitiveness must be viewed from a global perspective, as a phenomenon that goes through constant processes of change and improvement. Global competitiveness is not only an abstract desire that is stated declaratively, but it is a necessity that enables development. Seen from the perspective of companies, achieving competitiveness in certain cases is also a basic prerequisite for their survival.

Globalized competitive relations can be observed from the perspective of individual activities, as well as from the perspective of national levels. When studying various aspects of the globalization of competitive relations, more and more emphasis is placed on the effects that certain activities have on the competitiveness of national economies. As a result of globalization, they are increasingly present trends that are related to the "specialization" of certain countries for certain activities, which is most often a consequence of the desire of multinational companies to take advantage of certain national markets or to bring their subcontractors to locations that are close to their production facilities (Garelli, 2008).

The third level from which globalized competitive relations can be analyzed, which is also the most significant, is the level of companies. At this level, reliable and precise information can be gathered about the levels of integration of certain profit-oriented companies into the global economy. As sources of information that can be used during the assessment, data related to the length of time companies have been in business within a certain industry or country and the ability of companies to

adequately adapt to changes occurring in the environments in which they operate and on a global level (World Economic Forum, 2019).

Each of the above levels and each of the elements that make them up is important for competitiveness at the global level. Their importance varies with the passage of time and it has an increasing trend, which is a consequence of the development of the global economy, which is becoming more and more integrated. There are numerous interdependencies among different levels and forms of competitiveness, with each of them contributing in a special and dynamic way to the competitive relations that exist in the global environment.

There are parallel relationships between the process of globalization and the development of global competitiveness, which, due to their importance, are the subject of study by a large number of scientists. Research points to the conclusion that there are similar ways of development between globalization and competitiveness, which are a consequence of the fact that they are largely interconnected (Garelli, 2008). The development of global competitiveness has influenced changes in economic power relations in certain parts of the world. It has spread from Western Europe, the United States of America and Japan to other countries and regions, such as China or the countries of Southeast Asia.

One of the significant advantages of globalization, viewed from the perspective of competitiveness, is reflected in the fact that it has enabled companies and entrepreneurs from all parts of the world to get all the resources they need. In this way, very good preconditions were created for the development of digital entrepreneurship, which a large number of entrepreneurs used to create strong companies, some of which also conduct business on a global level. Creating good conditions for the development of digital entrepreneurship and a large number of ventures that have been started in this area is enabled individual countries to significantly improve their competitiveness at the global level (World Economic Forum, 2019).

GLOBALIZATION IN THE REPUBLIC OF SERBIA

Seen from a geostrategic perspective, the Republic of Serbia and the entire area of the Balkan Peninsula on which it is located are of great importance, primarily due to the fact that important roads connecting Western and Central Europe with its South and East, as well as with the Asian continent pass through it..The geostrategic position and the environment in which it is located influenced the significant specificities of the globalization process that took place in the Republic of Serbia. Serbia is one of the countries where the processes of globalization were influenced by numerous political and other non-economic factors, which resulted in a situation where the effects of globalization often appeared later than in most other countries (Terzić, 2014).

The starting positions from which Serbia entered the globalization process were very specific and included certain advantages, but also numerous disadvantages. At the beginning of the globalization process, Serbia had the position of a small country, with a relatively low level of economic development and socialist social order. Serbia's relatively poor position in globalization was also contributed to by numerous war conflicts during the last decade of the 20th century, political instability and international sanctions. All the mentioned factors had significant negative consequences for the inclusion of Serbia in globalization processes, which were increasingly intense and comprehensive.

The assessment of the effects that globalization has led to in Serbia, as well as in all other parts of the world, is a very complex and demanding process, primarily due to significant contradictions in the approach to this phenomenon and different attitudes regarding the positive and negative effects that arise as a consequence. Despite different views, that Serbia has gained or lost a lot due to globalization, it can be said with certainty that there are significant positive effects that it has led to. The main positive effect of globalization is reflected in the integration of Serbia into the global

economic system, which resulted in an increase in competition on the domestic market, as well as an increase in the value of imports and exports.

In order to strengthen the positive effects of globalization, it is necessary to emphasize the strengthening of the most significant competitive advantages of domestic companies and the national economy as a whole (Delloite Touche, 2019). One of the elements that must be given significantly more attention than is the case now is the strengthening of entrepreneurship, especially in the field of modern digital technologies, which in the modern global market is becoming one of the main sources of competitive advantages of countries. Putting more emphasis on digital entrepreneurship would also ensure more efficient use of local resources and potential. On this way highly educated human resources in the field of information and telecommunication technologies would be engaged more efficiently, which would have a positive effect on the reduction of their departure abroad. The adoption of information and telecommunication technologies and their development represents one of the most important positive effects that have arisen in Serbia as a result of globalization.

The biggest consequence of globalization in Serbia is reflected in the entry of a large number of multinational companies, primarily through the opening of new production facilities or the takeover of domestic companies. The takeover of domestic companies, usually those that were in trouble, in most cases resulted in the improvement of their efficiency and the restructuring of their operations, after which they became more competitive in the markets where they operate. The inclusion of Serbia in globalization processes, through the entry of multinational companies, can lead to significant additional positive effects on the development of the national economy and its competitiveness.

One of the shortcomings of the concept of attracting multinational companies, by providing various forms of state aid, was reflected in the fact that most of these investments were directed to labor-intensive activities, which are based on the use of cheap labor (Terzić, 2014). During the last few years, there are noticeable trends of a gradual increase in investments by foreign companies in areas that require higher levels of knowledge and skills of employees, which additionally contribute to increasing the competitiveness of Serbia on global markets.

CONCLUSION

The development of domestic companies and entrepreneurs in developing countries, where large investments by multinational companies are present, will in the near future result in significant changes in global competitiveness (Garelli, 2008). Multinational companies will have stronger domestic competition in the countries where they operate, which will be a consequence of the development of domestic companies, a significant part of which will be represented by entrepreneurial ventures, especially those in the field of digital technologies. Countries whose markets record rapid economic development are becoming more and more important competitors on the international market, which has significant consequences for global competitiveness. The processes of globalization that are currently taking place are largely characterized by the transition of local companies to the status of global ones, which have a very significant participation in the global market.

Placing more emphasis on the development of digital entrepreneurship would enable the Republic of Serbia to better and more efficiently fit into contemporary globalization trends. The development of digital entrepreneurship represents one of the very significant trends in the modern global market, which enables companies originating from countries that are not economically powerful and that possess small amounts of capital, to achieve market success. The Republic of Serbia must define as one of its development goals in the near future the provision of assistance to digital entrepreneurs in the development of their business and entering the international market, in order to achieve greater positive effects of investment compared to those achieved by providing financial incentives to foreign investors

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ANALYSIS OF EMISSION OF GREENHOUSE GASES BY ECONOMIC ACTIVITIES AND BY POLLUTANTS OF THE EUROPEAN UNION BASED ON THE RAM METHOD

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ABSTRACT

The problem of greenhouse gas emissions is very current. It is explored in the literature from different angles. In this study, greenhouse gas emissions are analyzed by economic activities and by pollutants in the European Union (EU) based on the RAM method. In the European Union, the largest emission of greenhouse gases, according to the results of the RAM method, was recorded in agriculture, forestry, and fishing. They are followed by: electricity, gas, steam and air conditioning, households, manufacturing, transport, other services, plumbing and construction, and mining and quarrying. According to the results of the research in this study, special attention must be given to the reduction of greenhouse gas emissions in agriculture, forestry, and fishing. Various measures can be used for these purposes (new technology, energy efficiency, effective manure management, efficient use of nitrogen, regulation, etc.).

Keywords: Greenhouse gas emission, Economic activities, Pollutants, European Union, RAM method.

INTRODUCTION

Recently, the problem of greenhouse gas emissions has been very pronounced. In the literature, it is extensively researched due to its importance. In the analysis of environmental problems (i.e. greenhouse gas emissions), multi-criteria decision-making (MCDM) methods (Balasbaneh & Sher, 2024; Dobrodolac et al., 2024; Lukic, 2012, 2013, 2023; Özdağoğlu et al., 2024). As part of that, significant attention is paid to the analysis of the problem of energy from renewable sources (Gribiss et al., 2023; Lukić & Molnar, 2023). In the field of sustainable logistics, multi-criteria decision-making methods are increasingly used (Khulud et al., 2023; Moktadir et al., 2024). In the literature, considerable attention has been devoted to the analysis of the CO2 emission problem based on multi-criteria decision-making methods (Seyit et al., 2023; Yang & Zhang, 2023; Wu & Niu, 2024; Lukic, 2017). Compared to the classical analysis, the application of multi-criteria decision-making methods in the analysis of the problem of greenhouse gas emissions provides more accurate results. Several indicators - greenhouse gas emission criteria are simultaneously used and their weighting coefficients are determined mathematically and not on a subjective basis. With that in mind, this study analyzes the problem of greenhouse gas emissions according to economic activities and European Union (EU) pollutants based on the RAM method.

RESEARCH METHODOLOGY

In the further presentations of the treated issues in this section, we will briefly point out the essential characteristics of the RAM method. The **RAM** (Root Assessment Method) method is the latest method of multi-criteria decision-making (MCDM) (Sotoudeh-Anvari, 2023). The advantage of this method is that it compensates for the compromise between favorable and unfavorable criteria and overcomes the phenomenon of rank change (Sotoudeh-Anvari, 2023). It is especially important to emphasize that a reversal in the ranking is a phenomenon where the ranking of options changes when the weights (weighting coefficients) criteria are changed or the data normalization method is modified.

Thus, for example, when adjusting the multi-criteria decision-making method by changing the weighting coefficients of the criteria or replacing the data normalization method itself, the option that was initially identified as the best may cease to be the optimal choice; in some cases, it may even become the least favorable alternative. This is a complex phenomenon in the multi-criteria decision-making process (Do Duc Trung, 2024). It should be noted that when using RAM, as with other multi-criteria decision-making methods, the ranking of alternatives may change as the weights of the criteria change. For this reason, different methods for calculating the weight of criteria are often used in comparison (Equal method, Entropy method, MEREC method, LOPCOW method, and others). The stages of using the RAM method for ranking alternatives are as follows (Sotoudeh-Anvari, 2023; Do Duc Trung, 2024):

Step 1. Constructing a decision matrix with *m* rows and *n* columns, where *m* and *n* denote the number of alternatives to be ranked and the number of criteria for each alternative, respectively. Let x_{ij} represent the value of criterion *j* for alternative *i*, where *j=1,...,n* and *i=1,...,m.* The letters *B* and *C* are used to denote the benefit and cost criteria.

Step 2. Normalization of data using a formula:

$$r_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{1}$$

Step 3. Calculation of the normalized value, taking into account the weights of the criteria, by formula:

$$y_{ij} = w_j . r_{ij} \tag{2}$$

where w_j is the weight of the *jth* criterion. Step 4. Calculation of the total normalized result, taking into account the calculated weights of the criteria, by formula:

$$S_{+i} = \sum_{j=1}^{n} y_{+ij} \quad if\ j \in B \tag{3}$$

$$S_{-i} = \sum_{j=1}^{n} y_{-ij} \quad if\ j \in C \tag{4}$$

Step 5. Calculation of the results for each alternative with the formula:

$$RI_i = \sqrt[2+S_{-i}]{2 + S_{+i}} \tag{5}$$

Step 6. Ranking the alternatives in descending order based on their scores.

RESULTS AND DISCUSSION

In this study, the research on the problem of greenhouse gas emissions according to economic activities and pollutants in the European Union is based on relevant criteria. Activities are economic activities. Criteria and activities, with original empirical data, are shown in Table 1. In the European Union the emission of carbon dioxide (CO2) is the highest in the supply of electricity, gas, steam, and air conditioning. The largest methane (CH4) is in agriculture, forestry, and fishing. Nitrous oxide (N2O) is the largest in agriculture, forestry, and fishing. Fluorinated gases (HFC, PFC, SF6, NF3) are the largest in other services, water supply, and construction. The total emission of greenhouse gases (GHG) is the highest in the supply of electricity, gas, steam, and air conditioning. In further presentations of the treated issues, we will rank economic activities according to the selected criteria

of greenhouse gas emissions in the European Union based on the RAM method. In this study, the weight coefficients of the criteria were determined using the Equal method (Thinh, 2022). When using this method, all criteria have equal values (Eurostat (online data code: env_ac_ainah_r2). The calculation procedure and the results of the RAM method are shown in Table 1. (The author's calculations and results.)

Table 1: Calculations and results of the RAM method

	Carbon dioxide (CO2)	Methane (CH_4)	Nitrous oxide (N_2O)	Fluorinated gases (HFC, PFC, SF6, NF3)	Total GHG
	xij				
	C1	C2	C3	C4	C5
Agriculture, forestry & fishing (A1)	92,928	248,747	124,456	1,051	467,183
Mining & quarrying (A2)	22,865	31,787	427	40	55,120
Manufacturing (A3)	711,084	10,705	6,461	16,486	744,736
Electricity, gas, steam, and air conditioning supply (A4)	725,713	13,587	4,345	1,718	745,363
Transportation (A5)	423,072	2,608	4,262	3,561	433,504
Other services, water supply, and construction (A6)	306,470	98,087	12,224	34,606	451,386
Households (A7)	675,311	20,860	6,311	15,077	717,560

	SUM(xij)				
	C1	C2	C3	C4	C5
Agriculture, forestry & fishing	2957443.0000	426381.0000	158486.0000	72539.0000	3614852.0000
Mining & quarrying	2957443.0000	426381.0000	158486.0000	72539.0000	3614852.0000
Manufacturing	2957443.0000	426381.0000	158486.0000	72539.0000	3614852.0000
Electricity, gas, steam, and air conditioning supply	2957443.0000	426381.0000	158486.0000	72539.0000	3614852.0000
Transportation	2957443.0000	426381.0000	158486.0000	72539.0000	3614852.0000
Other services, water supply, and construction	2957443.0000	426381.0000	158486.0000	72539.0000	3614852.0000
Households	2957443.0000	426381.0000	158486.0000	72539.0000	3614852.0000

	nij				
	C1	C2	C3	C4	C5
Agriculture, forestry & fishing	0.0314	0.5834	0.7853	0.0145	0.1292
Mining & quarrying	0.0077	0.0746	0.0027	0.0006	0.0152
Manufacturing	0.2404	0.0251	0.0408	0.2273	0.2060
Electricity, gas, steam, and air conditioning supply	0.2454	0.0319	0.0274	0.0237	0.2062
Transportation	0.1431	0.0061	0.0269	0.0491	0.1199
Other services, water supply, and construction	0.1036	0.2300	0.0771	0.4771	0.1249
Households	0.2283	0.0489	0.0398	0.2078	0.1985

	Wj				
	C1	C2	C3	C4	C5
Agriculture, forestry & fishing	0.2000	0.2000	0.2000	0.2000	0.2000
Mining & quarrying	0.2000	0.2000	0.2000	0.2000	0.2000
Manufacturing	0.2000	0.2000	0.2000	0.2000	0.2000
Electricity, gas, steam, and air conditioning supply	0.2000	0.2000	0.2000	0.2000	0.2000
Transportation	0.2000	0.2000	0.2000	0.2000	0.2000
Other services, water supply, and construction	0.2000	0.2000	0.2000	0.2000	0.2000
Households	0.2000	0.2000	0.2000	0.2000	0.2000

	Wj * nij				
	C1	C2	C3	C4	C5
Agriculture, forestry & fishing	0.0063	0.1167	0.1571	0.0029	0.0258
Mining & quarrying	0.0015	0.0149	0.0005	0.0001	0.0030
Manufacturing	0.0481	0.0050	0.0082	0.0455	0.0412
Electricity, gas, steam, and air conditioning supply	0.0491	0.0064	0.0055	0.0047	0.0412
Transportation	0.0286	0.0012	0.0054	0.0098	0.0240
Other services, water supply, and construction	0.0207	0.0460	0.0154	0.0954	0.0250
Households	0.0457	0.0098	0.0080	0.0416	0.0397

	S+i	Si	Rii	Rank
Agriculture, forestry & fishing	0.3059	0.0029	1.5176	1
Mining & quarrying	0.0200	0.0001	1.4213	7
Manufacturing	0.1025	0.0455	1.4381	4
Electricity, gas, steam, and air conditioning supply	0.1022	0.0047	1.4486	2
Transportation	0.0592	0.0098	1.4325	5
Other services, water supply, and construction	0.1071	0.0954	1.4272	6
Households	0.1031	0.0416	1.4393	3

In the European Union, the largest emission of greenhouse gases, according to the results of the RAM method, is in agriculture, forestry, and fishing. They are followed by: electricity, gas, steam and air conditioning, households, manufacturing, transport, other services, plumbing and construction, and mining and quarrying. Therefore, in the European Union, special attention should be paid to reducing greenhouse gas emissions in agriculture, forestry, and fishing. Greenhouse gas emissions in agriculture are caused, generally speaking, by animal husbandry, application of nitrogen fertilizers, rice cultivation, and energy use. It is considered very difficult to control greenhouse gas emissions in agriculture. Greenhouse gas (GHG) emissions from agricultural activities can be reduced by more efficient management of carbon and nitrogen flows within agricultural systems (Panchasara et al., 2021). In the European Union, in addition to agriculture, forestry, and fishing, a significant source of greenhouse gas emissions is the supply of electricity, gas, steam, and air conditioning. The negative effects of greenhouse gas emissions can be mitigated by more efficient energy management. Data from Eurostat statistics show that greenhouse gas emissions in agriculture, forestry, and fishing are the highest in France. Greenhouse gas emissions from mining and quarrying are the highest in Poland. In Germany, the largest emission of greenhouse gases is in production (manufacturing). The largest

greenhouse gas emission in the supply of electricity, gas, steam, and air conditioning is in Germany. In transport and storage, the largest emission of greenhouse gas is in Germany. Greenhouse gas emissions in other services, water supply, and construction are the highest in France. In the total production activity, the largest greenhouse gas emission is in Germany. In Germany, the largest greenhouse gas emission is in the household. In productive activity plus households, the largest greenhouse gas emission is in Germany. In the European Union, taken as a whole, the largest greenhouse gas emissions are in Germany and France. This is completely understandable when one takes into account the level of development of economic activities. It is far higher than in other European Union member countries (Eurostat (online data code: env_ac_ainah_r2).

CONCLUSION

The investigation of the treated problem in this study showed that in the European Union, the largest emission of greenhouse gases, according to the results of the RAM method, is in agriculture, forestry, and fishing. They are followed by: the supply of electricity, gas, steam and air conditioning, households, manufacturing, transport, other services, water supply and construction, and mining and quarrying. Special attention must be paid to the reduction of greenhouse gas emissions in agriculture, forestry, and fishing. Various measures can be used for these purposes (new technology, energy efficiency, effective manure management, efficient use of nitrogen, regulation, etc.).

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THE IMPACT OF THE OPEN BALKANS INITIATIVE ON THE EXPORT OF AGRI-FOOD PRODUCTS OF SERBIA

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ABSTRACT

The Open Balkans initiative represents the next step in economic cooperation and facilitation of foreign trade exchange between the three countries of the Western Balkans: Serbia, North Macedonia and Albania. This initiative was signed in 2021 and since then several things have been done in the direction of easier trade in agri-food products, and the intention to facilitate the flow of goods at the borders is especially important. The aim of this research is to assess the effects of the Open Balkans initiative on trade in agri-food products. In this direction, on the basis of the data of the Statistical Office of the Republic of Serbia, the trends in the export of these products, as well as the regional and commodity structure of exports, were analyzed. The results of the research show that Serbia achieves good positions when it comes to the export of agri-food products to countries that are signatories of the Open Balkans initiative, but that additional efforts need to be made in order to improve them.

Keywords: Open Balkan, Serbia, Competitiveness, Agri-food sector.

INTRODUCTION

The Open Balkans initiative, signed in 2021 between the three countries of the Western Balkans - Serbia, North Macedonia and Albania, aims to intensify foreign trade exchange, freer movement and economic development. In addition to the memorandum on the freer flow of foreign trade exchange, the agreement on cooperation in the field of veterinary, phytosanitary, and food and feed safety, which is particularly important for the agri-food sector, by which the three signatory countries agree that they will recognize test reports from laboratories of other countries, which enables easier flow of agri-food products between these countries. The Open Balkans initiative represents an upgrade to the existing CEFTA agreement, and despite the impossibility of making a clear distinction between the effects of CEFTA and the Open Balkans, this paper aims to review the regional competitiveness of the exports of the agri-food sector of these countries, and to reveal the potential effects of the Open Balkans initiative on competitiveness itself.

In this direction, with this research, special emphasis will be placed on Serbia, as the most significant player in the foreign trade exchange of agri-food from all the countries of the Western Balkans, and the tendencies in the foreign trade exchange, the regional and commodity structure of export and import of these products will be looked at in particular, and the changes that took place under the influence of the Open Balkan initiative itself, but also the crisis situations that followed the period after the signing of the initiative.

Although competitiveness research is widely present in the literature, due to the relatively recent suppression of this initiative, there is not a large number of studies in the literature dealing with the

effects of the Open Balkans initiative on the competitiveness of the agri-food sector of these countries, i.e. the export positions that are achieved both within the countries that signed the initiative, as well as on the entire export of this sector. Previous research (Zekić, Matkovski, Đokić, 2022) indicates that regional connection through the Open Balkans initiative, which, among other things, resulted in the facilitation of trade in agri-food products, can have very good effects for all the countries of the Western Balkans, both those that are part of this agreement and for those who are, so to speak, potential members. For Serbia, such agreements additionally facilitate the placement conditions on markets that are geographically closest to them and where they achieve competitive advantages, and additional growth in exports to these countries can be expected. On the other hand, for countries that are dependent on imports, such initiatives lead to easier realization of food security, that is, to the realization of stability on the market of agricultural and food products. The possible fear of competitive pressure from Serbia is not fully justified, since the production structure of agriculture in these countries is largely complementary, which can largely be said for the export structure of the agri-food sector. In this context, export growth can be expected for these countries as well, especially in sectors that achieve comparative advantages. Generally speaking, any trade liberalization leads to the intensification of foreign trade exchange, which in this case will lead to a better regional positioning of agri-food products from these countries. Of course, the effects of the process will largely depend on the expansion of the Open Balkans initiative to Bosnia and Herzegovina and Montenegro, without whose participation the results of regional integration will most likely remain at a modest level.

Previous research into Serbia's competitiveness in the regional framework showed that Serbia achieves good positions in the export of agri-food products to all countries of the Western Balkans (Birovljev, Matkovski and Ćetković, 2015; Božić and Nikolić, 2016; Matkovski et al., 2022). When it comes to the research of competitiveness positions within the Open Balkan initiative, the number of researches is very limited. Previous research has shown that Serbia achieves the best results in the export of agri-food products both on the international and regional markets and since the Open Balkans initiative, through the memorandum of understanding on cooperation in facilitating the import, export and movement of goods in the Western Balkans and the agreement on cooperation in the field of veterinary, phytosanitary, and food and feed safety, additional intensification of regional trade of agri-food products is expected (Zekić, Matkovski and Đokić, 2022). According to Bjelić and Kastratović (2023), the Open Balkans represents a step forward in regional integration in the implementation of measures in the area of facilitating trade and the free movement of people and labor, but the basics of the liberalization of trade in goods and services remain agreed within the framework of the CEFTA agreement, and therefore it is very difficult to separate results achieved by CEFTA than those achieved by Open Balkan. Also, some authors are very skeptical about this initiative, i.e. they expect only certain marginal effects, even if the implementation is complete (Kulo and Novikau, 2024).

The paper is organized as follows. After the introduction with literature review, methodology used in paper is defined. Presented results are elaborated with discussion and after that conclusion is elaborated with special focus on limitations and possibilities for future researches.

METHODOLOGY

In accordance with the set goals of the research, this research looked at the export position of the agri-food sector of Serbia on the market of Albania and North Macedonia. In this direction, the value of exports of agri-food products of Serbia in the period 2014-2023 was analyzed. Also, for each country individually, the commodity structure of Serbia's exports was analyzed, that is, the most represented sections in the exchange of these products.

The database of the Statistical Office of the Republic of Serbia (SORS, 2024) was used, namely data related to foreign trade. The term agri-food products includes the complete sectors 0, 1 and 4, as well as certain divisions from sector 2 (21, 22 and 29), all in accordance with the Standard International Trade Classification (SITC, Revision 4).

RESULTS AND DISCUSION

The value of the export of agri-food products from Serbia grew by both other Open Balkan signatories, which is particularly noticeable in the export of these products to Albania in the last three years (Table 1). The average annual growth rate of exports of agri-food products from Serbia to Albania in the analyzed period was 10.35%, that is, the value of exports from 45 million USD in 2014 more than doubled by 2023, when it amounted to almost 101 million USD. In the same observed period, the export of these products to North Macedonia grew at an average annual rate of 6.50%, i.e. from the initial 193 million USD in 2014, the value of the export of agri-food products increased to 302 million USD by 2023.

Table 1. Value of export of agri-food products of Serbia to other Open Balkan countries

	Albania	**North Macedonia**
2014	45,411	192,741
2015	41,147	171,260
2016	46,963	179,414
2017	46,608	203,620
2018	46,608	203,620
2019	52,070	219,843
2020	58,884	226,115
2021	82,447	283,719
2022	89,649	288,858
2023	100,844	302,372

When it comes to share of export of agri-food export of two Open Balkan countries in the total export of agri-food products, it is obvious that North Macedonia is about 5%, while share of export of agri-food products to Albania is much smaller, about 1.5% on average (Figure 1). In recent years, especially since 2020, there has been an increase in the share of these countries in the total export of agri-food products, which can be seen in both observed countries. The reasons should be sought in the Open Balkans initiative, which greatly facilitated trade between these countries.

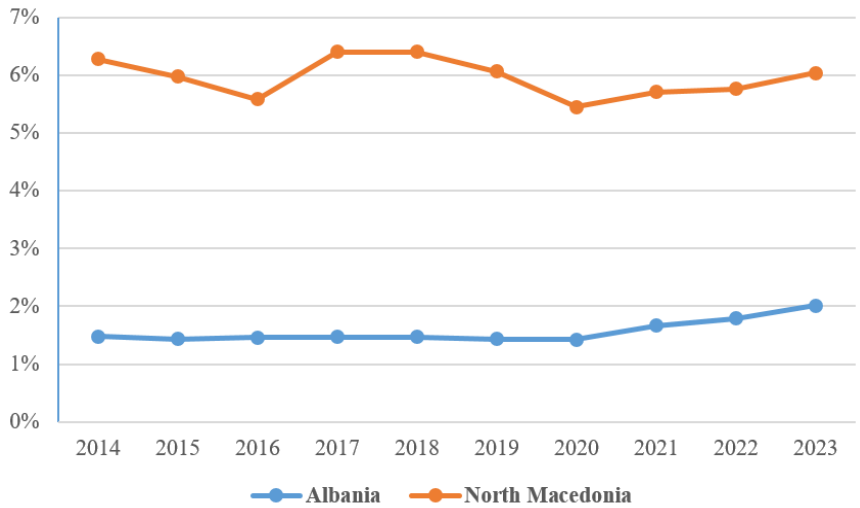

Figure 1: Share of export of agri-food products in total export of agri-food products of Serbia by country

When it comes to the commodity structure of export of agri-food products of Serbia to Albania, the dominant sector is 0 - food and live animals with 70% of the export of agri-food products (Figure 2). Sector 0 - beverages and tobacco with 27% of agri-food products also achieves a large export value, and therefore a large percentage of exports to Albania. When it comes to the main export products from Serbia to Albania, in 2023 they were livestock products: live animals, meat and milk.

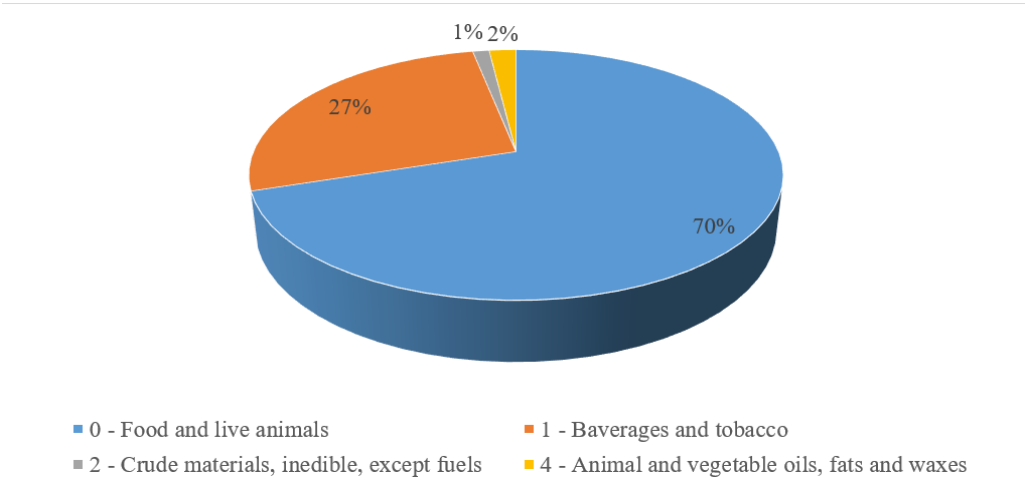

Figure 2: Commodity structure of export of agri-food products of Serbia to Albania

As for the commodity structure of export of agri-food products of Serbia to North Macedonia, as in the case of Albania, sector 0 – food and live animals is dominant with 76% of the export of agri-food products (Figure 3). This sector follows sector 1 – beverages and tobacco with a share of 16% in the total export of agri-food products. When it comes to the main export products from Serbia to North Macedonia, in 2023 they were livestock products: live animals, meat and milk.

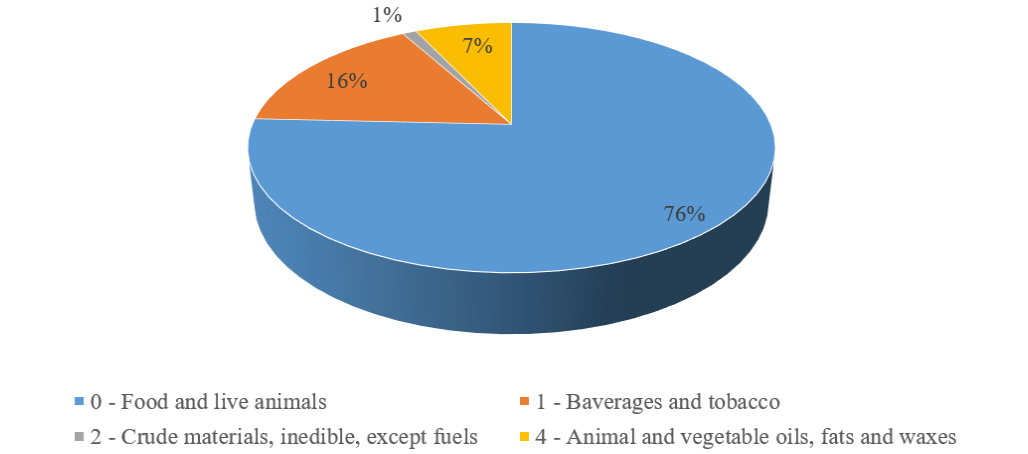

Figure 3: Commodity structure of export of agri-food products of Serbia to North Macedonia

Although Serbia is achieving really positive trends in the export of agri-food products, the export structure is not particularly favorable. Mostly to Albania and North Macedonia, as is the case with other export partner countries, products of plant origin at the lower processing phase are exported. This structure of exports is a consequence of an unfavorable production structure characterized by a high share of products with a low phase of processing. Because of this, the creators of agricultural policy should consider precisely in the direction of shaping measures that will improve animal production, as a generator of the intensity of agriculture.

Certainly, Serbia is the "locomotive" of the Western Balkans and it would be desirable for all the countries of the Western Balkans to join this initiative (Rikalović, Molnar and Josipović, 2022). Regional integration within the Open Balkan initiative can have positive tendencies in the form of regional cooperation (Tota and Culaj, 2023) and further foreign trade exchange, but it can also lead to an increase in food insecurity in import-dependent countries. Additionally, there are opinions that this initiative does not represent anything revolutionary or new in terms of ideas, proclaimed effects and actors, and that the results will be minor (Kulo and Novikau, 2024).

CONCLUSION

The results of this research indicate that in the period from the entry into force of the Open Balkan initiative, there has been a significant increase in the export of agri-food products from Serbia to other signatory countries of the initiative. However, the structure of the export itself is still unfavorable because the products of the lower phases of processing dominate. In addition, previous research shows skepticism as to whether there was an increase in exchange under the influence of the Open Balkans initiative or inertia, bearing in mind that trade barriers were previously removed through CEFTA. In addition, the potential benefits for Serbia are limited considering that the signatories of the initiative are not Montenegro and Bosnia and Herzegovina, which are very important foreign trade partners of Serbia.

This research has a large number of limitations, which will be eliminated by future research. The main limitation is the short period of time that has passed since the conclusion of the Open Balkans initiative, so that the long-term effect on export growth could be seen. Future research will include all Open Balkan countries, and comparative advantages will be assessed, but an attempt will be made to calculate the exact effect of the initiative itself by evaluating the gravity model. Namely, by evaluating the gravity model, it is possible to determine the effect of the initiative itself on the growth of exports of agri-food products.

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THE INFLUENCE OF INFLATION ON THE CREATION OF THE MONETARY POLICY OF SERBIA

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ABSTRACT

Ensuring sustainable price stability and stable economic growth is a complex task for all monetary policymakers. This task is especially not easy for Serbia with a long history of chronic inflation and hyperinflation, weak confidence in the national currency and monetary policy and high sensitivity to external shocks. Achieving low and stable inflation is a gradual process that requires coordination between the National Bank of Serbia and the state, so responsibility for its (non)achievement is shared by the National Bank of Serbia and the state. In an environment where a large part of prices is under administrative control, the National Bank of Serbia can effectively control that part of inflation that is determined by the market itself. On the other hand, the state is responsible for the second part of inflation, which is the result of the adjustment of administrative prices of those products that are under the direct control of the state.

Keywords: Inflation, Price index, GDP, Monetary policy, Standard of living.

INTRODUCTION

Inflation and hyperinflation were the most important characteristics of almost all economies in the world in the 20th century. The appearance of paper money opened a Pandora's box when the monetary authorities simply started printing money in order to cover huge budget expenditures. This was exactly the goal and motive of this work. The work is organized in two chapters.

In the first part of the paper, a presentation of different types of inflation, possible measurement methods and a conceptual explanation of hyperinflation as well as types of stabilization programs to reduce inflation is given. Demand inflation and cost inflation have received the most attention (Wynne, 2008). The cause of inflation is the growth of aggregate demand, usually caused by the growth of the budget deficit, which occurs when the government spends more than it earns. The difference between demand inflation and cost inflation comes down to a fact that shows us who is the cause of inflation (Vedrin, 2015).

In the second part of the paper, an analysis of inflation in Serbia was carried out, with special reference to the years 2021, 2022 and 2023. Stabilizing the economy as well as maintaining the stability of the financial system are the main goals of monetary policy in Serbia. The main problem is that the tasks are difficult to achieve or, even worse, unachievable. These are tasks of low, single-digit inflation.

CLASSIFICATION OF INFLATION AND POSSIBLE FORMS OF INFLATION MEASUREMENT

We classify inflation based on the following criteria: based on the origin of inflation, that is, from the aspect of the cause of inflation, it is divided into: demand inflation, cost inflation, structural inflation; according to the intensity of: creeping "latent" inflation, moderate, high-galloping, hyperinflation, self-generating hyperinflation; according to duration: short-term-acute, long-term-chronic (Dimitrijević, 1996).

Creeping "latent" inflation is ever-present and not dramatic in its scale. Moderate inflation implies a slight rise in prices, these are single-digit annual inflation rates. When prices are relatively stable, people have confidence in money. Galloping inflation is double or triple digit inflation, ranging from 20, 100 or 200% per year. Developed industrial countries can also have this type of inflation. So, for example, Brazil, Argentina and other Latin American countries had inflation rates of 50% to 700% per year in the 1970s and 1980s. Many economies survive galloping inflation, but hardly hyperinflation (Webber, 2022).

Demand inflation occurs as a consequence of excess aggregate demand AD when current and potential GDP are balanced, practically, when the economy is in a state of long-term equilibrium. The cause of inflation is the growth of aggregate demand, usually caused by the growth of the budget deficit, which occurs when the government spends more than it earns (Agarwal, 2022).

The difference between demand inflation and cost inflation comes down to the fact that it shows us who is the cause of inflation. Those two types of inflation are most often defined in the literature according to certain characteristics.

Acute and Chronic inflation was typical for Latin American companies. According to Bruno's criterion, chronic inflation occurs when the inflation rate ranges between 5% and 25% in a period of 5 to 8 years. The basic characteristics of chronic inflation are that it lasts for a long time and is between moderate and hyperinflation in terms of intensity (Mayer, 1988).

Inflation according to intensity can be: creeping - latent (up to 10%), moderate (up to 30%), high - galloping (up to 100% and more), hyperinflation (from 1440% to 12000%) and self-generating over the stated amounts (Ostojić, 2009).

Ways of measuring inflation

Measuring the change in the general price level is a very difficult task. For example, many economists believe that the consumer price index (CPI) overestimates the rate of inflation in previous decades, because this index does not adequately capture improvements in the quality of products and services (McCarthy and Peach 2010).

Methodologically, inflation is measured using the following types of aggregate indices: the price index of retail goods and services, ie the consumer price index; producer price index of products and services; cost of living index; implicit deflator of the social product.
The formula for calculating the inflation rate is given in the following form:

$$\Pi_t = \left(\frac{P_t - P_{t-1}}{P_{t-1}} \right) \times 100 \ \textit{ili} \ \Pi_t = \left(\frac{P_t}{P_{t-1}} - 1 \right) \times 100 \qquad (1)$$

Where Pt denotes the inflation rate, and it is the rate of change of the price level in period t-1 to period t, expressed as a percentage, Pt is the price level in period t, Pt-1 is the price level in period t-1. Based on these formulas, we obtain data on the decline in the purchasing power of money due to the effects of inflation (Vedrin, 2015).

Consumer Price Index

The consumer price index is used: as a general measure of inflation - an important element of macroeconomic analysis, especially in those cases where targeted inflation is a key element of monetary policy; for indexation carried out by the government - when adjusting, that is, harmonizing the wages of employees, pensions paid to retirees, social benefits and the budget; for harmonizing labor prices in private contracts; as a deflator in national accounts (Hobijn and Lagakos, 2003).

Consumer price indices in Serbia include: retail price index, which is used as a measure of inflation, a deflator of retail turnover and for value revaluation; the cost of living index, which is used to adjust wages, pensions and other social benefits.

Producer Price Index

In Serbia, producer price indices are also published, i.e. producer price indices. Those indices are: price index of producers of agricultural products (ie price index of agricultural producers); price index of producers of industrial products (ie price index of industrial producers). Prices of agricultural producers include: purchase prices; selling price (Salvucci, 2023).

Cost of living index

The cost of living index shows the price changes over time of those products and services that the average non-agricultural household purchased on the market (and legally) in the base year. The cost of living index is a special type of retail price index of products and services, which is formed on the basis of a special list of personal consumption products and services, the average retail prices of products and services from that list, that is, their individual price indexes and weights that represent the value structure of the purchased products and services of non-agricultural households according to the results of the Survey on consumption of non-agricultural households (Dumagan and Mount, 1997).

Stabilization programs to reduce inflation

A stabilization program is a set of coordinated and consistent economic policy measures aimed at stabilizing prices with minimal stabilization costs, and can be classified according to different criteria (Frattini, 2006).

The set of stabilization measures includes: fiscal measures to eliminate the budget deficit, which are aimed at: growth in tax revenues, reduction of public spending and budget expenditures; monetary measures for the realization of mon. stability through restrictive mon. policies; monetary reforms with the introduction of a new currency largely after devastating hyperinflation; exchange rate policy and exchange rate fixing, floating fluctuating exchange rate; income policy, which includes price control and limiting wage growth, which is directed against inflationary inertia and indexation; Structural reform measures, which includes privatization, restructuring of companies and the financial sector, and reform of the state sector (Musarat et al., 2021).

ANALYSIS OF INFLATION IN SERBIA

The economy of Serbia in the past three decades was characterized by price instability and high inflation rates, inadequate monetary policy and a very weak and underdeveloped financial sector. After the political changes in 2000, the international community gave Serbia a break to reach a satisfactory level of economic activity and macroeconomic stability using, mainly, non-economic measures (debt cancellation, donations, cheap loans for adjustment, technical assistance, etc.). Bearing in mind the specificity of the situation in which Serbia found itself, it led to the fact that at the end of August 2006, the NBS decided to switch to a new framework of monetary policy, which defined price stability as the main and basic goal of monetary policy, and all other goals remain subordinate to the basic to the goal.

Monetary policy is defined as that part of general economic policy that consists of measures that affect the course of economic life through the creation, cancellation, distribution and redistribution of monetary purchasing power." Monetary policy needs to be harmonized with other segments of economic policy, such as fiscal policy, income and price policy, foreign exchange policy, foreign exchange policy, foreign borrowing policy, etc. (Milunović and Jerinić, 2013).

Thus, in 2006, the NBS tried to gradually withdraw from the foreign exchange market in the sense that it does not carry out frequent and significant interventions with the aim of achieving a certain level or direction of the exchange rate movement. At the time of the introduction of the new monetary policy framework, the Retail Price Index (RPI) was used as the official measure of total inflation in Serbia. This was also the reason why the NBS defined its goals for base inflation in the form of a range for the end of the year at the very beginning: DECEMBER 2006: 7-9%, year-on-year rate; DECEMBER 2007: 4-8%, annual rate; DECEMBER 2008: 3-6%, annual rate; DECEMBER 2009: 2-5%, year-on-year rate; DECEMBER 2010: 3-6%, year-on-year rate; DECEMBER 2011: 2-6%, year-on-year rate; DECEMBER 2012: 2-6%, annual rate.

With the transition of the NBS to a new monetary framework and the realization of a greater degree of oscillations in the movement of the exchange rate, short-term market interest rates have become the main operational target. The key macroeconomic results until 2013 are: relatively high growth of gross domestic product, relative macroeconomic stability measured by the growth of retail prices at a rate of, average annual growth of investments and increase in the share of fixed investments in GDP, relatively high growth of exports, net inflow of direct foreign investments, significant cumulative growth of foreign exchange reserves: DECEMBER 2013: 2-6%, interannual rate according to NBS; DECEMBER 2014: 2-8%, interannual rate according to NBS; DECEMBER 2015: 3-6%, interannual rate according to NBS; DECEMBER 2016: 2-7%, interannual rate according to NBS; DECEMBER 2017: 2-5%, interannual rate according to NBS; DECEMBER 2018: 3-7%, annual rate according to NBS and RZS; DECEMBER 2019: 2-6%, annual rate according to NBS and RZS; DECEMBER 2020: 3-9%, annual rate according to NBS and RZS.

Inflation in Serbia in 2021

According to the November 2021 central projection, annual inflation was expected to temporarily move above the upper limit of the target (3 ± 1.5%) until mid-2022, when, as a result of the expected reduction from the second quarter of 2022, first return to those limits, and then to the lower part of the target range by the end of the year, where it will remain in 2023. This trend of inflation is influenced by higher world prices of oil, primary agricultural products and unprocessed food, as well as disruptions in global supply chains and significantly higher transport costs, with the weakening of the effect of these factors expected from mid-2022 and their almost complete disappearance by the end of 2022.

According to the NBS and RZS, the important factors of relatively low and stable base inflation were the relative stability of the exchange rate and the anchoring of inflationary expectations of the financial sector and the economy within the target limits.

Inflation in Serbia in 2022

According to the November 2022 central projection, year-on-year inflation was expected to remain elevated through late 2022 and early 2023, before falling sharply in the second half of 2023 and returning to target by the end of the projection period. The reduction of inflation should primarily be contributed by the effects of the tightening of monetary conditions, the slowdown of import inflation, the weakening of global cost pressures and the completion of their transfer to consumer prices, as well as the disinflationary effect of aggregate demand, primarily due to significantly lower external demand. In the event that some of the risks that could have resulted in the movement of inflation above the upper limit of the permissible deviation (16%) from the target in a longer period materialized, the National Bank of Serbia was ready to react as soon as possible with all available instruments .

According to the NBS and RZS, as in the previous period, core inflation, which is more influenced by monetary policy measures, was significantly below total inflation and amounted to 8.6% in September. The preserved relative stability of the exchange rate of the dinar against the euro continued to contribute to such dynamics.

Inflation in Serbia in 2023

Year-on-year inflation has been on a downward trajectory since April 2023, with its level in August and September even slightly lower than projected in the August medium-term projection. The slowdown in inflation to 10.2% in September is the result of lower growth in food prices and prices within the base inflation (consumer price index excluding food, energy, alcohol and cigarettes), whose year-on-year growth has been at a single-digit level since June and in September was reduced to 8.2%. In addition to easing global cost pressures, the tightening of monetary conditions also contributed to the fall in core inflation. The downward trajectory of inflation and its approach to a single-digit level was reflected in the reduction of inflation expectations of the financial sector for one year ahead, as well as the movement of expectations for two and three years ahead within the limits of the National Bank of Serbia's target.

According to the NBS and RZS, the risks of the projection of inflation and gross domestic product in the coming period are assessed as symmetrical, whereby the National Bank of Serbia will assess whether there is a need to react with additional measures.

DISCUSSION

Past experience shows that low and stable inflation makes a positive contribution to long-term economic growth and that it is the most effective support that monetary policy can give to the performance of an economy. Macroeconomic results in Serbia are predominantly positive. Serbia significantly reduced inflation in the first years of transition (2001-2010). The main generators of the price increase were the monetary credit expansion, the growth of domestic demand through the growth of wages and public consumption, a series of exogenous shocks related to the increase in the prices of crude oil, basic metals and raw materials on the world market, the correction of disparities in domestic regulated prices, occasional droughts and the increase in agricultural prices products and food, the introduction of value added tax, insufficient competition and the influence of monopolies.

Within the detailed analyzes included in the work (2021-2023), Serbia achieved a relatively high average annual rate of real growth of gross domestic product and cumulative GDP growth, which is a significant result of economic policy achieved in the conditions of the introduction of new measures and cyclical movements of the world economy. Realized investments and structural reforms, primarily the privatization of social enterprises, had a positive effect on growth. A more restrictive monetary policy, together with exchange rate appreciation, lowered inflation, while GDP and industrial production growth remained solid.

During the introduction of the new monetary framework, the NBS, like most other central banks, did not meet all the prerequisites for the introduction of the new regime. The experiences of the countries have shown that the fulfillment of the prerequisites is not what decisively determines the success of the regime. Considering our own experience from the beginning of the 2000s, it can be concluded that using this framework is a good solution in a situation where you want to lower inflation from high levels in a short period of time. With the introduction of inflation targeting, the reference interest rate of the NBS was successively reduced several times.

CONCLUSION

Based on the analyzes processed in the paper, it can be concluded that a lot is known about inflation, but still not enough to be able to "cure" it. Its behavior resembles dangerous viruses, because it does not choose the place or time where and when it will appear. These can be undeveloped as well as developed countries, regardless of whether their area is small or large. Another specificity that it has in common with the aforementioned virus is that it never occurs twice in the same form. Only after the

First World War did inflation become an almost constant phenomenon with drastic consequences. Inflation is present in the entire economy and primarily refers to the value of the medium of exchange in the economy. History shows that prices rise during wars and economic crises, but do not return to their original levels after wars and crises.

Unfortunately, from all of the above, it can be seen that the main and fundamental cause of inflation is bad monetary policy, or rather, bad monetary policy makers who are often under the strong influence of the state.

The idea behind the concept of inflation targeting is not that inflation should be on target, but that the monetary authorities bear responsibility for targeting inflation in the medium term. That is, only exceeding the goal in a long period of time would indicate the failure of the regime, which time will show. What is unfortunate for Serbia is that it was hit by a series of external shocks immediately in the second year of the implementation of the new monetary policy regime in 2008 (world economic crisis), and after that in 2014, as well as in 2020 under the influence of the corona virus pandemic that continued in 2021, and then an even bigger crisis shock hit Serbia in 2022 (Ukrainian crisis and consequences of the pandemic), and in relatively stable conditions (2006 and 2007) and (2015 and 2016) monetary authorities they had no problems with inflation. But more and more difficult years are coming, and therefore the monetary authorities can expect new strategies and measures to adapt to the conditions of the monetary regimes of both Europe and the whole world.

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INSURANCE INDUSTRY: OPPORTUNITIES AND CHALLENGES

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ABSTRACT

After the events of the last few years, the insurance industry has shown the characteristics of readiness for unexpected developments and major changes. In particular, insurers have shown that they can undertake large-scale change at a faster pace than expected within the industry. Additionally, imposed conditions in the macroeconomic environment and structural challenges expressed through low interest rates and rising inflation have encouraged the insurance industry to move towards the transformation of traditional business models. At the same time, the accelerated digitization and development of new technologies additionally influenced the changes in strategies applied within the insurance industry. On the other hand, all these factors have shown why the insurance industry is essential by highlighting the importance of insurance in the conditions before and after the COVID-19 pandemic. Decisions and actions taken by insurers have a significant impact on the future course of industry development as well as further development in the post-pandemic period. Today, collaboration or cooperation is becoming a pillar of support in insurers' strategies during ecosystem building and convergence with other sectors. The aim of the work is to analyze the global insurance industry, from the aspect of current indicators in the insurance industry, as well as future challenges faced by this industry. The first part of the work analyzes key indicators in the insurance industry from the aspect of total premium and profitability. The second part of the paper analyzes the challenges facing the insurance industry in terms of global risks after COVID-19.

Keywords: Insurance industry, Risk, Insurance companies.

INTRODUCTION

The global environment in which insurance companies operate faces the characteristics of fragmentation, a mixture of traditional and digital business models with a wide spread of cooperations. Today, collaboration or cooperation is becoming a pillar of support in insurers' strategies during ecosystem building and convergence with other sectors. Also, consolidation among existing insurance companies, some of which are linked to new entrants, increasing joint ventures and large and ongoing private equity investments are reshaping the landscape in which they operate. (Insurance, 2022).

Climate change is the challenge of the century that requires public-private partnerships at a new level. What's more, climate challenges also assign insurers a key role through the transformation towards new insurance models as they become agents of change, actively reducing risk in the system by influencing takeovers and investments and thus leading the shift towards sustainability (Colier, Eliott, & Lehtonen, 2021). To remain relevant, the industry must change accordingly, moving beyond prices and shifting the risk of changing outcomes from unsustainable behaviors and processes to sustainable ones (Alianz, 2022). That is why, after the COVID-19 pandemic, the insurance industry is faced with a dual role through risk insurers and investors, giving it a unique position to lead this transformation and lead to economic, social and environmental sustainability. Given the significant amounts of investment in the insurance industry and the environmental and social benefits, as well as the potentially attractive

long-term returns, sustainable investment strategies should be vital for insurers (Gatzer & Reichel, 2022).

Second, the insurance industry's response to the COVID-19 pandemic has forced insurers to make changes in terms of transitioning to a greener economy and promoting financial health, but also protecting society from cybercrime, the next pandemic or other threats in the future. (Prtzybytniowski, Borkowski, Pawlik, & Garasyim, 2022).

Thus, the insurance industry is also facing climate and demographic changes that are becoming drivers for demand in the domain of awareness of risk protection. However, annual growth of around 5% is expected over the next ten years (life insurance with a rate of 4.9%, P&C with a growth rate of 4.6%). Such growth corresponds to an increase of 67% or additional premium income of 2.8 billion euros by 2032, of which slightly less than 1.8 billion euros will be generated by the life segment (69%) and just over 1 billion euros from foreign companies segment (63%) (Alianz, 2022,).

METHODOLOGY RESEARCH

Secondary research was applied in the work. Analytical-synthetic, inductive-deductive, abstraction and generalization methods were used from the basic methods of knowledge, and for theoretical considerations of the research subject. Of the scientific methods, the method of content analysis was used. Data from available professional literature, scientific and professional works, the Internet and other sources were also used.

GLOBAL INDICATORS IN THE INSURANCE INDUSTRY

Globally, global insurance premiums are expected to grow by around 3% in real terms per year on average over the next two years, above the long-term trend (Figure 1). In non-life insurance, advanced Europe and emerging markets will grow above trend, while advanced Asia and Pacific and North America will grow in line with their long-term trend (Figure 2). Within life insurance, developed countries will see premium growth above trend, but emerging markets will lag below trend. The following chart shows forecasts of insurance premium trends based on increased risk awareness among consumers and companies following the shock of the COVID-19 pandemic. (Re, 2021).

As transparency plays a key role in the risk assessment of insurers' investment portfolios, insurers are increasingly developing more elaborate investment strategies. At the same time, insurance product innovation and offering will pave the way for providing complete solutions through risk management engagement and prevention as the key to creating insurance product value. Insurers understand that external shocks (pandemic and climate change) have directed business in the direction of formulating strategies further through the development of capabilities, managers and acquisitions (M&A), but also integration with the wider market. Mergers and acquisitions (M&A) activity has been a predictable market over the past decade, with the only major variation caused by the 2008 financial crisis. Since 2008, there has been steady growth, helped by a stronger insurance market (Standaert & Muylle, 2022).

Both before and after the financial crisis, factors included insurers looking to break into new markets and new geographies, defending their market position, growing market share, and the need and desire to increase digitization capabilities. The role of consultants and project managers is increasingly important as insurers adopt new business strategies, increase the use of digitization and innovation, and merge different work cultures. A key trend will be the design of sustainable, fully integrated business models that address the common problems around legacy platforms with the costs arising from simplification and remediation programs (McKisney & Company, 2022).

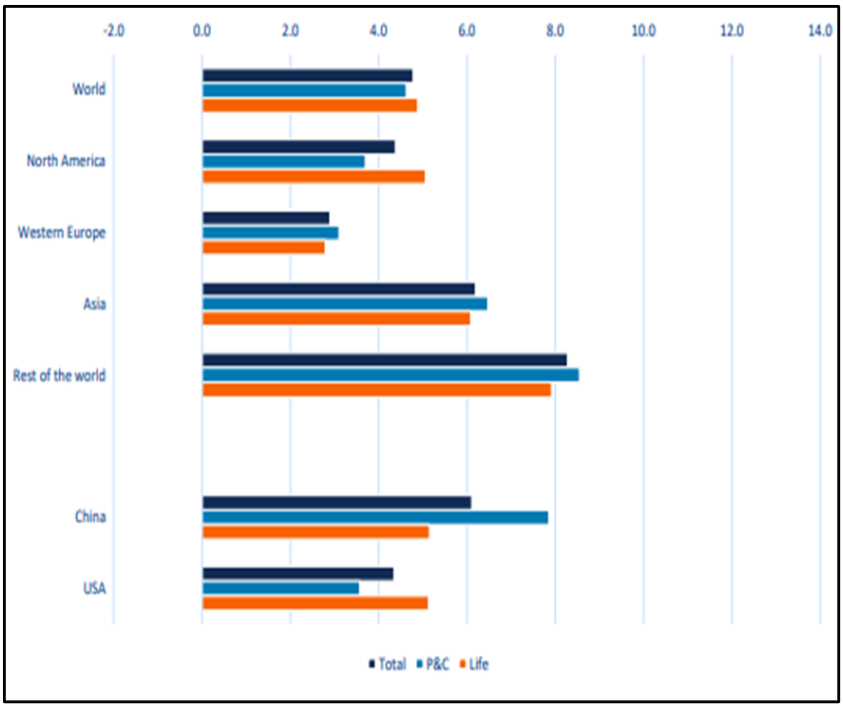

Figure 1: Growth of invoiced insurance premiums in 2022 (by region, in %)

	Total		Non-Life		Life	
	2021E	2022-23F	2021E	2022-23F	2021E	2022-23F
World	3.4% ▲	3.2% ▲	3.3% –	3.5% ▲	3.5% ▲	2.8% ▲
Advanced markets	3.3% ▲	2.4% ▲	2.8% ▲	2.4% –	4.1% ▲	2.3% ▲
North America	2.3% ▲	2.4% ▲	2.7% –	2.4% –	1.2% ▲	2.2% ▲
EMEA	4.9% ▲	2.0% ▲	2.3% ▲	2.3% ▲	6.9% ▲	1.7% ▲
Asia-Pacific	3.9% ▲	3.2% ▲	4.6% ▲	2.9% –	3.8% ▲	3.3% ▲
Emerging markets	3.4% ▼	6.4% ▼	5.8% ▼	8.2% ▲	1.4% ▼	4.6% ▼
Excl China	5.7% ▲	5.1% –	4.7% ▲	4.7% ▲	6.9% ▲	5.8% –
China	1.5% ▼	7.0% ▼	6.4% ▼	10.3% ▼	-2.8% ▼	3.6% ▼

Figure 2: Insurance premium by region (2022-2023)

In terms of ROE indicators for the overall insurance industry, average realized ROEs have remained at or slightly below the cost of capital over the past years, particularly in North America and Western Europe (Figure 3). What's more, insurance customers have high digital expectations as they compare their insurers to interactions with other service providers after the pandemic and shutdown period.

The experience of individuals spills over into the insurance industry as a reflection of the improvement of service provision through digital platforms and in other sectors. For example, in the banking sector, significant progress has been made in the development of the offer and its focus through digital platforms (Eling & Lehmann, 2018).

Digitization and big data initiatives in the insurance industry are growing faster than in other industries. While companies are truly modernizing and simplifying their IT systems and expanding their digital footprint, boards face a number of constraints, including industry regulation, legacy

systems, limited financial and talent resources, inappropriate organizational cultures and data security requirements. (Standaert & Muylle, 2022).

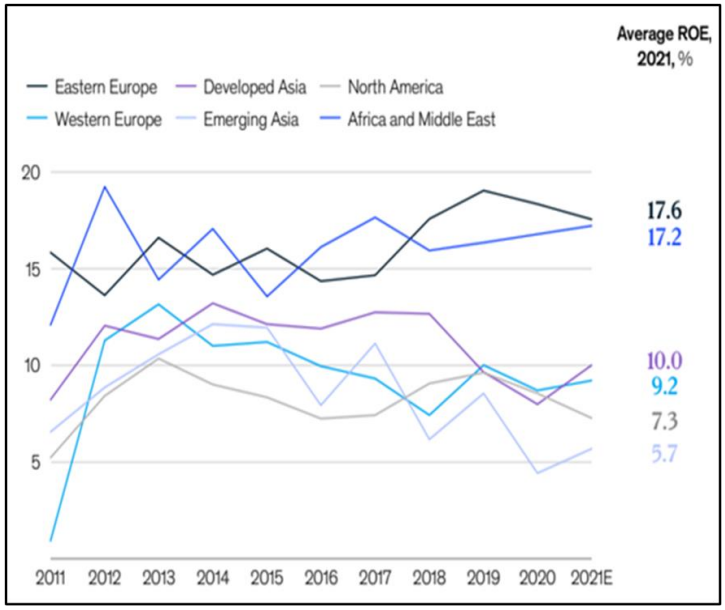

Figure 3: The trend of the average ROE of insurance companies in the period 2011-2021. year, observed by region (in %)

THE ROLE OF INSURANCE IN THE GLOBAL RISK ENVIRONMENT AFTER COVID-19

The multi-faceted nature of the COVID-19 pandemic has affected many areas of business within the insurance industry, and trade credit insurance, which has been related to coverage for companies and the situation if customers who owe money for products or services are late on obligations, travel, cyber liability due to increased work from home and event cancellation (Marina, Antonella, Valentina & Fabrizio, 2022).

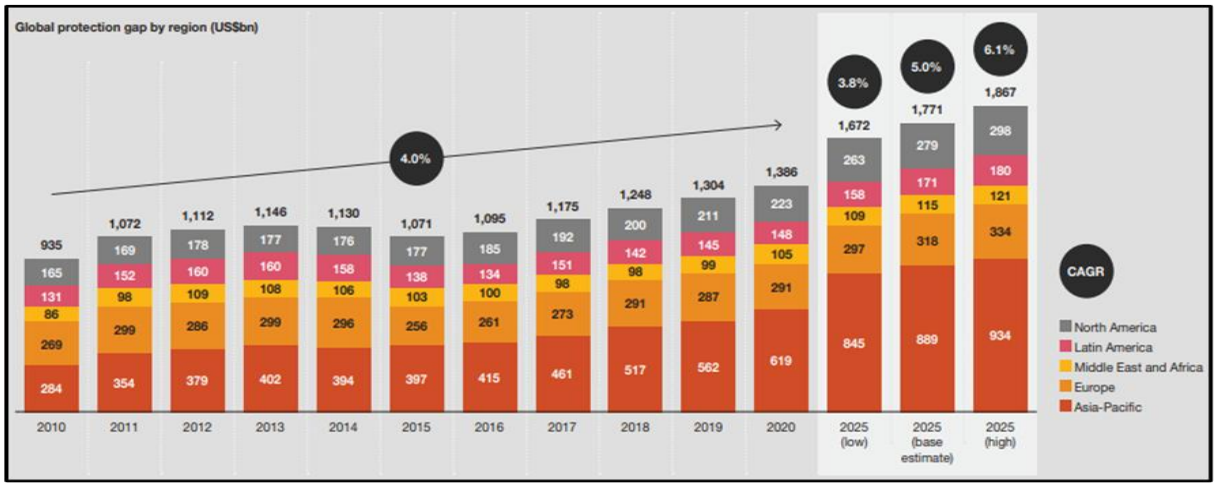

Figure 4. Global protection gap by region 2010-2025 (US$ trillion)

Therefore, in the dimension of risk accumulation, there are quantitative differences as a reflection of the impact of risk observed by region. So, "infectious disease catastrophes are global risk accumulations that affect many types of insurance at the same time, such as life insurance, business interruption, activity cancellation insurance, credit guarantee insurance, and more" (Kong, 2021).

On the other hand, the increasingly noticeable wealth gap accelerated by the pandemic has resulted in greater social distrust. "By 2024, developing economies (excluding China) will fall 5.5% below expected pre-pandemic GDP growth, while advanced economies will outpace it by 0.9% widening the global income gap" (Forum, 2022). So there is an urgency for insurance companies to define and implement strategies to address the trust challenge (Prtzybytniowski, Borkowski, Pawlik, & Garasyim, 2022).

Before the COVID-19 pandemic, insurance companies developed and implemented key anti-crisis development strategies, namely, a long-term planned change strategy, a strategy for balancing the interests of the insurance company and stakeholders, and a risk management strategy.

During the pandemic, insurance companies changed their approach to the formation and implementation of basic anti-crisis development strategies. The first, the strategy of concentration of efforts, is based on a combination of strategies of long-term planned changes and balancing the interests of the insurance company and stakeholders.

Second, an innovation strategy consisting of the development and implementation of new insurance services and risk compensation mechanisms due to the specific characteristics of the pandemic. This includes cyber insurance and a review of pandemic risk management mechanisms.

Third, a strategy for maintaining a sufficient level of financial sustainability of insurance companies, which is based on the concept of financial sustainable development. The concept of financial sustainable development indicates that the closer a company is to the center of the zone of financially sustainable development, the more risks it can face, which is especially important in the period of COVID-19 (Kong, 2021).

Therefore, the need to develop anti-crisis strategies is because insurers' losses from COVID-19 have grown rapidly, and the most vulnerable areas have been tourism companies, hotels, restaurants and healthcare. This undermined the financial stability of insurance companies, creating an imbalance in the insurance market. On the other hand, the industry was faced with low interest rates, low margins and constantly rising premiums with investment needs.

The rise of open finance together with ecosystems of financial solutions has contributed to the development of a new trend in the field of financial services during 2020. Such development of new trends represents a response to changes in the needs and expectations of clients. Accordingly, insurers' value creation is rapidly changing as a result of the introduction of other commercialized products and the growing demand for more affordable, transparent and customized insurance. (Kasminski & Polinkevych, 2021).

CONCLUSION

Business within the insurance industry cannot be characterized as predictable and stable after the pandemic. Today, the insurance industry is characterized by business with growth challenges at the sacrifice of profitability with climate change irreversibly affecting certain risk profiles, but also a focus on distribution needs and personalized insurance products.

Also, rising interest rates and changes in tax policy pose a challenge to the insurance industry as new conditions create new winners and losers in 2022. So, the current crisis can be a new beginning for the management of insurance companies. In order to respond to the changing market conditions due to COVID-19, the insurance industry will need to transform.

On the other hand, technology continues its accelerated progress and therefore the insurance industry is being forced to make more aggressive strategic choices in order to ensure successful operations. In addition, the COVID-19 pandemic has contributed to the development of the digitalization of the sale

of insurance products, downloads including alternative data sources and accelerated insurance and services as a significant improvement of the customer experience.

Therefore, in the coming years, the global insurance industry will be deeply shaped by certain megatrends that have emerged and accelerated since February 2020. Thus, open insurance as a result of the underlying trend of open finance stimulates insurers to use digital technology to exchange data with third parties to achieve process efficiency and developed new products and channels.

However, by introducing digitization into business platforms and models, it contributes to the development of new risks expressed as cyber risk or the risk of attacks that threaten data security. Cyber security threats are growing and threaten companies of all sizes, municipalities, state and federal governments.

The solution lies in strengthening defenses by anticipating new cyber threats and understanding the new defensive capabilities companies can use today and others they can plan to use tomorrow. Also, a risk of global proportions that threatens the entire planet is climate risk. Therefore, the insurance industry and its development should also move in the direction of climate change, taking into account the transformation of its business towards green insurance.

So the winners will be the companies that develop their strategies early and proactively engage with the regulatory agenda and take tactical steps to realize their ecosystem visions. At the same time, the connection and cooperation between private insurance companies and other interested parties will provide partnerships that will positively influence the further development of the insurance industry in the management of climate risks, pandemic risks and cyber risks in the present, but also in the future from a direct and indirect perspective.

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Session E: IT MANAGEMENT

Papers (pp. 233-280):

QUALITY OF SOFTWARE FOR EMBEDDED SYSTEMS – PRELIMINARY REVIEW

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ABSTRACT

In this work, a quality of software for embedded systems has been reviewed. By analyzing software metrics for quality, different approaches have been reviewed that could improve the quality of the source code resulting in elimination of the redundant code and overall performance improvements. By refactoring the source code, significant improvements of the memory management and power consumption could be achieved as well. Complexity of the embedded systems requires that developers consider different approaches during the development of the software, as well as hardware limitations of the desired systems and required speed of execution to achieve stable, optimized, and clean code.

Keywords: Embedded, Embedded systems, Quality, Software, Review.

INTRODUCTION

Quality of software for embedded systems plays important role of embedded systems development process due to hardware performance and limitations of the computational power of microprocessors, as well as available memory and storage of embedded devices. By the technological advancements of the world and improvements on the STM32, ESM32, Arduino, Raspberry Pi, Banana Pi and similar technologies, besides of standard procedural approach, the software development for embedded system introduced solutions that are object oriented, capable of multithreading and communicating between more modules. By increasing amount of possible devices and modules attached to these boards, more opportunities and features have been available to implement, but quality of the software has been harder to achieve, which was commonly followed by degradation of performances, bugs and unoptimized source code.

Overview on quality of software for embedded systems includes reviewing different ways of ranking quality of source codes such as software metrics which are designed to exemine coupling, cohesion, extensibility, population and complexity of the source code, bugs which could significantly impact the performances of the overall embedded system as well as readability and refactoring of the source code that can impact the performances in both positive and negative ways.

OVERVIEW ON QUALITY OF SOFTWARE FOR EMBEDDED SYSTEMS

Due to increased variety and complexity of embedded systems, the demand for software quality of embedded systems increased as well. Quality Models and Quality Attributes (QM&QA) for embedded systems already exist, but there is a lack of complete and detailed reviews about the research that propose QM&QA dedicated specifically towards the embedded systems (Oliveira et al, 2013).

Existing software quality models usually focus on quality characteristics such as ISO 25010 software quality characteristics, which usually focuses on quality assessments of the source code and do not sufficiently cover the particularities of the embedded systems. (Mayr et al, 2012).

Although there are various strategies focused towards improving the quality of the software for embedded systems, they highly depend on hardware which tends to make overall optimization and software quality difficult to achieve. New programming paradigms such as Object-Orientation and Aspect-Orientation as well as Model-driven engineering have merged, and embedded systems started relying more on software due to technological advancement which followed an increase of the embedded systems software size from 1-2MB all the way up to 16-128MB in modern systems (Oliveira et al, 2008; Redin et al, 2008).

As components are pieces of software with defined interface, they can often be reused in different applications. These components are usually not developed under programming restrictions for specific embedded systems because those restrictions mostly depend on the underlying hardware. Running such software on micro controllers that have limited resources can result in various problems such as memory overflow etc. (Jahnke, et al, 2000).

Software metrics for quality

Software metrics are important factors that can more precisely show the quality of the software and source code. Classification of coupling, cohesion, extensibility and reuse, population metrics and complexity metrics are designed to evaluate different parts of the software and provide overview on software quality. (Redin et al, 2008)

Coupling is related towards measuring the relationship between components, as well as calls and number of instances. High values of coupling metrics point out that application is poor in encapsulation, reuse and maintainability. Known metrics for coupling are Afferent Coupling (CA), Efferent Coupling (CE) and Instability metrics (I) (Redin et al, 2008).

Cohesion metrics are used to measure the degree to which the elements of a scope are functionally related. It is of a significant importance that implemented functionality is related to one feature of the software, and that it requires little or no interaction with other modules. One of the metrics related towards the Cohesion is Lack of Cohesion of Methods (LCOM) (Redin et al, 2008).

Extensibility and reuse metrics are designed to evaluate things such as the possible reuse of a scope, abstractness and depth of an inheritance. Some of the extensibility and reuse metrics are Abstractness (A), Normalized Distance from Main Sequence (Dn) as well as Depth of Inheritance Tree (DIT) (Redin et al, 2008).

Population metrics is designed to measure the system in terms of attributes, methods in classes. High values of these metrics indicate that performances are slower, the memory footprint is increased, and software solution is more complex. Several population metrics are also known as Number of Attributes (NOA), Number of Classes (NOC), Number of Methods (NOM), Number of Packages (NOPK), Number of Parameters (NOP), Number of Static Attributes (NOSA), Number of Static Methods (NOSM) and Total Lines of Code (TLOC) (Redin et al, 2008).

Complexity metrics, as the name suggests are used to measure the hardness to understand the source code, problem or the algorithm. Often related to alternative execution flows, element granularity and hierarchy as well as nested execution. Some of the commonly used complexity metrics are McCabe Cyclomatic Complexity (VG), Method Lines of Code (MLOC), Nested Block Depth (NBD) and Weighted Methods per Class (WMC) (Redin et al, 2008).

Bugs and impact on quality of software

One way to measure the quality of the software of embedded systems can be achieved by concerning and investigating the quality of attributes trough source code and its evolution. Important indicators of software quality are bugs, which were extensively investigated as important indicators of the quality itself. By using bugs to quantify quality, a common practice of classifying them in categories is used. The evaluation of critical quality attributes is mapped to three critical quality assurances which are correctness (Correctness and Multithreaded Correctness categories), performance (Performance category) and security (Security and Malicious Code categories). Based on the mapping of three critical quality assurance, the level of quality is measured by the numbers of detected bugs. (Feitosa et al, 2015).

Refactoring

Achieving highly efficient and readable source code is one of the important factors when developing software, specially if the software is designated to run on devices with limited hardware power such as embedded systems. Improvements of the source code could be achieved more reliably if the source code itself is written in a way that human can understand it easily. Functions and way of the execution can be altered in a more efficient way, providing faster execution time, better error handling as well as better memory management.

Table 1: Indicative source-to-source transformations for improving performance and energy efficiency (Papadopoulos et al, 2018)

Before	After
Transformation 1: Intermediate variable removal	

void foo(){
a = f(x);
g(a);
}
	void foo()
	{
	g(f(x));
	}

Improves performance/memory/energy and code quality	
Transformation 2: Avoid unnecessary variable reassignment	

for(i=0;i<N;i++){
for(j=0;j<N;j++){
a=arr[i];
}
}
	for(i=0;i<N;i++){
	a=arr[i];
	for(j=0;j<N;j++)
	{...}
	}

Improves performance/energy	
Transformation 3: Loop interchange	

for(i=0;i<N;i++){
for(j=0;j<N;j++){...}
}
	for(j=0;j<N;j++){
	for(i=0;i<N;i++){...}
	}

Improves performance/energy	
Transformation 4: Switch from dynamic to static allocation	

a=(int∗)malloc(SZ);
if(a==NULL){
//errormessage.
}
...
free(a);
	Int a[ENTRIES];

Improves performance/energy, code quality May increase memory requirements.	
Transformation 5: Switch from static to dynamic allocation (The opposite of Transformation 4) **May improve memory requirements.** **Increases execution time and energy consumption.**	

Table 2: Indicative refactorings for improving code quality (Papadopoulos et al, 2018)

Before	After
Refactoring 1: Extract Method	

void foo()
{
...//
fibonacci:
for(i=1;i<n;i++){
next_term=t1+t2;
t1=t2;
t2=next_term;
}
}
	Void foo()
	{...
	fibonacci(n)
	}
	
	Void fibonacci(n)
	{
	for(i=1;i<n;i++){
	next_term=t1+t2;
	t1=t2;
	t2=next_term;}
	}

Improves understandability, complexity, cohesion. Increases execution time	
Refactoring 2: Consolidate Duplicate Conditional Fragments	

if(a>0)
{
...
foo();
}
else{
...
foo();
}
	if(a>0)
	{
	...
	}
	else
	{
	...
	}
	foo();

Improves comprehensibility, maintainability, and code size	
Refactoring 3: Replace Conditional with Polymorphism	

Class Movie{
...
doublegetCharge(){
switch(priceCode){
case REGULAR:
//regular price
case CHILDREN:
//for children
}
}
}
	abstract classMovie{
	abstract getCharge();
	}
	class RegularMovie extends Movie{
	double getCharge(){
	//regularprice
	}
	}
	class ChildrensMovie extends Movie{
	doublegetCharge(){
	//forchildren
	}
	}

Improves maintainability memory and execution time	

CONCLUSION

Software quality as a term in embedded systems includes important factors such as readability of the code, performance optimization, energy consumption efficiency, as well as scalability of modules attached to the embedded systems. Software quality of the embedded systems itself is a field that is not researched enough, but by designing such systems, it is of great importance to make source code readable to other developers to make it easier for refactoring which often leads to increased performances and more efficient memory management. By making it optimized, energy efficiency is improved as well, as redundant code is evaded. By applying specific software quality metrics, it is possible to measure the quality of the source code and solve possible bugs that could occur during the development phase.

Further development of the embedded systems could be improved by utilizing hardware components that could benefit by having multithreading available, such as Banana Pi devices, which goes up to eight cores, or by having separate microprocessors designed to control different parts of the systems independently. By using more advanced modules, operative systems based on Linux could also be installed, which could improve overall control over the embedded system.

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OPERATIONAL RESEARCH IN FUNCTION OF MAINTAINING AN INFORMATION SECURITY RISKS OF CRITICAL INFRASTRUCTURE

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ABSTRACT

The problem of the research is represented by the fact that created from long years of practice that it has been established a complete matrix of real risks in order to establish a manageable information security management system organization in the state critical infrastructure system. Information systems are formed to provide numerous services to citizens, businesses and government authorities, so there are undisputed risks in the domain of information security. The goal of this work is to set experienced guidelines for a detailed analysis of the organization's information security risks using operational research that will be able to set the basic concept of realistic monitoring of an acceptable risk level. The paper emphasizes the need for segments of state critical infrastructure to properly establish an internal and external framework for real-time identification, analysis and evaluation of risks in technological, organizational and procedural frameworks.

Keywords: Information security management system, Information system, Risk, Operational research, Level of acceptable risk, Critical infrastructure..

INTRODUCTION

Digitization of information systems of state bodies implies the application of appropriate standards in the management of ICT systems both from the aspect of providing the necessary services to citizens, companies and other state bodies, domestic and international, as well as from the aspect of information security.

Emphasis is placed on preventing the realization of security incidents, control and management of access to information systems and prevention of data leakage, technological monitoring of adopted security tools, introduction of technological measures to monitor and protect data security within the implemented ICT systems of state bodies.

Practice shows that individual state bodies in the same department are consulted in the field of information security architecture, but there are few or no competent state bodies that carry out full coordination of design, implementation, monitoring and response to security incidents.

The ultimate requirement for state authorities that are part of the critical infrastructure system is the establishment of an information security management system that monitors information security risks in real time and is capable of reacting appropriately.

RISK ASSESSMENT FOR INFORMATION SECURITY

State bodies in the system of critical infrastructure basically have to identify Score, Context and Criteria as a basis for establishing a framework for the information security management system of organizations in the system of state critical infrastructure. Communication with other state authorities is necessary because a system of early identification of threats and vulnerabilities must be established, which must react predictively and not preventively. All the time, it is necessary to follow all identified interested parties, both those who want good for the organization's system, and those who have different intentions and initiatives.

Risk assessment is the next phase which must consist of risk identification, risk analysis and risk evaluation. Risk identification is a detailed and long-term job for multidisciplinary team of organization which must identify each and every individual risk, regardless of whether it represents a higher or lower risk level at the moment of identification.

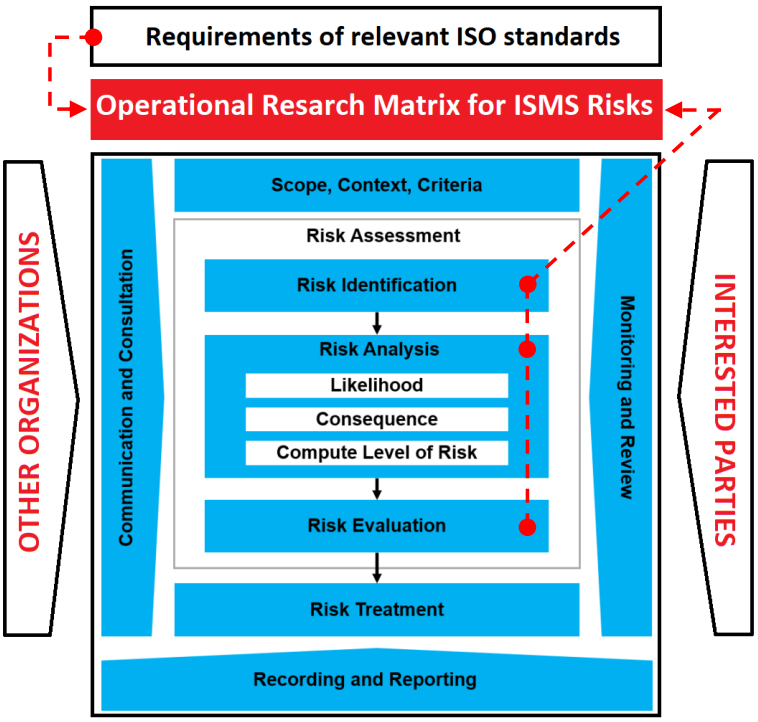

Figure. 1: Risk assessment(by ISO 31000) extended with correlation ORM and ISO standards requirements

The professional framework for risk analysis is represented by the standards: ISO/IEC 27005 - Information security, cybersecurity and privacy protection - Guidance on managing information security risks and ISO 31000 - Risk management - Guidelines. Risk analysis must consider all identified risks from the aspect of likelihood, consequences and calculate risk levels.

All three mentioned criteria must be set in such a way that the analysis observes and projects in real time with a large knowledge base that is the basis for calculating parameter values. A risk evaluation must provide a clear answer to a question that is not just a simple number but a multidimensional framework that shows trends and every single evaluation parameter in real time.

Risk treatment as the next phase is mainly oriented towards acting according to each individually identified requirement of the ISO standard within the matrix. The knowledge acquired in the process of treating risks during the management of the information security system is a significant source for further analysis using the principles of machine learning and possibly in the future also artificial intelligence (currently only one-way because the data cannot be delivered to entities outside the state administration system).

The assessment of the state of the actually implemented system is measured by the shortest and longest real-time interval of the identified parameters whose value is evaluated by this system.

IDENTIFICATION OF REQUIREMENTS FOR INFORMATION SECURITY

The initial framework for action in the domain of information security is defined within the requirements of the standard ISO/IEC 27001 - Information security, cybersecurity and privacy protection - Information security management systems - Requirements, ISO/IEC 27701 - Security techniques - Extension to ISO/IEC 27001 and ISO /IEC 27002 for privacy information management - Requirements and guidelines, ISO/IEC 27032 - Cybersecurity - Guidelines for Internet security, ISO/IEC 20000-1 - information technology - Service management - Service management system requirements and ISO/IEC 22301 - Security and resilience - Business continuity management systems – Requirements (International Organization for Standardization, Geneva Switzerland, www.iso.org) as well as other requirements within other requirements of the standard, it is certainly and inevitably necessary to treat the requirements of the ISO 9001 - Quality management systems – Requirements standard in the domain of detailed and complete analysis of opportunities and risks as part of a complete and detailed analysis of the organization's processes. A detailed risk analysis of the process is the place where threats, vulnerabilities and risks must be fully defined, using operational research methods, with a clear and complete connection to the parameters of the information systems of state authorities. It is especially important to respect the dynamism of changes in the initially identified parameters, connections, importance, and influence within the previously defined frameworks. A complete analysis of the process through the implementation of ISO 9001 requirements is the first and basic phase of the successful design of an information system that bases information security on risk management.

From this initial phase, operational research principles must be applied in order to establish a clear risk matrix that is related to specific process entities and risks at the base level. The implementation of the requirements of the ISO/IEC 27032 standard through the formation of the Cyber Security Program must be done for the entire organization of the government body, including all the components of information systems through business and IT-related functions, considering the fact that attacks and threats to information security can occur anywhere within the infrastructure of state bodies. It is necessary to implement the requirements of the standards ISO/IEC 27001, ISO/IEC 27701, ISO/IEC 27032, ISO/IEC 20000-1 and ISO/IEC 22301 in areas that include security in the intranet/internet space, i.e. intranet/internet security issues that focus on bridging the results of risk analysis between different domains of information security in the intranet/internet space.

According to the stated standards, it is necessary to implement technical guidelines for solving intranet/internet security risks, including social engineering attacks, hacking, spyware and attacks using potentially malicious malware software. These technical guidelines should provide controls for the treatment of these risks, including controls for preparing responses to attacks from malicious software (malware), malware organizations to detect and monitor attacks. It is necessary to generate a framework for efficient and effective information exchange, coordination and incident management among stakeholders in the intranet/internet space. Interested parties that may be involved are employees, customers and third parties, which may be different types of organizations or individuals, as well as providers, which include service providers as well as all those identified by the risk matrix.

The analysis of interested parties should not be limited only to cyberspace, but should perform a complete analysis of the technological, procedural, organizational framework, not neglecting the social and other specific general security aspects of state bodies.

As a particularly important segment, which needs to be protected in the ISMS framework, Cyberspace stands out as a complex environment that results from the interaction of people, software and services on the Internet using technological devices and the networks that connect them, and as an environment that does not exist in any physical form . For this reason, Cyber Security is established, which includes the protection of assets against threats that are mainly related to malicious and other unintentional human activities. Cyber security depends on information security, application security, network security, Internet security and Critical Information Infrastructure Protection - CIIP to achieve information security goals.

It is necessary to identify additional controls that are specific to the organization, not limited to the aforementioned basic controls of the standard. Identification of threats, vulnerabilities and risks within the requirements of ISO/IEC 27001, ISO/IEC 27701, ISO/IEC 27032, ISO/IEC 27011, ISO/IEC 20000-1, ISO 22301 and other relevant standards for the state critical infrastructure entity, based on the process approach

(ISO 9001) must identify the complete set of data that must be monitored, analyzed and form the basis for decision-making for the response. The corrective reaction is not a satisfactory level. Preventive reaction is satisfactory only in the process of implementation of the System. Predictive response is a target function that must be established in the system that represents the critical infrastructure of the state. The most common mistake in the implementation of such systems is that all risks of the state authority are treated as if they were part of the critical infrastructure of the state. There is no example of a state body as a factor of critical infrastructure where all processes and functions are part of critical infrastructure.

On the example of the identification of threats, vulnerabilities and risks within the requirements of the ISO/IEC 27001 standard, the same methodological basis should be established for the requirements of the ISO/IEC 27701, ISO/IEC 27032 and ISO/IEC 27011 standards, as well as for the requirements of the ISO/IEC 20000-1 and ISO 22301. The requirements of the relevant standards must be extended by the requirements of laws and by-laws that introduce certain additional requirements both for each state body in terms of localized tasks and in terms of requirements for the coordination of the work of individual services within government departments or coordination with the competent state body.

OPERATIONAL RESARCH METHODOLOGY AND RISKS

Operational research is a mathematical discipline, but at the same time one of the basic disciplines of management. It is for this reason that they are recognized to regulate the information security system as a technological category that must be based on the mathematical parameters of monitoring the information system of state critical infrastructure bodies within the framework of ISO standards that represent the management system primarily according to the information security management system (ISO/IEC 27001) but also according to other identified management systems (essentially, ISO/IEC 27701, ISO/IEC 27032, ISO/IEC 20000-1 and ISO/IEC 22301).

The problem of nonlinear programming is much more difficult to solve than the problem of linear programming, because the optimal solution of the nonlinear problem is sought in the interior point or on the border of the allowed set of acceptable risk levels. Nonlinear programming can also be seen as the process of solving an optimization problem where some of the constraints or objective functions are nonlinear. The optimization problem is one of the calculation of extremes (maximum, minimum or stationary points) of an objective function over a set of unknown real variables (variables in time), which is conditioned by satisfying a system of equations and inequalities (requirements for each individual risk), collectively called constraints (level information security).

The necessary conditions for the application of operational research methods in dealing with information security risks in the organization of parts of critical infrastructure are: that the problem being solved can be represented by a suitable mathematical model (a set of mathematical functions that describe the characteristics of the problem; the objective function and the system of constraints); teamwork to solve problems; numerous and reliable initial data; use of information technologies.

The following phases of work have been identified:

- FORMULATION OF THE PROBLEM - phase implies an accurate and complete formulation of the problem and a clear setting of the goal to be achieved, as well as considering the conditions under which the goal will be achieved. The phase is carried out by the state body independently or with the professional help of other experts appointed by the state for professional tasks in the field of information technology (for example, court experts for information technology who can be hired for the following phases as well).
- RESEARCH OF ALL FACTS, REQUESTS AND DATA - in this phase, all factors affecting the problem of information security are considered. The organization must take into account all parameters of threats, vulnerabilities and risks and convert them into numerical values. Simplifying the problem by introducing limiting assumptions or reducing them to a minimum number should be avoided. Initially, assumptions can be made that only simplify the problem, but in relation to the essence of the problem, they do not cause significant deviations from reality.
- SETTING UP A MATHEMATICAL MODEL - this phase involves translating the problem into mathematical language. In relation to mathematical models, there are two requirements:

- to reflect reality as faithfully as possible from the point of view of the objective of consideration,
- to be computationally and technically suitable for processing.
- The result of the joint work of a multidisciplinary team of organization experts who know well the practical side of the organization's information security problems must result in a model. A common problem is to set up the model correctly from a mathematical point of view, but its solution is unusable for solving the real problem, because the model does not represent the problem itself well enough. The model must be formulated in such a way that it retains the basic, essential properties of a clearly defined problem and that it can be solved by mathematical methods.
- SOLVING THE MODEL - with appropriate mathematical methods.
- CHECKING THE MODEL AND SOLUTION - this phase involves repeated checking of the model and its solution in terms of credibility with a real problem.
- DECISION-MAKING - it should be freed from the subjective opinion of the individual and decision-making must be based on adopted scientific methods. The acceptable level of risk for each of the parameters previously identified by the organization is set at this stage as a parameter that is the basis for decision-making.

Features of operational research that must be adopted for work in the field of information security are: systemic approach, continuous research, solution optimization and complex research.

OPERATIONAL RESEARCH MATRIX FOR ISMS RISKS

Operational Research Matrix - The ORM matrix is based on a process approach that emphasizes the ISO 9001 standard, which additionally describes the other standards of this family of standards. Looking at all the previously mentioned problems, we arrive at a model proposal that gives guidelines to organizations in the state's critical infrastructure system on how to establish a functional Operational Research Matrix for ISMS Risks. Correlation of operational research methods with the requirements of identified standards with the stages of Risk Analysis and Risk evaluation with the formation of a Knowledge base, in real time, based on the Process approach, all through the PDCA (continuous) cycle is given in the following figure.

In the section ISO standards requirements, an initial list of standards that should be applied is given, but some of the other ISO standards are also highlighted. The specificity of the state body's work in the state's critical infrastructure system, after the analysis, will define other relevant standards for entry into the Operational Research Matrix for ISMS Risks. Taxon requirements should also be entered into the matrix through reference controls, especially the requirements of the Law on Information Security, the Law on Protection of Personal Data and the Law on Critical Infrastructure with the requirements from their by-laws. The aforementioned laws represent the basis of the legal system of the countries of the European continent, but also of most countries of the world.

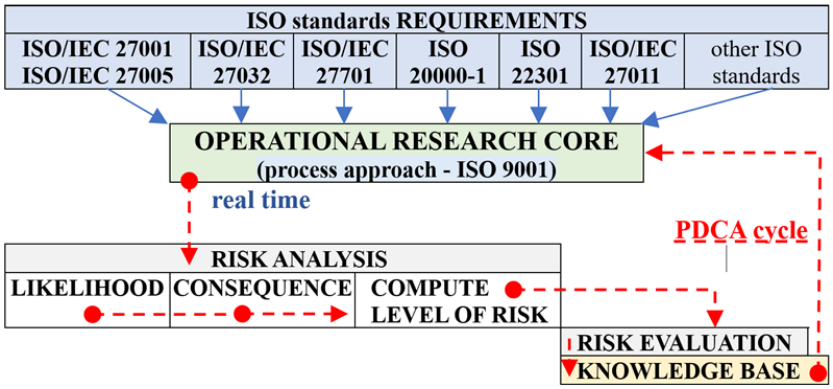

Figure. 2: Operational Research Matrix for ISMS Risks

Defined requirements are treated through Risk Analysis by stages: Likelihood, Consequence, Compute level of Risk. The next phase is the Risk evaluation with the Knowledge base, which is designed to collect all historical data on monitoring the state of information security, reactions of the information system to disturbances and measures taken by the state authority with elements of machine learning.

Artificial intelligence elements are currently not intended for integration for several well-known security reasons. The details of the Operational Research Matrix for ISMS Risks represent the development potential but also the obligation of each individual state authority in the critical infrastructure system. All collected information and knowledge is fed back to the Operational Research Core through the PDCA loop for repeated processing designed for real-time reaction.

CONCLUSION

We are witnesses of frequent malicious attacks on the services of state bodies. As a rule, attacks cause the obstruction of numerous services that disturb the normal life of people and business operations of companies. There is an awareness that there is no ideally protected information system from the aspect of information security. The reaction of the state body located in the system of critical infrastructure must not be corrective, but must evolve from a preventive approach into a predictive response in a technological, procedural and organizational framework. The solution of the implemented information security system cannot be copied from one state body to another, so the paper provides guidelines and a model of how to develop a predictive system for assessing and evaluating risks and reacting to unwanted situations and conditions. The presented Operational Research Matrix for ISMS Risks should set guidelines for the development of awareness of the need as well as the obligation to implement an information security system that will be able to establish a predictive information system for a state authority in a critical infrastructure system. Information systems that do not treat threats, vulnerabilities and risks do not have the capacity to understand what is happening in their environment and certainly do not have the capacity to manage an acceptable level of risk. The paper also defines the link Risk assessment extended with correlation Operational research matrix and ISO standards requirements for a complete understanding of the Operational Research Matrix for ISMS Risks.

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MACHINE LEARNING APPLICATIONS IN COMPLEX PROBLEM SOLVING IN ENTERPRISES

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ABSTRACT

This paper analyzes the integration and application of machine learning (ML) within enterprises to tackle complex problems effectively and efficiently. Focusing on predictive analytics, automation of routine tasks, operational efficiency, and fraud detection, the study provides a comprehensive analysis of how ML technologies can transform enterprises by improving decision-making, increasing productivity, and securing operations. Through detailed case studies and data analysis, the authors demonstrate ML's significant role in improving problem-solving capabilities within various industries such as healthcare, finance, and manufacturing. The findings suggest that ML not only automates and optimizes processes but also significantly improves strategic planning and risk management. This research notes the potential of machine learning to drive innovation and competitiveness in the business landscape, particularly in adapting to and thriving within the frameworks of Society 5.0. The paper concludes by discussing the implications of these technologies for future enterprise strategies and the necessary ethical considerations for their deployment.

Keywords: Machine learning, Complex problem solving, Enterprises, Artificial intelligence.

INTRODUCTION

Machine learning is transforming the landscape of problem-solving in enterprises by enabling them to harness complex data and automate decision-making processes. This technological advancement provides a robust framework for addressing various business challenges through detailed analysis, prediction, and process optimization. As organizations navigate an increasingly data-driven world, the role of machine learning in facilitating effective solutions becomes more pronounced (Lee & Shin, 2020). Predictive analytics is a cornerstone of machine learning that plays a pivotal role in problem-solving within enterprises. This predictive capability is crucial for strategic planning and decision-making. For example, in the supply chain sector, predictive models analyze past shipment data, weather reports, and buying trends to forecast potential delays and optimize routes. This not only improves efficiency but also reduces costs associated with transportation and warehousing (Maroufkhani et al., 2020).

Enterprises also deploy machine learning models for financial forecasting, where algorithms predict future revenue streams, market trends, and economic changes. This foresight enables businesses to adjust their strategies proactively, rather than reacting to market shifts, thus maintaining competitiveness and stability.

Machine learning significantly contributes to problem-solving by automating routine and time-consuming tasks. This automation extends across various domains, from customer service to back-office operations. In customer service, chatbots and virtual assistants powered by machine learning algorithms can handle a high volume of inquiries simultaneously, providing quick and consistent responses. This not only improves customer satisfaction but also allows human agents to focus on more complex and nuanced issues (Li et al., 2024). One of the significant applications of machine learning in enterprises is in the domain of security, specifically fraud detection. Financial institutions integrate machine learning models that analyze transaction patterns to detect anomalies indicative of fraudulent activities. These models learn from each transaction, improving their detection capabilities over time. By catching fraud early, enterprises can prevent substantial financial losses and protect their customers' trust.

Furthermore, machine learning aids in cybersecurity by detecting unusual network behavior that could indicate a security breach. By continuously monitoring network traffic, these models quickly identify and respond to threats, safeguarding sensitive information and infrastructure. Through predictive analytics, automation, improved operational efficiencies, and improved security measures, machine learning helps businesses not only respond to current challenges but also anticipate and prepare for future issues. As technology continues to evolve, the scope and impact of machine learning in enterprise problem-solving are expected to expand, driving innovation and productivity to new heights.

This paper aims to develop a theoretical model based on machine learning for resolving complex problems in enterprises and improving competitiveness. Additionally, suggestions for improving enterprise competitiveness. The paper consists of five main sections: Introduction, Machine learning and problem solving, Complex problem solving in enterprises, Suggestions and guidelines, and Conclusion.

MACHINE LEARNING AND PROBLEM SOLVING

Machine learning (ML) is an essential part of modern technology, enabling machines to derive insights from data patterns and make decisions with minimal human intervention. This innovative technology is utilized across various sectors such as healthcare, finance, manufacturing, and more, to solve problems ranging from the simple to the highly complex (Guariniello et al., 2022). The finance industry also benefits from ML through its ability to analyze large volumes of transaction data rapidly. Financial institutions use ML for various applications such as credit scoring, where algorithms assess an individual's creditworthiness more accurately and quickly than traditional methods. ML is also integral in detecting fraudulent transactions by identifying anomalies in transaction patterns, thereby improving security measures and reducing losses due to fraud.

Machine learning's real strength lies in its capacity to tackle complex problems that involve multifaceted relationships and dynamics. These problems are characterized by their scale, intricacy, and the requirement for adaptability in solutions. ML addresses these challenges by segmenting large problems into more manageable components, learning from each segment, and applying insights in a predictive and prescriptive manner (Janiesch et al., 2021). For example, in urban planning, ML algorithms analyze a variety of data sources including traffic patterns, public transportation usage, and urban growth trends to improve city infrastructure planning. By predicting high-traffic areas and times, city planners can create more effective traffic management strategies, thus reducing congestion and improving the overall quality of urban life.

In environmental science, ML helps in modeling complex scenarios such as climate change impacts. Algorithms analyze historical climate data to predict future conditions and assess the effectiveness of various intervention strategies. This predictive power is crucial for developing long-term environmental policies and for managing natural resources more sustainably. Machine learning is particularly effective in environments that require real-time data processing and decision-making.

Autonomous vehicles, for instance, rely on ML to process continuous streams of data from their surroundings. The ML algorithms must make immediate decisions about navigation, obstacle avoidance, and speed adjustment, all while ensuring passenger safety and adhering to traffic laws (Bertolini et al., 2021).

Another significant application of ML is in improving customer experiences through personalization. E-commerce platforms and content providers use ML to analyze user behavior, preferences, and previous interactions. Based on this data, algorithms can tailor product recommendations, content displays, and marketing messages to individual users. This level of personalization not only improves user engagement but also boosts customer satisfaction and loyalty. Machine learning is revolutionizing the way enterprises approach problem-solving. By automating the analysis of large datasets, providing insights into complex patterns, and enabling real-time decision-making, ML allows businesses to operate more efficiently and effectively. As this technology continues to evolve, its role in solving complex problems and improving various aspects of business and society is expected to grow even more significant, offering new ways to leverage data for strategic advantage.

COMPLEX PROBLEM SOLVING IN ENTERPRISES

Machine learning (ML) is rapidly becoming an integral part of how enterprises solve complex problems by leveraging large volumes of data to derive meaningful insights. This technology's ability to analyze, predict, and automate has profound implications across various aspects of business operations, including operational efficiency, customer experience, risk management, and decision-making processes. In the domain of operational efficiency, ML excels by automating routine tasks and optimizing complex processes. For instance, in manufacturing settings, machine learning algorithms analyze data from sensors embedded in equipment to predict potential failures before they occur. This predictive maintenance approach allows companies to carry out repairs during scheduled downtimes, thus minimizing disruptions in production lines and extending the lifespan of machinery. Beyond maintenance, ML algorithms optimize production schedules based on factors like demand forecasts and supply availability, ensuring that resources are allocated efficiently (Guarav et al., 2023). The supply chain and logistics sectors also benefit significantly from machine learning. Algorithms process real-time data to optimize routes and manage inventory, taking into account variables such as traffic conditions, weather, and changing consumer demands. This dynamic approach to logistics not only reduces operational costs but also improves delivery efficiency, improving customer satisfaction as products are delivered faster and with greater accuracy (Li et al., 2024; Wang et al., 2024).

Machine learning transforms customer interactions by enabling personalized experiences across various platforms. Retail companies, for example, implement ML algorithms that sift through massive datasets to understand customer preferences and buying behaviors. These insights allow companies to offer tailored recommendations, improve browsing experiences, and deliver targeted marketing campaigns, which lead to increased engagement and customer loyalty. Moreover, in customer service, machine learning powers sophisticated chatbots and virtual assistants that handle a wide range of customer queries. These AI-driven tools respond instantly and accurately, providing 24/7 support that improves customer relationships by ensuring constant availability and swift service (Khan et al., 2020; Kietzman & Pitt, 2020; Morariu et al., 2020). Risk management is another significant area where machine learning makes a significant impact. Financial institutions use ML to improve credit scoring models by incorporating a wider range of data points, including non-traditional variables such as utility payments and rental history, to gauge an applicant's creditworthiness. This broader data integration helps in making more accurate risk assessments, reducing defaults, and increasing financial inclusion by extending credit to underserved segments of the population. Additionally, ML algorithms detect patterns indicative of fraudulent activity, thereby improving the security of transactions. By identifying and addressing these risks proactively, businesses can safeguard their assets and maintain customer trust (Lee, 2021; Li et al., 2023). In decision-making processes, ML provides enterprises with powerful forecasting tools that analyze historical data and current market trends to predict future

scenarios. This capability enables decision-makers to anticipate market shifts, assess the potential impacts of their decisions, and plan strategically.

Overall, machine learning's ability to process and analyze vast amounts of data rapidly and accurately is indispensable for enterprises aiming to improve their efficiency, decision-making, risk management, and customer relations. As technology continues to evolve, the scope of ML's application within enterprise problem-solving is likely to expand, driving innovation and competitiveness in various industries. Based on the analyzed literature a theoretical model for improving enterprise competitiveness is developed. The model is presented on Figure 1.

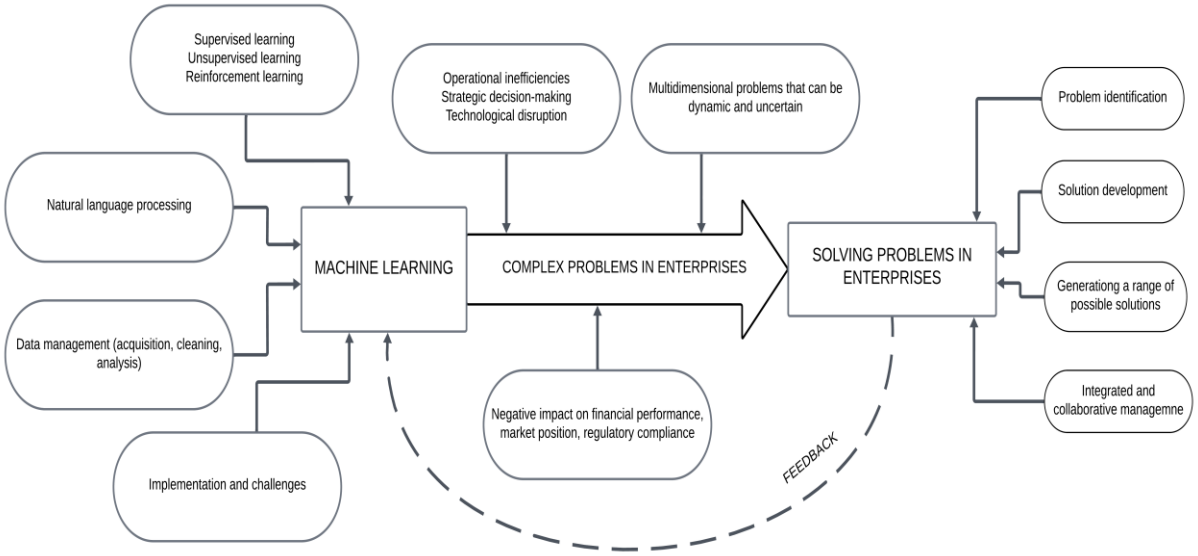

Figure 1: Model for improving the enterprise competitiveness through machine learning and problem solving

Starting with Machine Learning, the types of machine learning (supervised, unsupervised, and reinforcement learning) provide foundational techniques that can be tailored to specific types of complex problems within enterprises. For example, supervised learning can be directly applied to predictive maintenance by using historical equipment failure data to predict future failures. This not only addresses the complex problem of operational inefficiencies but also helps in refining the strategies for solving these problems by predicting and mitigating potential disruptions before they occur. The key technologies and tools sub-element of Machine Learning, such as neural networks and natural language processing, offer sophisticated methods to analyze and interpret large sets of unstructured data. These tools can be utilized to dissect customer feedback or to optimize decision-making processes in strategic planning, thereby directly influencing the enterprise's approach to solving complex problems like market positioning or regulatory compliance.

Data management practices within Machine Learning, including acquisition, cleaning, and analysis, ensure that the data used to solve enterprise problems is accurate and meaningful. Effective data management directly impacts the ability to identify and define problems accurately, which is crucial for developing relevant solutions. Clean and well-managed data leads to better model performance, which in turn improves the decision-making process in enterprise problem-solving scenarios. Moving to the complex problems faced by enterprises, these often involve layers of variables and stakeholders, as seen in operational inefficiencies and strategic decision-making challenges. The dynamic and uncertain nature of these problems makes them ideally suited for machine learning solutions, which can adapt and learn from ongoing data inputs. The ability of ML to handle multidimensional and dynamic data directly supports enterprises in navigating these complexities, leading to more informed and effective solutions. For solving problems in enterprises, the sub-elements of problem identification and definition, and solution development are crucial. Accurate problem identification ensures that the right type of machine learning technique is applied to the right problem, improving the efficacy of the

solutions developed. For instance, identifying a problem that involves predicting consumer behavior may lead to the application of unsupervised learning techniques to uncover hidden patterns in consumer data. In the solution development phase, ideation and feasibility analysis are supported by machine learning's ability to simulate and predict outcomes of various approaches. This allows enterprises to not only craft solutions that are data-driven but also to evaluate potential outcomes before full-scale implementation, thus reducing risks associated with new strategies. Implementation, monitoring, and adjustment processes are where machine learning's real-time data processing capabilities come into play. As solutions are implemented, machine learning models continue to learn and adjust, providing continuous feedback and improvements based on real-world interactions and results. This feedback loop is essential for refining solutions and adapting to changes, ensuring that enterprise problem-solving is dynamic and responsive.

Finally, the evaluation and feedback sub-element ties back to the continuous learning nature of machine learning. By establishing performance metrics and incorporating feedback into ML models, enterprises can continually improve their problem-solving processes. Machine learning algorithms thrive on feedback to adjust their parameters and improve their accuracy, thereby improving the overall strategy for problem resolution in enterprises.

SUGGESTION AND GUIDELINES

Based on the analyzed literature and the developed theoretical model, the following suggestions and guidelines for improving business and solving complex problems in enterprises are noted:

- Provide incentives for R&D in machine learning through grants, tax breaks, and subsidies targeted at adopting advanced analytics.
- Invest in education and training programs focused on data science and machine learning to equip the workforce with necessary skills.
- Update regulatory frameworks to ensure data usage complies with privacy and ethical standards while fostering innovation.
- Integrate machine learning into core operations to leverage data-driven decision-making.
- Invest in robust data infrastructure to facilitate high-quality data collection and management.
- Foster a culture that encourages the use of ML-driven insights in strategic planning and operations.
- Conduct training programs to keep staff updated on the latest machine learning techniques and tools.
- Implement pilot projects to test machine learning solutions on a small scale before widespread deployment.
- Collaborate with other companies and academic institutions to innovate and refine problem-solving methods.
- Continuously update personal skills in data analytics and machine learning through educational programs and self-study.
- Participate in industry conferences and engage with professional communities to stay informed on the latest developments.
- Advocate for ethical AI practices within their organizations, focusing on bias, fairness, and transparency.

CONCLUSION

This study notes the transformative potential of machine learning (ML) technologies in solving complex problems within enterprises. The research highlights how ML applications can significantly improve operational efficiencies, optimize decision-making processes, and secure enterprise operations against various risks, including fraud. Through predictive analytics, ML enables businesses to forecast and strategically plan with greater accuracy, leading to more informed decision-making and proactive management of resources. The automation of routine tasks not only improves efficiency but

also frees up human resources to focus on more complex and innovative tasks, thereby increasing overall productivity.

The findings of this paper suggest that as ML technology continues to evolve, its role in enterprise problem-solving is likely to expand further, offering new opportunities for businesses to improve their competitive edge in a data-driven market. However, the deployment of ML technologies must be managed with careful consideration of ethical guidelines and regulatory compliance, particularly concerning data privacy and security. Future research should focus on refining ML models to address these concerns while exploring new avenues for their application in business. Overall, machine learning stands as a pivotal tool in the arsenal of modern enterprises aiming to navigate the complexities of an increasingly digitized world.

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ARTIFICIAL INTELLIGENCE STANDARDISATION EFFORTS

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ABSTRACT

Understanding how people think and describing the decision-making process in a formal way has been the subject of numerous research studies. With the development of computing and the increase in processing power, numerous ideas became feasible for practical implementation. Artificial intelligence applications are increasingly numerous in various human activities and devices that we use every day. In addition to the legislative framework, it is very important to establish adequate industrial recommendations in the form of standards. This paper presents an analysis of standards in the field of artificial intelligence and some remarks on their practical applications.

Keywords: Artificial intelligence (AI), Standards, Information security, Risks.

INTRODUCTION

Understanding the way people think and describing the decision-making process in a formal way have been the subject of numerous research studies since the earliest period. Attempting to describe and reproduce even a part of human capabilities has long been reduced to some elementary operations and laws of logic. With the development of computing during the 20th century and the increase in processing potential, numerous ideas became feasible for practical implementation.

Artificial intelligence (AI) is a branch of computer science that aims to create intelligent systems, machines, and software capable of performing tasks that normally require human intelligence. Its potential applications are numerous, such as natural language understanding, identifying connections between data, learning from experience, and decision-making. AI technologies allow computer systems to mimic some human cognitive functions such as perception, reasoning, learning, problem-solving, and decision-making. Consequently, they are capable of autonomously performing tasks.

The European Commission is in the process of adopting the AI Act, which is a Regulation on Artificial Intelligence (European Commission, 2019, 2021). Identifying different levels of risk and introducing appropriate rules is one of the proposed solutions (Veale and Zuiderveen Borgesius, 2021). The proposed rules will have legal implications, and whether they will achieve the desired goals will be shown in their implementation. This is, first of all, important for the prevention of practices that lead to the manipulation of users, their psychological or physical harm, as well as the abuse of specific characteristics of users that make them vulnerable in any way. However, a big problem is the allocation of responsibilities, the necessity for personalization (individual use), and the application in numerous high-risk systems.

LITERATURE REVIEW

Artificial intelligence has gained importance in recent years. We have witnessed the rapid development of AI during the last decade. Its applications are increasingly numerous in various human activities and devices that we use every day. It is often just a phrase to describe certain adaptive capabilities of devices and software, which does not fully represent AI. Certain limitations of people, primarily their perception, reaction speed, and cognitive potential, have led to the development of devices that try to compensate for these limitations in different, more or less "intelligent" ways.

The introduction of computer equipment into various safety-critical systems can lead to an improvement in the performance of the safety system by increasing the number of identified hazards, which results in a reduction of the risks to which employees are exposed. Finally, this leads to a decrease in the value of certain key indicators of the system's outcome, i.e., the improvement of the safety system as a whole (Savić et al., 2021). However, the introduction of various computer-supported systems leads to new risks, so it is important to consider the aspects of information security (Janaćković et al., 2019), that is, to integrate them into the overall organizational risk management, and not to observe them independently (Savić et al., 2021).

There are numerous standards related to information security, as presented in (Janaćković et al., 2020), and their goal is to regulate the area of information management. Various data are collected in computer-supported systems and then temporarily or permanently stored and processed, so this can become a security problem, especially if they are compromised. Certain risk management approaches are therefore necessary to implement and adapt to the characteristics of these systems (Barafort et al., 2017; Mušicki et al., 2016; Savić et al., 2021; Janaćković et al., 2019). These approaches are, for the purposes of information security, supported by certain regulatory solutions at the state level. However, in the field of AI, the legal regulation is still in development (Veale and Zuiderveen Borgesius, 2021), although a significant improvement can be identified (Atabekov and Yastrebov, 2018; Ястребов, 2018; Понкин & Редькина, 2018).

The AI landscape describes the ecosystem or environment that includes the various components, technologies, and stakeholders. It represents the dynamic interplay between technological advances, societal needs, regulatory frameworks, and ethical considerations that are shaping the AI in the future. AI has applications in a variety of domains, including healthcare (Rong et al., 2020), finance (Goodell, 2021), manufacturing (Nti et al., 2022), transportation (Bharadiya, 2023), education (Holmes & Tuomi, 2022), and entertainment (Anantrasirichai & Bull, 2022). As artificial intelligence continues to advance, it has the potential to significantly advance industries, improve efficiency, and enhance decision-making. However, AI also raises different ethical, social, and regulatory considerations, highlighting the importance of responsible AI development and application (Naik et al., 2022; Mikalef et al., 2022; European Commission, 2019, 2021; Hagendorff, 2020). Therefore, it is necessary to pay special attention to the definition of the legislative framework that would prevent potential misuse, as well as the development of standards that would clearly define the desired quality. In addition to the legislative framework, it is important to establish adequate industrial recommendations in the form of standards. The introduction of a management system is a proposed solution to some of the previously mentioned problems.

STANDARDISATION EFFORTS

Standardisation is the process of the development, establishment, and implementation of standards. Standards are documented specifications, guidelines, or criteria aimed at ensuring the uniformity, consistency, and quality of products, conditions, or processes. They represent benchmarks that enable the interoperability and compatibility of systems, their reliability, and their security.

A standard is a set of rules, specifications, or requirements that provide guidelines, best practices, or technical specifications for a specific area or domain. Standards can be developed by various organisations, such as national and international standardisation organisations, professional

associations, or industry consortia. Standards are important for several reasons. Above all, they ensure interoperability and compatibility, which encourages effective collaboration and communication. Quality assurance minimises various deficiencies, defects, and variability, improves safety, and promotes compliance. This is especially important for safety-critical systems because processes prevent unwanted events, mitigate risks, and protect people's health. The constant need for monitoring and benchmarking encourages innovation, research and development, the adoption of good practices, and the exchange of knowledge within the organization. Also, the organisation gets the opportunity to participate in markets that require specific technical and other requirements.

AI standards

Rapid development has necessitated the need to define standards that aim to promote reliability, interoperability, and responsible development and application of AI technologies. The International Organisation for Standardization (ISO) and the International Electrotechnical Commission (IEC) Joint Technical Committee (JTC) 1, Subcommittee (SC) 42 on Artificial Intelligence, develop international standards related to AI technologies. Their representative standards are shown in Table 1.

Table 1: Representative standards in the AI landscape

Standard	Description	Classification	Stage
ISO/IEC 5338:2023	AI system life cycle processes	35.020	Published (60.60)
ISO/IEC 5339:2024	Guidance for AI applications	35.020	Published (60.60)
ISO/IEC TR 5469:2024	Functional safety and AI systems	35.020	Published (60.60)
ISO/IEC 8183:2023	AI - Data life cycle framework	35.020	Published (60.60)
ISO/IEC 23053:2022	Framework for AI Systems Using Machine Learning (ML)	35.020	Published (60.60)
ISO/IEC 23894:2023	AI - Guidance on risk management	35.020	Published (60.60)
ISO/IEC 22989:2022	Artificial intelligence concepts and terminology	35.020 01.040.35	Published (60.60)
ISO/IEC TR 24027:2021	Bias in AI systems and AI aided decision making	35.020	Published (60.60)
ISO/IEC TR 24028:2020	Overview of trustworthiness in artificial intelligence	35.020	Published (60.60)
ISO/IEC TR 24030:2021	AI use cases	35.020	Revised (90.92)
ISO/IEC TR 24368:2022	Overview of ethical and societal concerns	35.020	Published (60.60)
ISO/IEC TR 24372:2021	Overview of computational approaches for AI systems	35.020	Published (60.60)
ISO/IEC TS 25058:2024	Guidance for quality evaluation of artificial intelligence (AI) systems	35.080	Published (60.60)
ISO/IEC 25059:2023	Quality model for AI systems	35.080	Published (60.60)
ISO/IEC 38507:2022	Governance implications of the use of artificial intelligence by organizations	35.020	Published (60.60)
ISO/IEC 42001:2023	AI management system	35.020 01.040.35	Published (60.60)

Although general standards dedicated to information technologies and systems, such as those from the ISO/IEC 27000 series, can provide aspects of security and privacy, there are also standards specifically oriented towards AI. The IEEE P7000 series of standards is oriented towards various aspects of AI technologies, such as ethical norms, transparency, accountability, bias mitigation, and data privacy.

DISCUSSION

The development of an artificial intelligence solution usually involves several phases, which vary depending on the specific application, complexity, and requirements of the project. Common stages in AI development are problem definition and requirement specification, data collection and preparation,

model development and validation, monitoring, and maintenance. A systems approach can be used in developing a solution, considering the entire ecosystem surrounding the AI solution. A holistic approach better identifies constraints that may affect the development of solutions. There are also specific development methods and frameworks, such as Agile development, the application of DevOps principles, or the use of frameworks and libraries for the development of AI models.

The ISO/IEC 5338 standard describes the life cycle of AI systems. The life cycle consists of a set of concepts and processes. It is based on system standards 15288 and 12207, and the approach is slightly modified to adapt to the specifics of the AI process. The processes of defining, controlling, managing, and improving AI systems, applicable during the development or acquisition of AI systems, are described. The ISO/IEC 5339 standard goes a step further, addressing various challenges in developing AI solutions, such as risk management and reliability. It defines a framework that enables the active participation of all stakeholders, considering requirements, uses, and impacts, in order to consider the effects and promote the ethically correct and responsible implementation of AI solutions.

Consideration of appropriate risk factors is also important. ISO/IEC TR 5469 addresses aspects of functional safety. It describes the properties, processes, risk factors, and methods related to the use of AI within a safety function or the development of safety-related functions, as well as ensuring the safety of equipment.

The widespread use of AI in industry has led to the need to pay more attention to considering the specification, design, and verification of AI systems from the point of view of functional safety and how AI technologies can potentially affect safety. The ISO/IEC TR 5469 standard presents the connection between AI technologies and functional safety and compliance with functional safety standards. It describes the effects of AI technologies on systems, the implementation principle in three phases based on ISO/IEC 22989, as well as the risk factors for the functional safety of AI systems. The standard proposes possible solutions for verification and validation processes, mitigation, and control measures. It is possible to apply IEC 61508-3 to AI technologies, i.e., to connect the AI system life cycle from the ISO/IEC 5338 standard and the safety life cycle from the IEC 61508-3 standard.

The development of AI systems should reduce potential harm and risk, as well as contribute to the well-being of people. Several standards deal with AI risks and security. ISO/IEC 42001 defines the AI management system. It also introduces controls and control objectives that make it easier to manage AI innovations with the involvement of interested parties (Table 2).

Table 2: Controls and control objectives in the AI management system

Control objectives	**Controls**
Policies	AI policy, alignment with other policies, review
Organisation	Responsibilities and roles, concerns
Resources	Documentation, data, system resources, computing resources, human resources
Impact assessment	Assessment process, documentation, effects on groups, individuals, and the society
System life-cycle	Guidance on system development, system development life-cycle
Data	Data for the system, acquisition, quality, preparation
Interested parties	System documentation, user information, reporting, communication, incidents
Use	Responsible use, processes, objectives, intended use
Relationships	Responsibilities, suppliers, customers

ISO/IEC 23894 provides guidance on how organisations can manage AI risk. The analysis is based on ISO 31000:2018, and the principles, framework, and processes are defined. There is a clear connection and mapping between the AI life cycle and the risk management process. AI systems can use machine learning (ML) to learn from data or past experiences, optimise algorithms based on training data, or improve performance based on a defined objective function. The ISO/IEC 23053 standard describes those systems.

The quality aspects of AI software solutions are very specific. Therefore, ISO/IEC 25059 describes the quality model of AI systems, while ISO/IEC 38507 describes the consequences of using AI in organizations. Data is very important for AI systems, their initial setup, functioning, and incremental improvement during functioning. That is the reason why special attention is paid to the data life cycle. The ISO/IEC 38507 standard describes the data life cycle framework, stages, and processes.

Further development of the AI standards involves a more detailed description of different AI use cases (ISO/IEC TR 24030), consideration of AI-guided decision-making (ISO/IEC TR 24027), ethical principles (ISO/IEC TR 24368), and computational approaches (ISO/IEC TR 24372). Also, it is necessary to define clearer guidelines for evaluating the quality of AI systems (ISO/IEC TS 25058). These guidelines could be applied in accordance with the methods presented in the ISO/IEC/IEEE 29119 series.

Bearing in mind the potential social and ethical implications of AI technologies, it is necessary to strive for the development and respect of ethical principles in the process of the development and application of the technologies themselves (UNESCO, 2021). Let's just mention, as an example, the AI Ethics Guidelines by the Partnership on AI or Ethically Aligned Design by IEEE.

CONCLUSION

There are numerous challenges and problems in the development of artificial intelligence. Standardization aims to help stakeholders in the areas of ethics, accountability, transparency, and security, as well as to ensure the necessary interoperability. Standardisation plays a key role in fostering efficiency, quality, safety, innovation, and global cooperation. By defining appropriate industrial recommendations and applying them in practice, responsible development of artificial intelligence technologies and their application for the benefit of society can be achieved, while reducing risks and adverse impacts to an acceptable level.

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DATA MIGRATION WITHIN EXTENDING SOFTWARE FUNCTIONALITY: AN ACCOUNTING SOFTWARE CASE STUDY

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ABSTRACT

Applicative software maintenance usually includes extensions to existing functions and appropriate data structures. Aim of this paper is to present short related work regarding software maintenance and data migrations, particularly in contemporary professional and scientific results. In this paper, extensions to relational database and data migration from previous database were addressed and illustrated with accounting software, developed to be used in General hospital "Sveti Jovan" Zrenjanin, Serbia. The extension was made with consultation of accounting professional from accounting consulting company Ekonomski biro, from Zrenjanin, Serbia. The existing software for specification of medical service payments was enhanced for additional payment document type, as well as monthly summary reporting for all payment options.

Keywords: Software maintenance, Relational database, Extending functionality, Hospital administration, Accounting reports

INTRODUCTION

Software maintenance has been categorized by ISO standards (ISO, 2022) as one of four main types of activities – corrective (correcting errors), preventive (enhancements in structure or functions to prevent future possible problems), adaptive (adaptation of software to different working environment) and perfective (adding new features, improving functions or user interface and experience). During software maintenance, software evolves (Lehman, 1996). In modern agile software development, constant changes (Manifesto, 2001) are supported by modularization, continuous delivery and integration (Shahin et al, 2017), as well as change management and version control (Atlassian, 2024). Data migrations (Thalheim & Wang, 2013) are one of the regular activities within software development and maintenance, usually transferring data from one structure to another (similar or extended), within the same or other technology. In the case of software functions extensions (that are common situation in perfective software maintenance), one possible solution with relational databases extension, is to use IS-A hierarchy as a concept from Entity-Relationship model (Fahrner & Vossen, 1995) - another table with additional data fields to be linked with the table to be extended.

This work presents a short overview of related work regarding agile software development, in the context of software evolution, maintenance, change management and version control, with particular emphasis on data models and technologies that support data migration within adding new functions to software solution. After the related work section, a case study will present implemented software solution in accounting area, that was implemented and enhanced by Ljubica Kazi and Zoltan Kazi, to be used in General hospital "Sveti Jovan" in Zrenjanin, Serbia. This case study presents software evolution from previous version to the new version where additional software functions were added for new data acquisition and monthly reporting. Specification of user requirements regarding software enhancements were made by Vesna Prljic and Ninoslava Nenin from General hospital "Sveti Jovan" and Tanja Kohajm from Ekonomski biro, Zrenjanin, Serbia. In transition to new version of applicative software, new data were defined to be collected and new reports that were to be generated from both old and new data. In aim to support reports, some additional changes have been made to the data structure. Finally, software module for data transition from old structured relational database to new structured relational database has been developed and it is also presented in this paper. Final section of this paper brings conclusions and future work ideas.

BACKGROUND AND RELATED WORK

Agile software development as an approach was systematically defined by Agile Manifesto (Manifesto, 2001), where some elements of software development process are valued more, i.e. agile manifesto principles value "Individuals and interactions over processes and tools; Working software over comprehensive documentation; Customer collaboration over contract negotiation; Responding to change over following a plan". In modern agile software development, changes required from clients are embraced and good cooperation within teamwork and with all stakeholders is encouraged. In ever-changing environment of agile software development, to maintain software solution to be up-to-date with client requirements and business needs, as well as technology changes, it constantly evolves. (Lehman, 1996) defined several software evolution laws, where one of the most important are: 1) "An E-type program that is used must be continually adapted else it becomes progressively less satisfactory." 2) "As a program is evolved its complexity increases unless work is done to maintain or reduce it." 3) "Functional content of a program must be continually increased to maintain user satisfaction over its lifetime."

A study has been conducted in aim to systematize documentation and other artifacts to be included in the process of software maintenance (deSouza et al, 2005). In this study, two types of software projects were analyzed for development and maintenance artifacts – structured and object-oriented software development. In both types of software projects, data migration plan was considered as very important (with more then 35% of importance, as per questionnaire) artifact and, therefore, in focus within maintenance. In aim to keep tracking and managing changes, specific tools for source code version control are developed (Atlassian, 2024). These tools enable reducing development time and increase quality and success in deployments. Recent research results regarding data migrations are related to cloud-based solutions. Data migrations are important part infrastructure maintenance of cloud-based data centers (Pant & Thakur, 2013). A user-control framework was proposed to enable users to be included in the process of migrations of data stored at cloud infrastructure, by using software services (Danga et al, 2024). According to (Torchiano et al, 2008), software migrations are important part of software maintenance and are, having IEEE standards consulted, considered as "Modification of a software product performed after delivery to keep a computer program usable in a changed or changing environment." So, (Torchiano et al, 2008) consider software migrations as adaptive software maintenance. In this study, questionnaire was conducted among 59 decision makers from Italian software developing companies or consultants. Results of this questionnaire show that most of the software that was analyzed for maintenance was from Public Administration or Banking domains. The most common reasons why software had to be changed were because of changes in: operating system, DBMS (database management system), programming language, software architecture, user interface, hardware. In these migrations, there were data migration tools and software development tools used for this purpose of data and applicative software changes

CASE STUDY

This section presents results of the project Improvement of billing software – recapitulation ("Unapredjenje softvera za fakturisanje – rekapitulacija", shortly "Rekap project") that is conducted in year 2024, in cooperation of Technical faculty "Mihajlo Pupin" Zrenjanin, Serbia with General hospital "Sveti Jovan" Zrenjanin and consultancy of Ekonomski biro, Zrenjanin, Serbia.

Initial aim of this project was to enable monthly reporting ("Recapitulation") about all types of billing, i.e. issuing invoices for patients' payments for medical treatment expenses. One of the results of this project was enhancement with additional user interface screen (Figure 1), made for the purpose of printing recapitulations. Figure 3. also shows four types of reports – recapitulation for persons ("Rekapitulacija za fizicka lica"), Recapitulation for companies ("Rekapitulacija za pravna lica") with subcategories for bill specifications, administrative orders ("Administrativna zabrana") and invoices ("Profakture"). After selection of document type and period (month and year), button starts print preview of the document, so it could be printed from that additional pop-up screen.

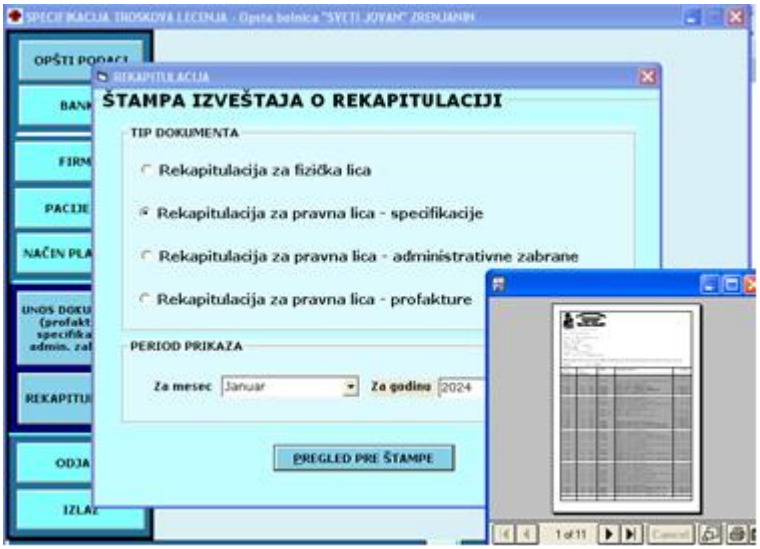

Figure 1: Selection of monthly reports for each type of billing option

Previous version of software had data entry form, i.e. user interface screen that enabled creating two types of documents – Invoice ("Profaktura") and Bill specification ("Specifikacija racuna"). Type of document could be selected from a drop down menu ("Tip dokumenta") during data entry for at billing user interface screen (Figure 2). After selection of document type, automatically the next number of document is inserted in first text box of document number ("Broj dokumenta"), while second text box, after "/" receives current year (obtained from system clock of the computer).

The complete set of billing documents should include "Administrative order" ("Administrativna zabrana") as well, but data entry and printing of this type of document was not supported by previous version of software. Therefore, in data entry user interface screen (Figure 3.) new option has been added within the "Type of document" ("Tip dokumenta") drop down list. Support to additional data collection was also provided (Figure 3.), such as patient ID ("Poziv na broj JMBG"), as well as data about the paying person. Paying person could be different person then the patient (for example, if patient is a child, the child's parent pays expenses).

In aim to support new reporting functions for monthly recapitulations, as well as data entry and printing of additional billing document type "Administrative order", new relational database fields were added to the main data table entitled "Billing_MasterTable" ("Naplata_zaglavlje"). Figure 4. presents only new data fields:

1. Data to be derived from existing data - ID_CompanyPays (“PIB_PlacaFirma”), PatientID (“JMBG_PozivNaBroj”), Bill Month (“Mesec racuna”), PayingCompanyName (“NazivFirmePlaca”);
2. Data to be obtained from enhanced user interface, related to administrative order (“Admz_”) - Paying person ID (“Admz_JMBG”) to Monthly paying amount (“Admz_MesecniAnuitet”).

Figure 2: Previous version of software for billing specification

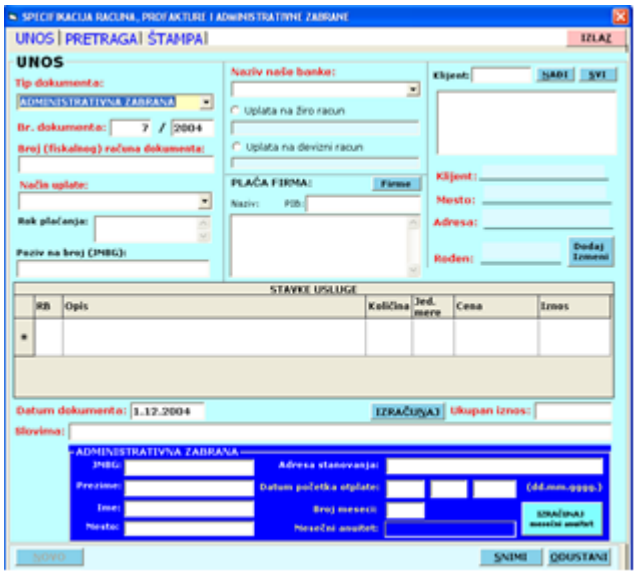

Figure 3: Main user interface screen for billing data entry, enhanced with “Administrativna zabrana”

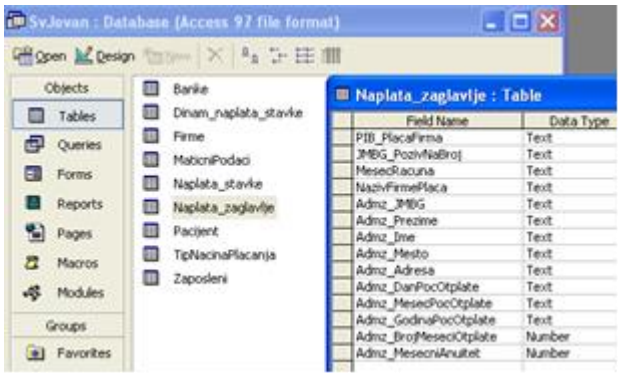

Figure 4: New data fields added to the structure of the main table Naplata-zaglavlje

Figure 5: Software module for data migration from old to new database

Since data structure has been changed, comparing to database from previous version, it was needed to enable new database model to be created, used for new applicative software, but also filled with existing data. Figure 5 presents a simple additional module that was developed to support adaptable data migation from existing relational database to new database, having broader structure. Adaptability was supported by enabling to create and change structure of the new database (named “Database model”), then copying the Database model into a new file to be filled with old data and starting the data copying – migration. Figure 5 presents these three options (Erasing data from Data model database – “Obrisi podatke modela”, copying blank database model file into new one – “Prekopiraj fajl modela kao novu bazu podataka”, starting the copying – “Pokreni presipanje”). After starting the option “Pokreni presipanje”, visualization is supported by message boxes for each phase of copying, as well as graphically with a progress bar (changing background colors of labels attached to each database table). In this way, the user can track the progress of the data migration. At Figure 5 it could be seen that table “Basic data” (“Maticni podaci”) has received green color (obtaining this color after Message box with meaning – finalized data copy). Other tables (“Tabele za presipanje”) have yellow background color (yellow color have meaning of status - ”waiting to be processed”). At Figure 5. is

shown that table Zaposleni is finished with data copy as per Message box and will be colored green after the user selects OK button at the Message Box.

During this data migration, some additional processing, supported by SQL (Structured Query Language) queries were needed in aim to derive new data (within table "Naplata_zaglavlje") from existing ones. For most cases, derived data in the main table "Naplata_zaglavlje" are obtained from processing of data from the same table (i.e. from the field Placa firma or Datum Dokumenta).

Table 1: Derivation of data within data migration

INPUT TABLE - DATA FIELD OUTPUT DATA	TRANSFORMATION PROCESS / SQL QUERY
INPUT: Data table: Naplata_zaglavlje Data Field: PlacaFirma OUTPUT FIELD: PIB_PlacaFirma	*Obtaining from last row (all text after PIB keyword) of the compact text Placa firma describing multiple data about company, SQL query:* UPDATE Naplata_zaglavlje SET PIB_PlacaFirma = Mid(PlacaFirma, InStr(PlacaFirma, 'PIB')+4, Len(PlacaFirma)-InStr(PlacaFirma, 'PIB')-4);
INPUT: Data table: Naplata_zaglavlje, Pacijent Data Field: Prezime, Ime, Godina_rodjenja OUTPUT FIELD: JMBG_PozivNaBroj	*Taking Name, Surname and Year born from table Naplata_zaglavlje and finding in another data table Pacijent, extracting Patient's ID JMBG. Two SQL queries:* 1. Select * from Pacijent WHERE Prezime='" + rsNaplataZaglavljeStaraZaRekonstrukciju!prezime + "' and Ime='" + rsNaplataZaglavljeStaraZaRekonstrukciju!ime + "' and Godina_rodjenja=" + CStr(rsNaplataZaglavljeStaraZaRekonstrukciju!Godina_rodjenja) + " 2. UPDATE Naplata_zaglavlje SET JMBG_PozivNaBroj='-' WHERE Prezime='" + rsPacijentZaJMBG!prezime + "' and Ime='" + rsPacijentZaJMBG!ime + "' and Godina_rodjenja=" + CStr(rsPacijentZaJMBG!Godina_rodjenja) + ";
INPUT Data table: Naplata_zaglavlje Data field: Datum_dokumenta OUTPUT FIELD: MesecRacuna	*Transforming month as a number into a Serbian word for appropriate month, SQL query* - "UPDATE Naplata_zaglavlje SET MesecRacuna = 'Januar' WHERE Month(Datum_dokumenta)=1;"
Data table: Naplata_zaglavlje Data field: PlacaFirma OUTPUT FIELD: NazivFirmePlaca	*Extracting first row from the compact text about company ,from beginning to first appearance of CHR(13) which is invisible symbol for new line, SQL query* - UPDATE Naplata_zaglavlje SET NazivFirmePlaca = Mid(PlacaFirma, 1, InStr(PlacaFirma, Chr(13))-1);

CONCLUSION

Aim of this paper was to present short review of published papers related to data migration in the context of software maintenance, namely in software enhancements with adding new software functions. The software evolution and data migration processes were illustrated with the case study of two software projects implemented by team from Technical faculty "Mihajlo Pupin" Zrenjanin, Serbia to be used in General hospital "Sveti Jovan" in Zrenjanin, Serbia.

The "Rekap project" was conducted in 2024 and it could be categorized as perfective type of software maintenance project. Initial specification of user requirements was focused on documents to be created as monthly reporting – recapitulation. Later, during development iterations, new functionality appeared as required – data entry and invoice printing for additional type of billing – Administrative order. Finally, as all required changes lead to data broadening, additional module has been developed to enable data migration. While data migration, not only corresponding data were copied from old to new relational database, but also some new data were obtained from existing data by transformations, based on SQL queries, which were also presented in this paper.

Future activities regarding this software could be directed towards automated data backup as well as adaptive user interface for graphical elements positions and colors, in aim to enable better user experience. Research derived from this paper results could be related to exploration of functional and data extensions during software evolution, with different technologies and software architectures, as well as to relate these extensions to adaptive and adaptable solutions, i.e. automated and manual adaptations of user experience and functionality.

ACKNOWLEDGEMENT

This paper presents results of two projects where team from Technical faculty "Mihajlo Pupin" Zrenjanin implemented software solutions. Projects were supported and financed by General hospital "Sveti Jovan" Zrenjanin, Serbia: 1) Software for specification of medical services expenses in 2022 ("Softver za specifikaciju troskova lecenja"); 2) Improvement of billing software for monthly reporting ("Unapredjenje softvera za fakturisanje – rekapitulacija").

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THE OWNER-COMPONENT RELATIONSHIP IN THE TEACHING OF OBJECT-ORIENTED PROGRAMMING

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ABSTRACT

The most frequent client relationship is owner-component relationship, which appears in the forms – composition and aggregation. This paper presents differences between composition and aggregation and shows the possibilities for their implementations in C++ and Java programming languages.

Keywords: C++, Java, Owner-component relationship, Teaching

INTRODUCTION

A class represents a model of a class concept. Complex relations between class concepts are modeled using relationships between classes. Relationships between classes can be divided into two groups - client relationships and inheritance (Meyer, 1997). Within the client relationship, classes have two roles – client and server. The relationship works so that the client class receives services from the server class.

The most famous client relationship is *owner-component relationship*, which models relation "contain" and appears in two forms – composition and aggregation.

From definition, composition is an owner-component relationship, where owner and components are constructed and destructed together, i.e. at the same time. On the other hand, aggregation is an owner-component relationship, where owner and components are constructed and destructed independently, i.e. not at the same time (Kupusinac, 2020).

In the teaching of object-oriented programming, there is a frequent doubt among both students and teachers – how to implement composition or aggregation. This paper discusses the different realizations of composition and aggregation through the examples given in C++ and Java programming languages.

THE OWNER-COMPONENT RELATIONSHIP IN C++

The programming language C++ allows that owner-component relationship can be realize on few ways. Let us consider owner-class **Cylinder_1**, that contains component-classes **Circle** and **Rectangle**, as a simple example:

```
class Circle {
private:
  double hd;// half-diameter
public:
  Circle(double x=1) {hd=x;}
};
```

```
class Rectangle {
private:
  double a;  // side a
  double b;  // side b
public:
  Rectangle(double x=1, double y=1) {a=x; b=y;}
};

class Cylinder_1 {
private:
  Circle crc;
  Rectangle rct;
public:
  Cylinder_1(double x, double y) : crc(x), rct(2*x*M_PI,y) {}
};
```

The object of previous class **Cylinder_1** will contain components inside of its memory space and represents typical example of composition in C++. On the other hand, object class **Cylinder_2** has pointers on components. The constructor and destructor provide that owner and components will be created and destroyed together, at the same time:

```
class Cylinder_2 {
private:
  Circle* crc;
  Rectangle* rct;
public:
  Cylinder_2(double x, double y) {
    crc = new Circle(x);
    rct = new Rectangle(y);
  }
  ~Cylinder_2() {
    delete crc;
    delete rct;
  }
};
```

The class **Cylinder_2** represents composition, since owner and components will be created and destroyed at the same time. Object destruction in the class **Cylinder_2** will be done by destructor. On the other hand, the class **Cylinder_3** is an example of aggregation in C++, since owner and components will be created and destroyed independently:

```
class Cylinder_3 {
private:
  Circle* crc;
  Rectangle* rct;
public:
  Cylinder_3(Circle *px, Rectangle *py) {
    crc = px;
    rct = py;
  }
};
```

THE OWNER-COMPONENT RELATIONSHIP IN JAVA

Now, let us consider owner-class Cylinder_1 written in Java:

```
class Circle {
   private double r;
   public Circle(double r) {
      this.r=r;
   }
}

class Rectangle {
   private double a;
   private double b;
   public Rectangle(double x,double y) {
      this.a=x;
      this.b=y;
   }
}

class Cylinder_1 {
  private Circle crc;
  private Rectangle rct;
  public Cylinder_1(double x, double y) {
    crc = new Circle(x);
    rct = new Rectangle(2*x*Math.PI,y);
  }
}
```

Also, let us consider owner-class **Cylinder_2**:

```
class Cylinder_2 {
  private Circle crc;
  private Rectangle rct;
  public Cylinder_2(Circle x, Rectangle y) {
    crc = x;
    rct = y;
  }
}
```

The objects of previous classes **Cylinder_1** and **Cylinder_2** will contain solely references, but components will be outside of their memory space. The class **Cylinder_2** can be used as typical example for aggregation in Java. If we provide that owner and components are created and destroyed at the same time, the class **Cylinder_1** can be used as an example of composition. Since owner destruction is under the jurisdiction of garbage collector, there is no guarantee when owner and components will be destroyed. Based on that, the class **Cylinder_1** can be solely a simulation of composition in Java.

CONCLUSION

This paper presented possibility for implementations and differences between composition and aggregation in C++ and Java programming languages. This paper gives an answer to a frequent doubt among both students and teachers – how to implement composition or aggregation.

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THE USING OF EXPERT SYSTEMS IN STUDY PROGRAMS ACCREDITATION

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ABSTRACT

An expert system is solving real problem based on expert knowledge in given area. This paper disscusses the possibility of expert system using in study programs accreditation procedure, as a useful tool for the preparation and control of documentation.

Keywords: Expert system, Accreditation, Study program.

INTRODUCTION

Expert systems is a form of artificial intelligence and have a very wide application in solving real problems from various fields. Their main feature is to simulate the way of solving problems as an expert would do it. The expert systems are expected not to give worse answers, i.e. they can be an adequate replacement for the expert knowledge. However, in real-life, they usually represent a support in the decision-making of an expert (Leondes, 2002).

The parts of the expert system are knowledge base, inference system and interface. The knowledge base is a formal form of expert knowledge and consists of facts and rules. The inference system imitates the expert's inference based on the knowledge base and uses some suitable algorithms (e.g. IF-THEN rules). In addition to decisions, the inference system can provide instructions and explanations to eliminate errors. The interface includes the communication of all participants in the creation and implementation of the expert system, i.e. input of data, facts and rules, as well as visual display of results. The simplest example of an expert system is a system for algorithmic diagnosis. This system looks at symptoms and suggests a diagnosis based on them. His role is not to replace the doctor, but to help the doctor in deciding.

In this paper, we will consider the possibility of applying expert systems during the accreditation of study programs at the National Entity for Accreditation and Quality Control in Higher Education in Republic of Serbia (abbreviated National Accreditation Entity), which performs accreditation, quality control of higher education institutions and their constituent units, evaluation of study program and quality assurance in higher education. The accreditation procedure determines whether the higher education institution and study programs meet the standards prescribed by the National Council for Higher Education, that is, whether the higher education institution has the right to issue public documents in accordance with the law. Such an expert system would be useful both for the preparation and control of documentation, more precisely it could facilitate the process of accreditation of higher education institutions and study programs in which the structure, content, quality and scope of study programs, the required number of competent teaching staff, the necessary space and equipment for quality teaching, all in accordance with the proposed number of students that the higher education institution plans to enroll. Upon completion of the accreditation procedure, National Accreditation Entity issues a certificate on the accreditation of the higher education institution, that is, the study program, or decides on the rejection of the request for accreditation (Law, 2023).

There are three levels and two types of higher education in the Republic of Serbia - academic and applied. The first level studies are undergraduate academic studies, undergraduate applied studies and specialist applied studies, while the second are master academic studies, master applied studies and specialist academic studies. The doctoral academic studies are the third level (Law, 2023).

STUDY PROGRAMS ACCREDITATION

The accreditation procedure determines whether the study program meets the standards defined by the Ordinance on Standards and Procedure for the Accreditation of Study Programs (Ordinance, 2023).

The possibility of creating a suitable expert system will be illustrated in C++ pseudocode. Standards describe the elements of the study program, course and teaching staff. Based on that, classes **StudyProgram**, **Course** and **TeachingStaff** can be modeled as follows:

```
class StudyProgram {
  string name;
  list<string> objectives;
  string type; //type of studies
  string title;
  list <string> requirements; //requirements for enrollment
  list <Course> courses; //list of courses
  list <TeachingStaff> teachingStaff; //list of teaching staff
  string method; //method of conducting studies
  int time; //required time
  int ects;
  int finalWork; //ECTS of final work
  string way; //way of choosing courses from other study programs
  string conditions; //conditions for transferring from other study programs
  // etc.
};

class Course {
  string code;
  string name;
  int ects;
  string type;
  int term;
  int lectures;
  int exercises;
  // etc.
};

class TeachingStaff {
  string code;
  string name;
  string title;
  int load;
  int loadTotal;
  // etc.
};
```

Now, let us consider few examples that demonstrate how an expert system based on IF-THEN rules could be useful for standards fullfilness checking.

Standard 1 (Structure of Study Program)

The Standard 1 proposes that study program must contain elements established by law. Based on that, an expert system should check the following:

```
if(!name.isEmpty()) return TRUE;
if(!objectives.isEmpty()) return TRUE;
if(!type.isEmpty()) return TRUE;
if(!title.isEmpty()) return TRUE;
if(!requirements.isEmpty()) return TRUE;
if(!courses.isEmpty()) return TRUE;
if(!method.isEmpty()) return TRUE;
if(time!=0) return TRUE;
if(ects!=0) return TRUE;
if(finalWork!=0 && (type=="UNDERGRADUATE_ACADEMIC" ||
                    type=="SPECIALIST_ACADEMIC" ||
                    type=="MASTER_ACADEMIC" ||
                    type=="DOCTORAL_ACADEMIC")) return TRUE;
if(!way.isEmpty()) return TRUE;
if(!conditions.isEmpty()) return TRUE;
```

Also, an expert system should check whether type of studies and number of ECTS is in accordance with type of studies.

```
if(ects==180 && type=="UNDERGRADUATE_APPLIED") return TRUE;
if(ects>=60 && type=="SPECIALIST_APPLIED") return TRUE;
if(ects>=120 && type=="MASTER_APPLIED") return TRUE;
if(ects>=180 && ects<=240 && type=="UNDERGRADUATE_ACADEMIC") return TRUE;
if(ects>=60 && type=="MASTER_ACADEMIC") return TRUE;
if(ects>=60 && type=="SPECIALIST_ACADEMIC") return TRUE;
if(ects>=180 && type=="DOCTORAL_ACADEMIC") return TRUE;
```

Standard 5 (Curriculum)

The Standard 5 describes conditions that curriculum must satisfied. Here, we will demonstrate some of them:

```
int ectsT; // ECTS in term T
for(i=0; i<courses.length; i++)
  if(courses[i].term==T)
    ectsT+= courses[i].ects;

// ECTS per term should be 30, with tolerance 20%

if(ectsT>=(30-30*(20/100)) && ectsT<=30+30*(20/100))
  return TRUE;
```

Also, sum ECTS of elective courses should be at least 20%.

```
int ectsEC; // ECTS of elective courses
for(i=0; i<courses.length; i++)
  if(courses[i].type=="ELECTIVE")
    ectsEC+= courses[i].ects;

if(ectsES>=(20/100)*ects)
```

```
  return TRUE;
```

Standard 9 (Teaching staff)

The Standard 9 considers teaching staff load on study program and total. Maximal teacher's load on study program should be 6 classes weekly, with tolerance 20%. Maximal total teacher's load should be 12 classes weekly. Based on, an expert system could check the following:

```
bool p=TRUE;
for(i=0; i<teachingStaff.length)
  if(teachingStaff[i].load>=6-6*(20/100) &&
    teachingStaff[i].load<=6+6*(20/100) &&
    teachingStaff[i].loadTotal<=12)
      p=TRUE;
  else
      return FALSE;
return p;
```

CONCLUSION

This paper presented an idea for possibility of expert systems using during the accreditation procedure of study programs at the National Entity for Accreditation and Quality Control in Higher Education in Republic of Serbia.

ACKNOWLEDGMENTS

This work was supported by the Faculty of Technical Sciences in Novi Sad as part of the implementation of the project entitled "Improvement of teaching processes, scientific and artistic research with challenges followed by new models of funding and ranking of scientific-research organizations".

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BRIDGE THE GAP: A USABILITY PLATFORM TEST METHOD FOR ENHANCED EDTECH-ACADEMIA COLLABORATION

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ABSTRACT

The landscape of education is undergoing a profound transformation, driven by the emergence of new business models and the exigencies of the Covid-19 pandemic. This shift has propelled the EdTech industry to greater prominence, offering innovative digital solutions to meet diverse educational needs. However, many EdTech applications struggle to gain traction in the market due to ineffective penetration strategies and a gap between traditional and digital education paradigms. To address this gap, this research paper introduces the Usability Platform Test, derived from the Horizon Europe project EdTech Talents. This structured evaluation method aims to facilitate collaboration between EdTech companies and academia by optimizing the usability and market readiness of educational technologies. The paper outlines the development and employment of the Usability Platform Test, highlighting its potential to guide EdTech companies through the complexities of market expansion. Ultimately, the Usability Platform Test offers a systematic approach to drive educational innovation and meet the evolving needs of learners and educators worldwide.

Keywords: EdTech Talents, Usability Platform Test, Education, Gamification.

INTRODUCTION

The emergence of new business models has fundamentally reshaped the landscape of education, transitioning it from traditional methodologies to innovative digital platforms (Ashraf Alam & Atasi Mohanty, 2022). This paradigm shift is driven by the fusion of digital technologies with the profound impacts of the Covid-19 pandemic, compelling educational institutions to adopt digital solutions for delivering their courses (Leoste et al., 2021). Furthermore, the exigencies of the Covid-19 era have propelled the EdTech industry to greater prominence, amplifying its influence through the proliferation of numerous applications catering to diverse educational needs (Stack, 2015). Despite the abundance of EdTech applications available today, many struggle to find their foothold in the market due to a lack of effective market penetration strategies (Babik et al., 2024). Indeed, there exists a discernible difference within the realm of education (Kousa & Niemi, 2023). On one hand, we encounter the traditionalists, comprising professors and researchers deeply entrenched within the conventional paradigms of education (Stack, 2015). Their preference leans towards the tried-and-tested methods, rooted in the rich range of traditional pedagogy. On the other hand, we confront the burgeoning EdTech companies, brimming with innovation and zeal to revolutionize education through digital means (L & Naseema, 2024). However, their eagerness to introduce novel educational solutions often outpaces their thorough understanding of the intricate nuances within the education ecosystem (Himani Sharma, 2022). This gap between the traditionalist approach and the rapid influx of digital solutions underscores the need for a more nuanced and collaborative approach toward educational

innovation. In order to facilitate the bridging of the divide betwween EdTech companies and Education Institutions, this research endeavors to present a foundational concept of the Usability Platform Test, derived from the Horizon Europe project EdTech Talents. Subsequently, the proposed research question is:

How could the Usability Platform Test aid EdTech companies in bridging the gap with academia?

The remainder of the paper is organized as follows: Section 2 describes the Horizon Europe project EdTech Talents, Section 3 shows the Usability Platform Test, and Section 4 offers a conclusion of the findings, along with an exploration of the limitations inherent in the study, and suggestions for future research.

EDTECH TALENTS PROJECT

The overarching objective of the EdTech Talents initiative is to foster enhanced integration of technology within education systems across widening countries such as Estonia, Serbia and Hungary. This project is designed to leverage the expertise garnered from well-established EdTech firms in Austria, Germany, and Spain, with the aim of facilitating a more effective learning experience for researchers and administrative staff within the workspace of these developed nations' companies. Additionally, researchers from these more advanced countries will actively contribute their extensive experience and knowledge to EdTech companies operating within widening countries, through visits and consultancy sessions conducted directly on-site. This four-year long project is realized through the provision of comprehensive guidance and training, streamlining the process for all involved parties to exchange innovative ideas and critical information seamlessly. Such an initiative aligns seamlessly with a broader strategic vision aimed at fortifying inter-country and inter-industry ties, fostering cooperation, and promoting education talent exchange on a global scale. Figure 1 presents the exchange concept in the project EdTech Talents.

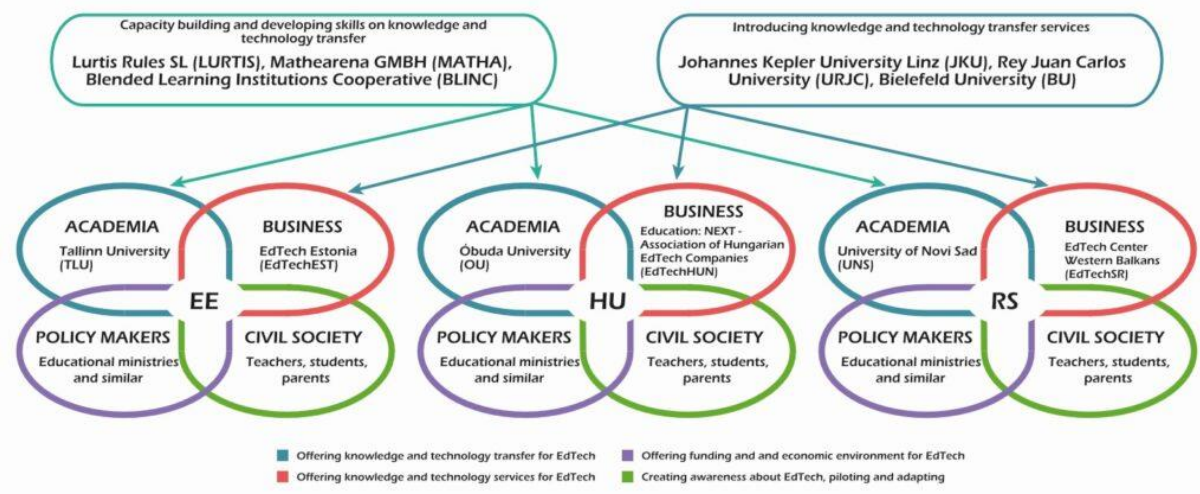
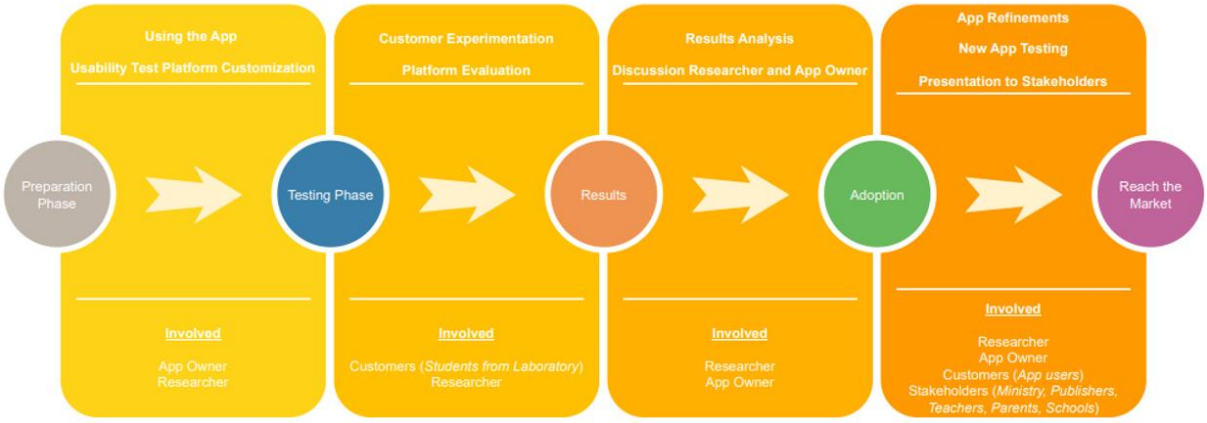


Figure 1: Exchange concept in the project EdTech Talents (Janika Leoste, 2023)

According to Figure 1, it can be concluded that one of the primary objectives of this project is to facilitate visits by researchers from widening countries to EdTech companies in developed nations. These visits aim to provide valuable consultation in the development of knowledge services. In this manuscript, the authors present the development of the Usability Platform Test as one such knowledge service.(Ashraf Alam & Atasi Mohanty, 2022)

RESEARCH FRAMEWORK: USABILITY PLATFORM TEST

The Usability Platform Test is a structured evaluation method designed to assess the effectiveness, efficiency, and satisfaction of digital platforms, particularly in educational contexts (Grani, 2024). This test involves observation, data collection, and analysis to gauge the usability of a platform or application (Norizan Mat Diah et al., 2010). By systematically evaluating various aspects of usability, including ease of use, navigation, and visual design, the Usability Platform Test aims to identify strengths and weaknesses in the platform's design and functionality, thereby informing iterative improvements and enhancing overall user satisfaction and engagement (Kuhnel et al., 2018). Drawing upon existing literature and aligned with the project objectives, researcher from the University of Novi Sad embarked on the development of a prototype for the Usability Platform Test during their visit to the Austrian EdTech company, MatheArena. The developmental phase was structured around two primary components: challenges and objectives. Expanding an EdTech application into new international markets poses a multifaceted challenge, encompassing issues such as cultural and language barriers, regulatory compliance, diverse educational systems, technological accessibility, payment models, competition, marketing strategies, user support, content localization, partnerships, technical hurdles, and security concerns. To navigate these challenges, the researcher devised the Usability Platform Test with overarching goals, including the creation of a cross-market Usability Testing Platform for EdTech Apps, leveraging expert guidance from EdTech researchers within a Virtual Talent Pool, facilitating market entry collaboration processes, customizing the Usability Testing Platform, providing comprehensive guidance through local researchers and Serbian partners, and fostering stakeholder engagement. Figure 2 present the employment of the Usability Platform Test.



According to Figure 2, the Usability Platform Test's main employment is divided into five phases: preparation, testing, results, adoption, and market launch. In the first phase, there are two stages: "Using the App," where the research team collaborates with the App owner to assess its functionalities comprehensively, and "Usability Test Platform Customization," where the platform is tailored to align with the application's specific requirements. The second phase also comprises two stages: "Customer Experimentation," where the application is introduced to a group of new customers for evaluation, and "Platform Evaluation," where customers provide feedback through the specialized Usability Test Platform. Moving to the third phase, there are two stages: "Results Analysis," where the research team analyzes quantitative and qualitative data, and "Discussion," where primary findings are presented to the App owner to collaborate on enhancing the application's quality. In the fourth phase, consisting of three stages: "App Refinements," where necessary adjustments are made based on feedback, "New App Testing," where fresh testing targets potential customers in a new market segment, and "Presentation to Stakeholders," where the application is presented to key stakeholders, signaling its readiness for deployment. Upon completing all stages, the EdTech company is ready for the fifth phase, "Market Launch". The prototype of the Usability Platform Test is accessible via the following link: https://sites.google.com/view/usability-platform-test/home?authuser=0.

CONCLUSION

In conclusion, this research paper has contributed significantly to the discourse on bridging the divide between EdTech companies and academia by presenting the Usability Platform Test as a foundational concept. By addressing the research question, "How could the Usability Platform Test aid EdTech companies in bridging the gap with academia?" the authors have highlighted the test's potential to facilitate collaboration and enhance stakeholder engagement. Through a comprehensive examination of the Usability Platform Test's structure and employment, this study has unveiled its capability in fostering the development and deployment of effective educational technologies. The main findings underscore the significance of the Usability Platform Test in guiding EdTech companies through the complexities of expanding into new international markets, providing a systematic approach to optimize usability and market readiness. However, it is imperative to acknowledge the study's limitations, including the necessity for further validation and refinement across diverse educational contexts and market segments. Future research endeavors should aim to address these limitations and explore additional strategies to bolster the efficacy and applicability of this framework, ensuring its relevance in driving educational advancement and meeting the evolving needs of learners and educators worldwide. Considering the proposed limitations and future implications, the authors advocate for the new employment of the Usability Platform Test in testing EdTech solutions from partner company MatheArena for potential launch in new markets.

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THE APPLICATION OF QR CODES IN THE FIELD OF E-BUSINESS IN THE CASE OF ORDER TRACKING AND LOGISTICS

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ABSTRACT

The use of QR codes in the field of e-business has brought significant progress in the efficiency of order tracking and logistics. This study explores how QR codes can be integrated into e-commerce systems, with a focus on shipping and logistics processes. The use of QR codes enables accurate tracking of products from order to delivery, thus increasing transparency and reducing the occurrence of errors. Customers can track the status of their orders in real time using QR codes, which improves customer experience and satisfaction. In the area of warehouse management, QR codes provide quick access to inventory data, which significantly increases the efficiency of work processes. In addition, the use of QR codes in inventory identification and management enables the implementation of automatic data entry and inventory updating, which reduces administrative burdens and minimizes the possibility of human error. The study points out that the use of QR codes not only enables the improvement of current systems, but also offers new opportunities for the development of intelligent logistics solutions. Overall, the introduction of QR codes into e-business logistics and order tracking processes is an innovative step that can provide companies with a sustainable competitive advantage in the long term.

Keywords: QR code, E-business, Order tracking, Logistics.

INTRODUCTION

In the world of e-business, technological development is constantly shaping business models and consumer expectations. The fast and accurate transmission of information has become crucial for modern businesses. QR codes (Quick Response codes) as simple and efficient means of data transmission play a significant role in modern e-commerce systems. QR codes enable quick and easy access to large amounts of data, which is particularly important in order tracking and logistics (Denso Wave, 2021).

The use of QR codes in the field of e-business has many advantages. Order tracking and logistics processes can benefit significantly from the integration of QR codes, as these codes enable accurate tracking of products from order to delivery. This transparency not only provides customers with reassuring information, but also gives companies the opportunity to reduce errors and optimize processes (Liu et al., 2021).

The positive impact of QR codes on the customer experience is also significant. Customers can use QR codes to track the status of their orders in real time, which increases customer satisfaction and trust (Zhou, 2011). Information is easily accessible by the customer and the accurate order tracking contributes to making customers more loyal to companies.

During warehouse management and logistics processes, QR codes provide quick access to inventory data. This significantly increases the efficiency of work processes, as the use of QR codes can reduce administrative burdens and minimize the possibility of human errors (Stoltz et al., 2017). The use of QR codes in the identification and management of stock allows for automatic data entry and stock updating, which further increases efficiency.

Industry 4.0 brought new dimensions of digitalization, automation, robotics, drone technology and data analysis to industrial processes and production (Gubán and Udvaros, 2022; Udvaros et al., 2022). Education must adapt to this paradigm shift and develop skills in students that meet the requirements of the Industry 4.0 work environment. During education, it is also important to mention the legal regulation of drones (Udvaros and Bódi, 2023). Students' rights must also be respected in the case of new challenges in education (Bódi, 2023).

The purpose of this study is to demonstrate the benefits of integrating QR codes in e-business order tracking and logistics processes. It points out that the use of QR codes not only enables the improvement of current systems, but also offers new opportunities for the development of intelligent logistics solutions (Brous et al., 2020). In the framework of this study, we discuss in detail the technological foundations of QR codes, their integration methods, their practical application and their future possibilities in the field of e-business. Overall, the introduction of QR codes into the logistics and order tracking processes of e-business is an innovative step that can provide companies with a sustainable competitive advantage in the long term (Zhong et al., 2019; Udvaros and Forman, 2024).

QR CODES IN E-BUSINESS

QR codes (Quick Response codes) are two-dimensional barcodes that can store large amounts of data. Their use in e-business is advantageous from several points of view, especially in terms of transparency, real-time information and warehouse management efficiency.

Transparency and traceability

QR codes allow you to follow the entire path of products from order to delivery. This transparency not only gives customers peace of mind, but also gives companies the opportunity to reduce errors and optimize processes. Tracking products using QR codes also reduces the risk of fraud and counterfeiting. The traceability provided by QR codes helps to manage logistics processes more accurately and transparently, which is especially important in the dynamic and rapidly changing environment of e-business (Zhang et al., 2016).

Real-time information

Customers receive real-time information about the status of their orders using QR codes, which increases satisfaction and trust. Real-time tracking improves the customer experience as customers receive immediate feedback on the status of their order, reducing uncertainty. The use of QR codes in customer relations enables a new level of interactivity, which is a fundamental element of satisfying modern consumer needs (Narang et al., 2012).

Efficiency of warehouse management

QR codes provide quick access to inventory data, facilitating inventory management and reducing human errors. The use of QR codes in warehouse management enables the implementation of automatic data entry and stock updating, which significantly increases the efficiency of work processes and reduces administrative burdens. Through automatic data entry, stock registration becomes more accurate, the occurrence of inventory shortages and excess stock decreases, thereby optimizes stock management (Stoltz et al., 2017).

APPLICATION OF QR CODES IN ORDER TRACKING

QR codes are extremely useful in the order tracking process as they help identify individual products and track their location in real time. The process steps are detailed below:

Taking an order

Each order is assigned a unique QR code. This code contains all relevant data related to the order, including the product identifier, customer details and shipping information. Generating a QR code is the first step that ensures that all further steps of the order can be easily tracked. QR codes help to record data quickly and efficiently, which reduces the occurrence of errors and increases processing speed. The use of technology enables the immediate identification and tracking of individual order items, which is essential in the dynamic and fast-paced environment of e-business (Santos and Marins, 2015).

Update shipping status

The status of the order is updated in the system by reading the QR codes at various points of the delivery. When the package leaves the warehouse, arrives at a distribution center or is being delivered, scanning the QR code updates the order status in the company's systems in real time. This enables accurate tracking and optimization of the delivery process. System-generated updates help to quickly identify and manage discrepancies and minimize the risk of delays and losses. The QR code-based system ensures continuous monitoring of the supply chain and data integrity in an automated way (Pipatprapa, 2019).

Customer information

By scanning the QR code, customers receive immediate information about the status of their order. This interactive element significantly enhances the customer experience, as customers can check the status of their order at any time and receive real-time notifications about the status of the package. This level of transparency and communication increases customer trust and satisfaction. Real-time tracking for customers reduces uncertainty and increases overall customer satisfaction as customers receive accurate information on when their package will arrive (Reyes Ruiz, 2022).

THE ROLE OF QR CODES IN LOGISTICS

The use of QR codes in logistics processes has many advantages, the most importants are increased efficiency, automation and inventory accuracy.

Efficiency increase

In warehouses, QR codes speed up the loading and unloading of goods. Using QR codes, warehouse workers can easily and quickly identify products, which significantly reduces the time and possibility of errors in manual data entry. This technology makes it possible to optimize warehouse processes, as it ensures faster and more accurate handling of products. The increase in efficiency is also manifested in the speed of warehouse operations and better utilization of the workforce (Khan and Javaid, 2022). For example, through the introduction of QR codes, warehouse workers can easily and quickly track the movement of goods, which results in significant time savings. Research has shown that the use of QR codes can increase the efficiency of warehouse operations by 25%.

Automation

Automatic entry and updating of data reduces the administrative burden. QR codes enable the automation of data collection, which minimizes the need for human intervention and reduces administrative costs. Automatic data entry ensures the accuracy and reliability of data, which is essential for the smooth operation of logistics processes. Automatic data updates allow companies to work with real-time information, which increases process transparency and improves decision-making (Patel, 2023). The use of QR codes reduces the possibility of human errors and increases the efficiency of data entry processes, thereby improving the operation of the logistics chain as a whole (Caballero-Gil et al., 2013).

Ventory accuracy

Real-time data enables accurate inventory records and quick response to inventory changes. When using QR codes, inventory movements are automatically updated in the system, which ensures inventory accuracy and minimizes the occurrence of inventory shortages. Instant data updates allow warehouse managers to work with real-time information, which increases the efficiency and accuracy of decision-making. Research has shown that the use of QR code-based inventory can reduce the occurrence of stock shortages and overstocks by up to 30%, resulting in significant cost savings in the long run. The use of QR codes contributes to the optimization of inventory management, as it is possible to respond quickly and efficiently to inventory changes based on real-time information (Sarac et al., 2010).

NEW OPPORTUNITIES IN INTELLIGENT LOGISTICS SOLUTIONS

QR codes not only increase the efficiency of current systems, but also enable the development of new innovative solutions. The use of QR codes in intelligent logistics systems can contribute to the control of automated vehicles and drones, as well as to integrated supply chain management (see Figure 1).

Figure 1. A modern warehouse where advanced robots sort packages, automated assembly lines and a logistics control center with large screens displaying real-time data and analytics. Image generated by AI.

Artificial Intelligence in Logistics

The integration of artificial intelligence (AI) into logistics and supply chain management strengthens and expands human capabilities. AI technologies enable fast and efficient processing of large amounts of data, which facilitates more accurate and faster decision-making. AI-based systems can predict inventory needs, optimize delivery routes, and respond immediately to market changes, thereby increasing the flexibility and reliability of logistics processes. In addition, AI-based chatbots and virtual assistants can improve the efficiency of customer service by providing quick answers to customer questions (Boute and Udenio, 2022).

Efficiency increase and Cost reduction

Intelligent logistics solutions based on the use of big data and related technologies offer significant advantages in improving logistics efficiency and reducing costs. Real-time analysis of data allows companies to optimize and minimize unnecessary inventory. Automated systems reduce the need for manual work, which not only reduces costs, but also the number of errors. The use of robotic warehouses and autonomous vehicles also contributes to increasing efficiency as they enable faster and more accurate operations (Zhang, 2021; Li and Wang, 2021).

Smart Logistics and Economic Transformation

Smart logistics provides an opportunity for logistics companies to reduce costs, increase efficiency and promote economic efficiency. The introduction of intelligent logistics solutions is in line with the requirements of economic transformation and development, as these systems are able to adapt to the rapidly changing market environment. Smart technologies such as blockchain improve the traceability and transparency of shipments, thereby increasing trust between partners in the supply chain. This not only reduces logistics costs, but also increases customer satisfaction (Guo and Liao, 2021; Weiwei and Ying, 2020).

Technological Integration

The development of intelligent logistics systems involves the integration of advanced information technology, intelligent technology and the Internet of Things (IoT) to provide efficient, low-cost and integrated logistics services. IoT devices enable real-time data collection and analysis, which improves the transparency and responsiveness of logistics processes. Intelligent systems can also automate routine tasks, reducing the possibility of human error and increasing the reliability of the logistics chain. For example, smart warehouse systems equipped with QR codes instantly identify and track the movement of goods, thereby minimizing inventory time and costs. Through the integration and analysis of data, companies can better understand and optimize their logistics processes, which provides them with a sustainable competitive advantage in the long term (Wang and Dai, 2014).

Therefore, intelligent logistics solutions not only enable the optimization of current systems, but also offer new opportunities for dealing with the logistics challenges of the future, contributing to the development of sustainable and efficient supply chains. Through innovation and technological development, companies will be able to meet rapidly changing market demands while increasing efficiency and reducing costs.

CONCLUSION

The use of QR codes in the order tracking and logistics processes of e-business is an innovative step that can provide companies with a sustainable competitive advantage in a long term. By providing transparency, providing real-time information and automating processes, QR codes significantly contribute to increasing efficiency and improving the customer experience.

The study presents the benefits of integrating QR codes in e-business order tracking and logistics processes. The use of QR codes increases transparency and customer satisfaction as they allow real-time tracking of products. The use of QR codes in warehouse management reduces administrative burdens and minimizes the possibility of human errors. In future developments, the integration of QR codes will open up new possibilities in the field of intelligent logistics solutions. Intelligent logistics solutions, such as automated vehicles and drones, further increase efficiency and contribute to the development of supply chain management.

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Session F: ABSTRACTS

Abstracts (pp. 283-284):

THE IMPORTANCE OF PROBLEM-SOLVING COMPETENCIES IN ACHIEVING CUSTOMER SATISFACTION

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ABSTRACT

In today's business environment, in which customer satisfaction plays a crucial role in an organization's ability to survive, problem-solving competences are considered essential, since they enable organizations to efficiently identify, analyze and solve problems that could have an impact on the customer experience. It is no longer enough for employees in direct contact with customers to be just kind and helpful, today it is necessary for them to respond quickly and efficiently to challenges that affect customer satisfaction. Problem-solving competencies are widely regarded as a fundamental skill necessary for success in the modern world and are of key importance for all business activities, particularly in customer relations. Along with the primary objective of satisfying customers, successful problem-solving also fulfills the requirements and principles of quality standards linked to improvements, resulting in better quality of products and services, more efficient business processes, greater customer trust and enhanced business reputation. The authors of this paper point to the issue of insufficient employee motivation in the area of developing problem-solving competences. There are several reasons for this attitude among employees: the accelerated development of digital technologies encourages the acquisition of digital skills; employees have insufficient awareness of the advantages of gaining competences; managers' lack understanding of the benefits of problem-solving competencies; and young people encounter insufficient opportunities to acquire problem-solving skills within their formal education.

Keywords: Competencies; Problem-solving; Customer satisfaction; ISO 10002.

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ARE ESG CORPORATE INVESTMENTS REWARDED BY HIGHER RETURNS AT LOWER RISK?

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ABSTRACT

Recent business models are based on environmental and community sustainability alojUDITngside the returns on diversified stock portfolios. Taking into account ESG characteristics means paying attention to firm properties that are not directly related to the usual financial or economic performance; and it could have an indirect impact on the financial performance that is relevant for investors. Our research question is whether the inclusion of ESG approach could lead to higher returns at lower (systematic) risk to the investors. By reflecting to the academic literature and reflecting to practitioners' opinions, we are presenting our own results comparing market returns of general and ESG portfolios. In our research we employed the Generalized Autoregressive Conditional Heteroskedasticity model. Finally, our findings suggest that the volatility of market returns is higher in conventional index as compared to the ESG index; and it has reliable implications to the advanced risk management of private companies.

Keywords: ESG approach, Firm value, Systematic risk, Profitability.

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