

UTILIZATION OF THE HR SCORECARD IN POTENTIAL DEVELOPMENT AND LEARNING GROWTH

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Abstract:

Research background: The paper addresses the issue of growth potential and learning in service-providing enterprises from the perspective of modern business performance management methods. It highlights their relevance in today's deepening crisis.

Purpose of the article: The aim of the article is to analyse the HR Scorecard model and its impact on the efficiency of management processes, with a focus on the fourth perspective of the Balanced Scorecard, incorporating current insights and trends in innovation.

Methods: The article examines the strengths and weaknesses in this field by comparing findings and evaluating processes and the quality of strategic management, particularly from the standpoint of learning, growth, and organizational development. It suggests methods and approaches to enhance enterprise and individual performance effectively, grounded in the strategic management system for organizational advancement.

Findings & Value added: To enhance work quality, the article incorporates elements of process management and analysis. It emphasizes the application of a potential improvement methodology, which enables the identification of bottlenecks within the learning and growth process and calculates the potential for improvement.

Keywords: human resources management; HR scorecard; digitization; efficiency; performance

JEL Classification: O12; O15; L25

1. Introduction

In the current business environment of the 21st century, enterprises face the challenge of navigating a multifaceted and constantly evolving landscape. To effectively manage complexities, it is essential to thoroughly understand and effectively apply strategic management frameworks such as the Balanced Scorecard (BSC). The fourth perspective of the BSC, namely learning and growth, deserves special attention (Kaplan and Norton, 1992). Learning and growth are generally considered the cornerstone of the Balanced Scorecard (BSC) framework. It recognizes the importance of human capital, information capital, and

organizational capital, serving as a catalyst for driving change and fostering innovation within the enterprise.

Recently, there has been a notable shift in emphasis towards the service sector, characterized by a high level of knowledge intensity and the requirement for continuous learning and development. Despite the significant importance of the service sector, there is a lack of scientific research regarding the implementation of the fourth perspective of the Balanced Scorecard (BSC) in service sector companies, especially concerning modern management techniques. This study offers an in-depth examination of organizations in the service sector from the perspective of the Balanced Scorecard's learning and growth perspective. The aim of this investigation is to thoroughly explore the utilization of contemporary management techniques and their impact on the market position of the mentioned entities.

This study aims to fill the gap in the existing literature by focusing on two fundamental issues. The initial step involves assessing the fundamental indicators that measure organizational performance and their optimal utilization in strategic management, specifically concerning the capabilities of the entity. The second objective of this study is to present a theoretical framework focused on enhancing the educational and developmental capabilities of individuals. To increase management efficiency and move the economy towards digitization, we propose the implementation of dashboards to monitor the fourth perspective of the Balanced Scorecards. These dashboards would allow for predicting their progress and evaluating their impact on company performance. The success of a business entity is conditioned by the competence and excellence of its management personnel, who are responsible for leading and guiding their subordinates towards achieving desired goals. According to Nikiforova et al. (2018), managers are accountable for using their professional and social competencies to effectively lead individuals to constructive work ethics, which ultimately leads to achieving desired work outcomes.

This study aims to explore the correlation between the learning and growth perspective and contemporary management theories by addressing a series of fundamental research questions. This study evaluates the state and performance of companies in the given sector using contemporary perspectives of the Balanced Scorecard (BSC) and the Human Resources (HR) Scorecard. The goal is to increase the performance and efficiency of these companies. The study further examines issues related to human resources management, business development, continuous management practices, and related phenomena.

The study demonstrates a comprehensive understanding of the learning and growth aspect in the service sector and provides valuable insights that can assist in the development of strategic management and the subsequent improvement of enterprise performance. The presented study shows the results of our research and proposes new methodologies for service-oriented enterprises aimed at improving their operational procedures and increasing their competitive advantage. The service sector, along with the entire industry, will need capable and proactive human resources to overcome the current crisis. These individuals must have the ability to anticipate and effectively solve operational problems within the enterprise. It is essential that the strategic human resources assessment system functions as a coherent system with components and connections not only within the organization but also considering external factors affecting its operation and overall efficiency. It is essential that the system can analyze dynamic conditions and respond accordingly. The onset of the second crisis, specifically economic and humanitarian, was facilitated by the ongoing pandemic and the exacerbation of existing issues. Effective management and resolution of these phenomena require human resources that are well-prepared and sufficiently educated to analyze their causes and propose viable solutions. The aim of this study is to clarify the procedures associated with strengthening

the strategic management framework with a focus on the fourth dimension of learning for the growth and development of the enterprise in industrial companies operating in the service sector.

2. Literature review

The Balanced Scorecard is a managerial tool that can be used to oversee an enterprise and evaluate its strategic objectives (Kumar et al., 2021). Fatkueva and Krupina (2020) argue that the balanced scorecard approach offers a thorough understanding of all aspects of the enterprise. This methodology allows the organization's leadership to monitor its internal standards, regulations, processes, and strategic goals as a cohesive whole. According to Tawse and Tabesh (2023), this particular management tool has a significant impact on both strategy formation and the implementation of control measures. Asiaei and Bontis (2019) suggest that developing an appropriate conceptual model utilizing a sustainable balanced scorecard can serve as a crucial link between corporate social responsibility and overall business performance. Pierce (2022) states that comprehensive performance measurement, whether financial or temporal, is a monumental task. Consequently, the use of a balanced evaluation table is considered advantageous for aligning metrics and optimizing the potential of obtained data. The balanced scorecard is used as a performance measurement system rather than a management control mechanism, with private sector organizations showing a greater inclination towards using the balanced scorecard compared to their public sector counterparts (Kumar et al., 2021).

The EFQM model is widely recognized and frequently used as a strategic formulation tool (Murthy et al., 2022). Dobrovic et al. (2019) believe that managers use this comprehensive tool to enhance and evaluate business performance. Fonsesca et al. (2021) argue that the EFQM model offers a comprehensive and cohesive framework that can be used to enhance business performance in the context of Industry 4.0. De Menezes et al. (2022) suggest that quality management is conditional upon stakeholder management and that the EFQM model creates both direct and indirect links between sustainability and orientation. According to Liu et al. (2021), EFQM model scores in various industries are uniform, necessitating score adjustments based on industry to ensure model credibility and obtain necessary information. Sony et al. (2020) argue that Six Sigma has recently become a significant quality management methodology for process improvement. The Six Sigma methodology has been widely implemented across various sectors, including healthcare, where it serves as a valuable tool for quality management and ensuring patient safety (Ninerola et al., 2020). Process improvement is the primary objective of using process statistics and data. The term "Lean Six Sigma" is commonly found in the literature as a method of enhancing current performance, competitiveness, quality, and cost-effectiveness of the enterprise, as noted by Tampubolon and Purba (2021). In addition to increasing productivity, it boosts employee morale and improves user or customer satisfaction. Costa et al. (2021) supported this assertion, further arguing that Lean Six Sigma represents an effective approach to eliminating waste and reducing deviations. Implementing Lean Six Sigma tools in organizations is associated with various benefits, including facilitating continuous improvement and identifying root causes of problems (Byrne et al., 2021). Rudanic et al. (2021) assert that business management is a continuous effort prioritizing the cultivation of the enterprise's human resources and achieving its strategic goals. Despite ongoing trends of robotization, automation, and digitalization, human capital remains widely regarded as the main factor contributing to business performance (Andersen, 2021).

Abujraiban and Assaf (2022) verified that strategic human resource planning results in a favorable outcome for the overall performance and efficiency of all employees in an

organization. Therefore, businesses must ensure that their employees are appropriately selected, educated, motivated, trained, and developed to maintain sustained growth and competitiveness in the market (Ahmad and Jalagat, 2022). Currently, there is significant competition among enterprises in acquiring skilled workers. As a result, it is essential for businesses to increase their attractiveness to employees and ensure the retention of talented workers (Stuss, 2020). This notion is also supported by Coculova and Tomcikova (2021), who argue that attracting and retaining qualified individuals is a key aspect of contemporary business management. Gelinas et al. (2022) believe that human resource management encompasses six dimensions: strategic human resource planning, recruitment and placement, employee development and education, human resource performance management, employee remuneration, workplace relationship management, and legal and ethical behavior. Fechter (2023) argues that evaluating the effectiveness and performance of human resources facilitates a specific tool, simultaneously creating a connection between human resources, performance, and strategy throughout the enterprise environment to achieve optimal organizational outcomes (Ermayanti and Ro'ifah 2016). Kowalczyk and Kucharska (2020) argue that a business is primarily composed of human resources, requiring the use of the HR Scorecard tool for effective management of these resources. According to Sadeghi and Biancone (2018), the HR Scorecard is a useful tool for human resource managers in setting goals and strategies for the upcoming period. Achieving goals in the near and distant future is conditional upon utilizing the competencies and capabilities inherent in the organization's human resources (Ismail and Sembiring, 2019).

Nelson and Ellis (2018) noted that the first two decades of the 21st century saw rapid development in digital technologies and digital data. According to Gramss (2020), digitalization holds significant importance for businesses and changes their overall requirements. The advent of digitalization has brought numerous perspectives for both suppliers and consumers by providing a considerable volume of new data that they can utilize (Peukert and Reimers, 2022). The impact of digitalization on business entities can be characterized by the duality of positive and negative outcomes, contingent upon the effectiveness of digitalization implementation (Travkina, 2022). The influence of digitalization extends beyond the business realm, permeating various aspects of the daily lives of most individuals, thereby affecting communication patterns (Wenzel, 2019). Erickson and Rothberg (2019) argue that digitalization has the potential to enhance business efficiency in the foreseeable future.

They attribute this primarily to the amount of big data that enterprises can leverage and adapt to their requirements. Currently, the integration of digitalization in manufacturing enterprises is becoming more frequent due to its potential to expand business perspectives and increase competitiveness, as noted by Fusko et al. (2019). Kirillova and Dorozhkin (2019) documented that digitalization is a global phenomenon adopted across various sectors of the economy. Antonov et al. (2020) argue that the term "effectiveness" is commonly used by various organizations. An enterprise's ability to achieve predetermined goals with minimal expenditure and effort is commonly referred to as efficiency, although this term is often confused with performance. A business requires an effective knowledge management model, particularly concerning technological advancements and potential generational differences in adapting to new digital technologies. Andriani et al. (2022) argue that developing an effective management model is crucial for businesses to ensure longevity and competitiveness in the market environment. Lin and Yi (2021) argue that management efficiency is key for enterprises as it has the potential to enhance the operational efficiency of the entire business. According to Yang et al. (2022), effective human resource management is essential for businesses to achieve long-term success in a competitive enterprise environment. According to Chernoiivanova et al. (2021), achieving efficiency requires a business to allocate resources for innovative

development, thereby unlocking its potential. Lehyani et al. (2023) argue that the activities and processes carried out in an organization significantly impact employee efficiency, either positively or negatively. According to Guliyeva et al. (2020), the use of information technology in companies' human resources departments has the potential to significantly increase their efficiency. Salehi et al. (2022) argue that performance is a key measure of a company's triumph and a determinant of its growth and persistence in a competitive environment. To succeed, businesses must possess dynamic capabilities that match those of their competitors, as noted by Rehman et al. (2020). Chang and Jeong (2021) argue that the activities of managers are crucial for achieving performance and positively influencing business operations, while Zhu et al. (2022) argue that innovative activities have a notable impact on increasing performance. Finally, it is essential for an organization to create a well-defined organizational structure and implement effective knowledge management practices. If these elements are properly established, the enterprise can achieve financial stability and enhance its performance in a competitive enterprise environment (Kavalic et al., 2021).

3. Methodology

The main objective of the research was to analyze the condition of enterprises in the service sector from the perspective of the fourth Balanced Scorecard perspective, that is, learning and growth, with an emphasis on using modern management methods and the success of these enterprises from the market position perspective. Within this goal, we evaluated key performance indicators and their more efficient utilization in strategic management concerning the management of the entire enterprise, particularly from the potential perspective. Based on the findings, we proposed a model for improving potential in the area of learning and growth. In the direction of improving and increasing management efficiency and in the context of transforming the economy towards digitalization, we proposed dashboards for monitoring the fourth BSC perspective with predictions of their development and impact on enterprise performance.

The basic research topic focused on researching the perspective of learning and growth compared to modern management theories. The fundamental research question was to determine the state of the enterprise and the success of enterprises in the analyzed sector concerning contemporary insights in the Balanced Scorecard and HR Scorecard concerning their performance with the goal of increasing the performance and efficiency of enterprises. The established research questions primarily focused on HR management and monitoring business development, ongoing management processes, and related phenomena.

The questions we were interested in included:

Q1: Does increased quality and level of HR also improve management processes in the enterprise?

Q2: How is enterprise performance measured in the analyzed sector, and what methods are used for this?

Q3: What is the potential for improving human resource management in the observed sector?

Q4: How high is employee satisfaction in these enterprises with their management, and how does this relate to learning and growth?

Q5: What barriers and risks are encountered in the area of learning and growth in the service sector? In our research, we also aimed to determine whether employees are regularly trained and at what intervals these educational activities are conducted.

Q6: Are KPI indicators used in the employee evaluation process?

During the research conducted in 2021 and 2022, we contacted 393 different industrial enterprises in the service sector through an electronic questionnaire survey. A total of 92 surveyed enterprises participated in the research. We primarily targeted senior and middle management. Some responses were also received from lower management. The research sample mainly consisted of managers working in this sector. Based on the aforementioned research questions, we formulated the following hypotheses which were the subject of the research work.

Hypothesis H1: We hypothesize that the implementation of modern strategic management methods from the perspective of the fourth BSC perspective in the management of industrial enterprises in the service sector will increase the performance of workers operating in this sector.

Within this hypothesis, we examined the impact of modern management methods on their performance, which is very important as in other industrial enterprises. We assumed whether the performance evaluation system corresponds to modern insights and trends used globally and whether it relates to key performance indicators.

To verify the hypothesis, we used a two-sample F-test and t-test. We verified the strength of the relationship using correlation dependence with Pearson's correlation coefficient. The resulting value was $F_{stat} = 0.5$. From the analysis, we found that $F_{stat} < F_{crit}$, thus accepting the null hypothesis and using the t-test for equality of variance. The test statistic t_{stat} was equal to 1.813, meaning it lies in the area of acceptance of the null hypothesis, which is the interval $(-1.973, 1.973)$, and at the significance level $\alpha = 0.05$, we accept the hypothesis at any significance level greater than 0.072. A very low p-value would indicate that we have a serious reason to reject the null hypothesis, which was not confirmed in this case. The strength of the relationship based on Pearson's correlation coefficient is 0.64, indicating that the strength of the relationship is not negligible. Respondents' opinions confirmed our assumption that there is a correlation and stronger links between modern management methods and performance. The conclusions were used in the proposal section to design a strategic HR Scorecard model. From common practice, it can be traced that companies use these modern management systems very little, as shown by the survey, where only 75% of organizations in the examined sample stated that they also use the Balanced Scorecard method of balanced performance indicators.

Hypothesis H2: We hypothesize that modern insights gained by employees during the process of education and increasing their expertise are sufficiently utilized in managing businesses in the area of learning and growth.

This hypothesis verified the assumption that strategic management is not only oriented towards customer-related indicators, but modern management methods, whose knowledge managers and other workers acquired during qualification and professional development, are fully utilized in the management process.

To verify Hypothesis H2, we used statistical methods of the two-sample F-test and t-test. The resulting value was $F_{stat} = 0.364$. Since $F_{stat} < F_{crit}$, we accept the null hypothesis of equal variances and use the t-test for equality of variances. The test statistic $t_{stat} = 0.644$ lies in the area of acceptance of the null hypothesis, which is the interval $(-1.973, 1.973)$. At the significance level $\alpha = 0.05$, we accept the null hypothesis at any significance level greater than 0.5203. The strength of the relationship determined by correlation is 0.19, indicating a relationship strength that is not so significant and can be considered weak. Respondents' opinions confirmed our assumption that there is a correlation between modern management methods and education, but it does not have such strong links. From common practice, it can be observed that companies are trying to limit training costs or deal with it in other ways. This area has been particularly strongly affected by the ongoing crisis and inflation, forcing

entrepreneurs to save, thereby reducing the links between the examined variables. This is a negative trend as it does not support performance growth but rather has a negative impact.

Hypothesis H3: We hypothesize that key performance indicators oriented towards strategic business goals are used in employee performance evaluation.

Within this hypothesis, we examined whether the use of a modern performance evaluation system based on KPI is sufficient to improve business performance.

To verify Hypothesis H3, we also used statistical methods of the two-sample F-test and t-test. We verified the strength of the relationship using correlation dependence with Pearson's correlation coefficient. The significance level was $\alpha = 0.05$. The resulting test value was $F_{stat} = 1.0039$. Since $F_{stat} > F_{crit}$, the null hypothesis of equal variances is rejected. We perform a t-test for unequal variance. The test statistic $t_{stat} = 1.1947$ lies in the area of acceptance of the null hypothesis, which is the interval $(-1.981, 1.981)$, and at the significance level $\alpha = 0.05$, we reject the null hypothesis. The correlation coefficient has a value of 0.47, which is a value indicating a medium relationship strength. Respondents' opinions did not confirm our assumption that there is a correlation between performance and the use of KPIs. The links between these variables are also transitional. This indicates poor use of KPIs that do not correspond to the company's goals. This error is very common in practice.

Hypothesis H4: We hypothesize that ineffective work in the area of learning and growth is related to the use of outdated management methods.

This hypothesis examined whether inefficiently expended work is related to management processes and thus reduces business performance. This hypothesis primarily concerned the proposal and calculation of improvement potential in management processes.

To verify Hypothesis H4, we used statistical methods of the two-sample F-test and t-test. For these tests and the Pearson correlation coefficient, we chose them because they provide a three-level evaluation: assessing the normality of the sample, testing the hypothesis, and indicating the strength of the relationship between the sample variables. The resulting test value was $F_{stat} = 0.101$. Since $F_{stat} < F_{crit}$, we accept the null hypothesis of equal variances. The t-test for equal variances states $t_{stat} = -1.3564$, so at the significance level $\alpha = 0.05$, we reject the null hypothesis. The correlation coefficient has a value of -0.15, which is a value indicating a relationship strength that is not very weak. Respondents' opinions did not confirm our assumption that there is a correlation between engagement and business performance. The influence here is very weak with a negative character. The conclusions of the tests can point to a very important factor of poor performance evaluation or the connection of performance with the area of remuneration and motivation. It also shows us deficiencies in performance management and the need to adopt a new modern learning and growth model that corresponds to current modern trends in the development of this science and the analyzed sector.

Hypothesis H5: We consider experienced and highly qualified personnel to be the most important factor influencing work efficiency and business performance.

Within this hypothesis, we want to verify the assumption that work efficiency is closely related to the growth of personnel qualifications.

To verify Hypothesis H5, we used statistical methods of the two-sample F-test and t-test. The resulting test value was $F_{stat} = 2.302$. Since $F_{stat} > F_{crit}$, we reject the null hypothesis of equal variances and perform a t-test for unequal variances. The test statistic $t_{stat} = 1.0750$ does not lie in the area of acceptance of the null hypothesis, which is the interval $(-1.975, 1.975)$, and at the significance level $\alpha = 0.05$, we reject the null hypothesis. The correlation coefficient has a value of -0.091, which is a value indicating no relationship strength or a very low one.

From respondents' opinions and interviews, it can be inferred that the issue of learning and growth and enterprise development in service enterprises is therefore in various areas and of

different characters. The survey shows that the strategic management system from the perspective of the fourth BSC perspective in this sector is also very important and has many reserves. The solution would be a comprehensive approach to managing learning and growth and development from the perspective of the entire enterprise, not just on an operational basis, but also with a clear vision for the future and strategic management focused on the satisfaction of not only customers but also employees and the entire staff comprehensively, as indicated by the perspective of learning and growth and the potentials of the enterprise.

4. Results and Discussion

Learning and growth of enterprise resources can be defined as a method of strategic management and performance management aimed at the success of the enterprise. This means a method that analyzes situations and proposes solutions that guarantee the success of enterprises through the effective use of human resources and their activities. A new perspective on strategic management through the HR Scorecard is given by focusing on the highest goal, which is no longer profit but the development of the enterprise, its growth, and employee satisfaction. Only the development of the enterprise ensures its success and continuous cost reduction. Profit achievement is no longer the primary measure of enterprise success. This shifts its place in the economy and finance, bringing issues related to the fourth perspective of the Balanced Scorecard with elements of modern controlling management with the acceptance of process digitization in this area. HR controlling expands strategic management with a new perspective through the eyes of management towards success. An important element in this process is the people - employees who work in the enterprise. The success of the enterprise also depends on the personnel and their quality.

4.1. Results of the survey

In addressing the issues of the fourth perspective of the BSC in the service sector, we were interested in how individual enterprises view the studied issues and how they deal with them. Within the research, we cross-sectionally processed views on the studied issue. We are aware that management issues are specific to each enterprise and should independently shape its future. However, we sought common features that would support the development of the enterprise and learning, growth, and improvement of its quality. In terms of gender, the views of male managers predominated, with more than 65%. More than 55% of respondents were from top management, and 21.7% of views were from middle and lower management. They were represented from all regions and were of different ages. We tried to adjust the distribution scale by age to the manager's career curve, and from this perspective, we also created an age structure, with a group that is still developing, a group of managers already capable in the second stage of their careers, then a group of experienced managers, and finally a group that was already touching the late stage of the manager's career. Education played an important role in this process. Most respondents had a full university education at level II (65.2%). Various job functions were represented, from owners, top management, middle, and lower-level managers. Regarding the size of enterprises by the number of employees, most had between 10 and 49 employees (76%).

Through the survey, we found that almost 60% of respondents indicated a lack of qualified employees. Opinions on employee recruitment varied over time, but three opinions predominated: once a year (28.3%), once a quarter (23.9%), and mostly permanent employees (21.7%). The most common source of information for recruiting new employees was advertisements (78.6%). Recommendations also carried significant weight (17.1%). In

education, up to 70.7% of respondents stated that they are educated according to current trends. Only 4.3% of enterprises stated that they do not educate themselves. This group might have a problem with enterprise growth and development. The most common form of education was consultation (30%). Coaching and work meetings, mentoring, instructions were also frequently used (15% of the total 30%).

In the next part, we focused on employee performance and satisfaction. Up to 25% of enterprises evaluate employees monthly. A fairly large percentage also evaluated annually and at other intervals (over 22%). According to KPI indicators, 46.7% evaluated, and 53.3% of enterprises did not use them, which is relatively high given the current trends. Regarding the balance of KPIs, it is an unbalanced system where most enterprises preferred economic, organizational, and performance indicators (28.6%). Economic key performance indicators were often reported within other groups. In deeper analysis, we found that specific KPIs (37%) and purely economic ones (15.5%) prevailed in this group. There were also 21.5% performance-oriented KPIs. From this perspective, it is clear that the used indicators have no direct connection with the strategy and vision of the organization since almost no examined company used a comprehensive BSC, with one exception. Career growth is applied in up to 78.3% of facilities, which is a very high percentage, and we evaluate it positively. Up to 91.3% of facilities support motivational systems. Regarding remuneration in institutions, there are various forms, but high wages prevail (36.7%), followed by a combination of salary and career growth (16.7%) and 10% in combination with benefits. The remuneration system consists of 34.3% salary and 24.5% praise and recognition. Self-development is supported by up to 95.7% of respondents. Engagement is relatively high, indicated by 78.3% of respondents. Employee satisfaction on a scale from 1 to 4 was expressed by 39.2% of respondents, which is relatively low. Only 3.3% of respondents were very satisfied. This percentage indicates the need for more effective HR management according to modern insights in this area, which we then addressed in the design section. In personal interviews and examining these dependencies directly in various enterprises, these conclusions were repeatedly confirmed.

4.2. Proposals and recommendations

Based on our professional experience and studies, we have processed and described the basic processes occurring in the area of strategic management. We proposed a system to increase performance potential concerning strategic goals. In the proposal section, based on conducted research and hypothesis testing as prerequisites for further development in the area of learning, growth, and organizational development, we developed a model for calculating improvement potential and thereby increasing the quality and efficiency of the given facility's work. In connection with process optimization and improvement potential, a process map is also compiled.

4.3. Principles of a process-oriented enterprise

It is necessary to understand that this is not about routine process improvement but systematic activity based on the ABC/M concept. Most systems in this area focus on improving existing processes. These solutions are more commonly found in industrial practice than in services. The Balanced Scorecard theory recommends that managers construct the entire value chain - from the innovation process, detecting current and future needs, and developing new ways to address these needs through process management to providing existing services with new innovation potential and ending with the offer of services at the level of current trends with a future perspective that adds value to the provided services.

4.4. Proposal of the strategic HR scorecard management system in the fourth perspective of learning and growth

When modernizing enterprise management, it is also important to use modern management systems based on a balanced indicator system based on long-term key performance indicators. This approach can balance the efficiency of management and the KPI (key performance indicator) monitoring system, not only concerning customers and their operations but also managers and other employees. This provides a better overview of the company's and its workplaces' condition, allowing for a more efficient transition to AI-based management in the future. This trend is already underway and is also related to the process of digitalization and the digital society.

4.5. Discussion of results and contribution to theory and practice

The knowledge processed in the context of this paper was targeted, analyzed, and further processed to help improve management processes of customer care from a business performance perspective. At the same time, we tried to collect and present information to help improve processes in the theoretical field of HR Scorecard knowledge, especially at the enterprise level in this sector. We aimed for this information to be useful in the process of educating managers but also among the broader professional public and employees working in this sector.

In our research, we also conducted a survey of opinions from various stakeholder groups – managers, professionals, the broader professional public closely related to this issue. The research showed that the strategic management process in the fourth perspective of the BSC in the service sector is at a good level and corresponds to trends in this area, but from the perspective of modern management theories, there are significant reserves in the management system, and there is potential for improvement. Therefore, in this work, we also emphasized the most important potentials for improving the strategic management process in this sector. The biggest gap we found was in the management of their performance. Regarding KPIs for providing customer care, it can be said that it is at a very good level, but concerning performance indicators, there are significant differences, especially in their use. Most of the examined enterprises had an unbalanced system of performance indicators. When viewed from the perspective of the Balanced Scorecard method, we found that almost all key performance indicators are focused on the customer perspective, and financial indicators are also strongly represented. These indicators rarely relate to the process perspective of development and even less to the perspective of growth, learning, and personnel. In the context of these perspectives, we see the quality and efficiency of the examined enterprises. From the perspective of strategic management, we found quite large gaps, confirmed by both practice and previous research. Quality employees with managerial experience and knowledge can play a very important role in the future. The concept of key personality and indicators related to these persons is completely lacking in enterprises.

5. Conclusions

In this paper, we dealt with the issue of the Balanced Scorecard in service enterprises with an emphasis on the application of the HR Scorecard system. The issue of learning, growth, and enterprise development is less developed. Therefore, we tried to bring a new perspective on this area of strategic management and the possibilities of its development with our research work. In this area, we see significant potential for improvement, especially concerning strategic management itself. The increasingly supported digitization of processes based on modern

digital technologies in the context of digital transformation throughout the EU brings a new perspective on this issue. These processes need to be managed and controlled. There are great reserves, but with good management, this can be achieved within a few years. Above all, it presupposes a good vision and strategy, a system of quality balanced performance indicators, and quality teamwork.

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*Utilization of the HR Scorecard in Potential
Development and Learning Growth*

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SECTORAL VIEW ON FINANCIAL MANAGEMENT OF SMES. EMRPIRICAL RESEARCH IN V4 COUNTRIES

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Abstract:

Research background: The importance of small and medium enterprises to the development of economic condition of developed and developing countries are so vital, yet SMEs are extremely vulnerable to default due economic and competitive pressure from the large firm.

Purpose of the article: The aim of paper was to define important factors of financial management of SMEs and compare answers of respondent in three the most important sectors in V4 countries.

Methods: The empirical research was conducted in June 2022 in the V4 countries. Data collection was carried out by the external agency MNFORCE using the "Computer Assisted Web Interviewing" (CAWI Research Method). The total number of respondents in the sample was 995. The statistical hypothesis was tested through descriptive statistics and Z-score at $\alpha = 5\%$ significance level.

Findings & Value added: The results of the empirical research confirmed that SMEs in the V4 countries within the sample set of the top three sectors have a relatively positive attitude towards selected aspects of financial management. SMEs in each country presented an understanding of the basic attributes of financial management, a correct perception of financial risk and also the ability to manage financial risks appropriately. At the same time, these firms were relatively positive about the current financial performance of their firms and showed a considerable amount of business optimism. The best results were found in Hungary, followed by Poland, Slovakia and the Czech Republic in last place. Statistically significant differences in firms' attitudes within the most important SME business sectors were found only in Poland. The manufacturing sector was significantly more likely to agree with the statement that SMEs understand the most important aspects of financial management compared to the tourism and trade sector.

Keywords: small and medium-sized enterprise; financial management; business sectors; V4 countries

JEL Classification: D22; G23; L26

1. Introduction

The importance of small and medium enterprises (SMEs) to the development of economic condition of developed and developing countries are so vital, yet SMEs are extremely vulnerable to default due economic and competitive pressure from the large firm. It is accounted that in most of developing and developed countries about 99% of the businesses are operated under SMEs but in most cases, they are not able to sustain for the long run due to their poor financial management and inability to maintain enough free cash flow to use in the dire financial situation of the firms. A several studies argued that the SMEs are the major drivers for the socio-economic growth and also it helps to increase gross domestic product as well as the national output of a country (Amoah, 2018; Lewandowska and Stopa, 2019; Belas et al., 2017).

Financial management is a purposeful process of managing and controlling a firm's financial resources and financial operations in order to achieve long-term and short-term financial stability, efficiency of spending and long-term sustainability of the firm in the marketplace.

In the context of financial management of small and medium-sized enterprises, important activities include managing financial risks, measuring and evaluating the firm's financial performance, and deciding on the use of equity and external capital and the most appropriate financing methods for the firm, including borrowing, issuing bonds, repaying existing debts, or using internal financial resources.

The financial management of SMEs has some specific features and challenges compared to the financial management of large companies, such as limited financial resources and limited access to bank financing, dependence on owners, rapid adaptation to change, simple information systems to support financial management, priority focus on cash-flow.

Good financial management is key to the long-term success and sustainability of a company because it helps ensure that the company has sufficient financial resources to fund its operations and growth, while minimizing financial risks that could threaten its existence.

In this paper, we examine the approach to financial management of SMEs in the three most important SME business sectors in the Visegrad Four countries (V4 countries) based on propositions that aptly describe this area.

2. Literature review

COVID-19 had a tremendous impact on the profitability of the firms, and which has subsided many business activities and specially SMEs were impacted more than the larger ones. Achim et al. (2022) showed that about 37% of the business activity declined in the context of Romania due to the global pandemic and among that 80% of the SMEs were largely impacted due to less sales. In this paper we would like to shade light in financial management of SMEs in V4 (Czech Republic, Slovakia, Hungary, and Poland) countries by focusing on a couple of main sectors such as manufacturing, services, trade, and tourism industries. Historically, these countries are heavily depended on the manufacturing or services but due to COVID-19, these sectors were significantly affected financially, and many businesses had to close due to lack of sales.

There are many studies in the financial literature highlighted that the failure of SMEs is not only related to the poor business performance or unable to generate enough sales but also it is significantly related to their owner/managers lack financial management skills (De Bruyckere et al., 2020; Cera et al., 2019; Rahman et al., 2017). There are handful of research shows that the owner managers lack of ability to manage credit risk, financial management and also their personality choices have significant impact on the business performance as well as their long term sustainability (Hudakova et al. 2018, Belas et al. 2018, Kljucnikov et al. 2016). It is quite

common to see that the SMEs are not able to hire professional financial managers to manage the business, rather mostly done by the owners and hence it poses a risk on the firm long term financial sustainability (Bilan et al., 2017). In this paper the goal is to acquire the knowledge on how owners' managers in different sectors manage their financial risk and what are the most important aspect of long-term financial sustainability of SMEs in Czech Republic, Slovakia, Hungary, and Poland. In that regard:

A study by Karadag (2015) showed that 99.9% of the businesses in Turkey are categorized by SMEs but they face serious survival problems due to lack of proper financial management and to have skilled managers who understand the significance of financial risk. The study highlighted that the main causes of business failures are due limited knowledge of financial planning and access to finance when needed. It was also discussed in the paper that; the SME owners are not emphasizing working capital management for which SMEs are often bound to take loans or borrow money from local lenders with high interest rate. By borrowing with high interest rates SMEs often put the firm under immense credit risk and their propensity to default is significantly higher than the firms those maintains a good working capital management.

Dutescu et al. (2014) examined the importance of financial management of SMEs in tourism industries mainly SMEs operating in the hotel business in Romania. A total number of forty-two owners/managers of SMEs participated in the survey where they are overwhelming suggested that the lack of profit management is the major issue for their business to sustain in the long run. It was also found that the business success is significantly depended on how the business was funded, it was showed that firms with owners funding are more likely to success as they don't need to pay high bank interest rate. It could be seen that bank high interest rate is a barrier for SMEs to grow and survive.

A similar study by Kengatharan and Suganya (2015) in the context of SMEs in Sri Lanka, those are mainly operated in the tourism industry showed that there is a significant difference between SMEs which can manage their working capital have less financial risk than those are not managing their working capital properly. It was also found that capital structure of the SMEs is extremely important for their survival chances and performance. They have suggested that it is better for the SMEs not to leverage their equity structure because high debt poses high capital costs and that could reduce the chance of long-term survival of SMEs.

A similar study was done by Wolmarans and Meintjes (2015) in South Africa by focusing on SMEs operated in trade, manufacturing and services industry. Their study confirms that SMEs with high propensity of bank finance and inability to manage working capital properly are more prone to default. The study also concludes that there are differences between opinion of owners/managers in the SMEs in managing financial risk. It could be seen that; owners prefer more to manage the profitability of the business whereas the managers are more willing to better management of working capital of SMEs.

Virglerova et al. (2016) examined the perception of financial risk of SMEs in the Czech Republic by doing a survey of 1,141 SME owners and managers conducting business in trade, manufacturing and services industries. They study found that about 75% of the SME owners responded that financial risk is the biggest risk of their business and only about 28.5% of the business owners understand how to manage financial risk. This shows that although managers understand the importance of financial risk management, but they are not skilled or trained to manage this risk in their businesses.

A later study was done by Lesakova et al. (2019) in the context of Slovakia those are producing engineering products. This sector is very important sector for the overall Slovak economic structure because they are specialized in tool manufacturing. The study was

conducted among 728 SMEs and most of them are in the small firms with employees around 10-49. The study reveals that SMEs have difficulty in profitability management due to high competition and as such it poses significant financial risk for the firm. They have also presented that SMEs those are operating under a well-trained financial manager performs better in the long run compared to SMEs operated by their owners. This finding is quite significant in understanding the proper training of financial manager in the survival of the SMEs.

Another study by Nunkoo et al. (2020) highlighted that the managerial capacity has a significant impact on the financial risk management of SMEs in the tourism industry of Mauritius. The study was conducted in 384 SMEs operating the tourism industry which is one of the biggest economic drivers of Mauritius. The study reveals that the managerial autonomous financial decision making has a significant positive impact on the financial performance of the SMEs. They have also shown that when a manager is not under pressure from the owners, they tend to make better financial choices and hence it improves financial risk management of the firms. The authors also showed that it is extremely vital for the managers to be competent in decision making while not being forced to make any choices from the owners and that helps them to survive longer time in the business. They concluded that the skilled financial managers are the key drivers for the SMEs operating the tourism sectors and their success to a long-term performance.

A recent study by Belas et al. (2020) highlighted that the SMEs in the services sectors are significantly different in their financial performance and the opinions between owners' and managers skills in operating the business. The study conducted in the Czech and Slovak Republic showed that owners are very actively managing their financial risk in Slovakia and on the other hand, owners in the Czech Republic has limited knowledge on financial risk management of the firm. The study further showed that financial risk management is the key to success for the SMEs, however not all SMEs can hire professional financial managers to better manage their business decision making due to lack of resources. The study did find that the owners in both countries agree on the performance of the businesses needs to be evaluated continuously and hence they can find any opportunities for improvements in business profitability.

3. Methodology

The aim of paper is to define important factors of financial management of SMEs and compare answers of respondent in three the most important sectors in V4 countries.

The empirical research, which aimed to survey the attitudes of SMEs, was conducted in June 2022 in the V4 countries. Data collection was carried out by the external agency MNFORCE using the "Computer Assisted Web Interviewing" (CAWI Research Method). The questionnaire could be completed by the owner or the top manager of the SME.

In the Czech Republic, the total number of respondents was 347. The structure of SMEs: 45.2% micro enterprises, 30.8% small enterprises and 23.9% medium enterprises. The largest number of firms were engaged in services 138 (39.8%) and manufacturing 72 (20.7%), followed by the following areas: 60 (17.3%) trade, 32 (9.2%) construction, 11 (3.2%) transport, 7 (2.0%) agriculture, 3 (0.9%) tourism, and 24 (6.9%) respondents indicated other business sector.

In the Slovak Republic, the total number of respondents was 322. The structure of respondents in terms of company size was as follows: 51.9% micro enterprises, 26.7% small enterprises and 21.4% medium enterprises. The largest number of firms were in services 129 (40.1%) and trade 79 (24.5%), followed by the following: 42 (13.0%) manufacturing, 37 (11.5%) construction, 7 (2.2%) transport, 3 (0.9%) agriculture, 3 (0.9%) tourism, and 22 (6.9%) respondents indicated other business sector.

In Poland, the total number of respondents was 381. The structure of respondents in terms of company size was as follows: 47.2% micro enterprises, 27.8% small enterprises and 25.0% medium enterprises. The largest number of firms were in tourism 110 (28.9%) and manufacturing 78 (20.5%), followed by the following: 56 (14.7%) trade, 49 (12.8%) services, 31 (8.1%) construction, 13 (3.4%) transport, 17 (4.5%) agriculture, and 27 (7.1%) respondents indicated other business sector.

In Hungary, the total number of respondents was 348. The structure of respondents in terms of company size was as follows: 50.0% micro enterprises, 28.2% small enterprises and 21.8% medium enterprises. The largest number of firms were in tourism 110 (31.6%) and trade 69 (19.8%), followed by the following: 52 (14.9%) services, 34 (9.8%) manufacturing, 23 (6.6%) transport, 19 (5.5%) agriculture, 13 (3.5%) construction, and 29 (8.3%) respondents indicated other business sector.

In this article, we will assess respondents' attitudes according to the three most important business sectors in the V4 countries. In the Czech Republic, these will be the following sectors of the economy: services, manufacturing and trade. In Slovakia, services, trade and manufacturing. In Poland, tourism, manufacturing and trade. In Hungary, tourism, trade and services.

On the basis of previous research and qualitative analysis of the literature, statements have been established that appropriately characterize the importance of business ethics in SME entrepreneurship:

ST1: I understand the most important aspect of a company's financial management.

ST2: I consider the financial risk to be a part of the daily life of a company.

ST3: I can adequately manage financial risks in our company.

ST4: I examine the financial performance of our company positively.

ST5: Our company will survive on the market in the next five years.

Based on the method of expert estimation, we set the following statistical hypotheses:

H1: The average level of agreement with the ST1 statement is above 80% for all V4 counties. There are no statistically significant differences in respondents' positive attitudes by the three most important sectors across the V4 countries when evaluating ST1.

H2: The average level of agreement with the ST2 statement is above 80% for all V4 counties. There are no statistically significant differences in the positive attitudes of respondents by the three most important sectors across the V4 countries when evaluating ST2.

H3: The average level of agreement with the ST3 statement is above 80% for all V4 counties. There are no statistically significant differences in respondents' positive attitudes by the three most important sectors across the V4 countries when assessing ST3.

H4: The average level of agreement with the ST4 statement is above 80% for all V4 counties. There are no statistically significant differences in respondents' positive attitudes by the three most important sectors across the V4 countries when assessing ST4.

H5: The average level of agreement with the ST5 statement is above 80% for all V4 counties. There are no statistically significant differences in respondents' positive attitudes by the three most important sectors across the V4 countries when assessing ST5.

The statistical hypothesis was tested through descriptive statistics and Z-score at $\alpha = 5\%$ significance level. If the p-value is greater than or equal to 0.05 the null hypothesis is confirmed. If the p-value is less than 0.05 the null hypothesis is rejected. Calculations were made using available software on the internet (Z Score Calculator, 2023). If a p-value less than 0.05 occurs more than 30% of the time, we consider the null hypothesis to be unconfirmed.

4. Results and Discussion

The following tables present the results of the research, including the verification of each scientific hypothesis.

Table 1: Results of the ST1 by the most important sectors in the V4 countries

ST1: I understand the most important aspect of a company's financial management.	CR	SR	PL	HU
	S/M/Tr	S/Tr/M	T/M/Tr	T/Tr/S
	138/72/60	129/42/79	110/78/56	110/69/52
1. I completely agree	48/22/17	48/15/34	52/45/32	53/47/30
2. I agree	67/34/28	62/22/36	52/33/17	47/18/19
Total 1+2	115/56/45	110/37/70	104/78/49	100/65/49
Percentage of positive responses	83/78/75	85/88/89	94/100/87	91/94/94
Average value in %	79	87	94	93

Note: Czech Republic - CR; Slovak Republic - SR; Poland - PL; Hungary - HU; services - S; trade - Tr; manufacturing - M; tourism - T

Source: own research

Table 2: Statistical calculations of ST1 by the most important sectors in the V4 countries

Z score: p-value			
CR: S/M; S/Tr; M/Tr	0.3271	0.1707	0.7114
SR: S/M; S/Tr; M/Tr	0.6455	0.4965	0.9362
PL: T/M; T/Tr; M/Tr	0.0357	0.1096	0.0013
HU: T/Tr; T/S; Tr/S	0.4237	0.4654	0.9920

Source: own research

The results of the empirical research showed that the percentage of positive responses to the ST1 statement varies from 75% (the level of agreement with the ST1 statement in the trade sector in the Czech Republic) to 100% (the level of agreement with the ST1 statement in the manufacturing sector in Poland). The average level of agreement with the statement varies from 79% (Czech Republic) to 94% (Poland) in the V4 countries. The average agreement rate for all V4 countries is 88%. Statistically significant differences were found only in Poland. The manufacturing sector was significantly more likely to agree with the statement that SMEs understand the most important aspects of financial management compared to the tourism and trade sector. The number of p-values lower than 0.05 is at 17%. H1 was confirmed.

Table 3: Results of the ST2 by the most important sectors in the V4 countries

ST2: I consider the financial risk to be a part of the daily life of a company.	CR	SR	PL	HU
	S/M/Tr	S/Tr/M	T/M/Tr	T/Tr/S
	138/72/60	129/42/79	110/78/56	110/69/52
1. I completely agree	35/18/21	44/12/29	42/38/25	44/32/30
2. I agree	70/45/26	68/27/38	54/32/21	53/32/17
Total 1+2	105/63/47	112/39/67	96/70/46	97/64/47
Percentage of positive responses	76/87/78	87/93/85	87/90/82	88/93/90
Average value in %	80	88	86	90

Source: own research

Table 4: Statistical calculations of ST2 by the most important sectors in the V4 countries

Z score: p-value			
CR: S/M; S/Tr; M/Tr	0.0500	0.7279	0.1585
SR: S/M; S/Tr; M/Tr	0.2891	0.6818	0.2005
PL: T/M; T/Tr; M/Tr	0.6031	0.3735	0.2041
HU: T/Tr; T/S; Tr/S	0.3222	0.6745	0.6384

Source: own research

The percentage of positive responses to statement ST1 is between 76% (the level of agreement with statement ST2 in the service sector in the Czech Republic) and 93% (the level of agreement with statement ST2 in the trade sector in Slovakia and Hungary). The average

level of agreement with the statement ranges from 80% (Czech Republic) to 90% (Hungary) in the V4 countries. The average agreement rate for all V4 countries is 86%. Statistically significant differences were indicated only in the Czech Republic (p-value has a borderline value). The manufacturing sector was significantly more likely to agree with the statement that SMEs perceive financial risk as an inevitable part of doing business compared to the service sector. H2 was confirmed.

Table 5: Results of the ST3 by the most important sectors in the V4 countries

ST3: I can adequately manage financial risks in our company.	CR S/M/Tr 138/72/60	SR S/Tr/M 129/42/79	PL T/M/Tr 110/78/56	HU T/Tr/S 110/69/52
1. I completely agree	32/16/11	25/12/25	38/30/24	50/35/28
2. I agree	71/41/33	81/22/40	56/40/21	49/31/18
Total 1+2	103/57/44	106/34/65	94/70/45	99/66/46
Percentage of positive responses	75/79/73	82/81/82	85/90/80	90/96/88
Average value in %	76	82	85	91

Source: own research

Table 6: Statistical calculations of ST3 by the most important sectors in the V4 countries

Z score: p-value			
CR: S/M; S/Tr; M/Tr	0.4654	0.8493	0.4295
SR: S/M; S/Tr; M/Tr	0.8572	0.9840	0.8572
PL: T/M; T/Tr; M/Tr	0.3843	0.4009	0.1236
HU: T/Tr; T/S; Tr/S	0.1707	0.7642	0.1362

Source: own research

The results of the empirical research showed that the percentage of positive responses to the ST3 statement varies from 75% (the level of agreement with the ST3 statement in the trade sector in the Czech Republic) to 96% (the level of agreement with the ST3 statement in the trade sector in Hungary). The average level of agreement with the statement ranges from 76% (Czech Republic) to 91% (Hungary) in the V4 countries. The average agreement rate for all V4 countries is 83%. No statistically significant differences were found in any of the V4 countries. H3 was confirmed.

Table 7: Results of the ST4 by the most important sectors in the V4 countries

ST4: I examine the financial performance of our company positively.	CR S/M/Tr 138/72/60	SR S/Tr/M 129/42/79	PL T/M/Tr 110/78/56	HU T/Tr/S 110/69/52
1. I completely agree	28/22/12	27/8/22	33/34/24	45/34/29
2. I agree	78/35/33	72/28/36	59/40/23	45/27/18
Total 1+2	106/57/45	99/36/58	92/74/47	90/61/47
Percentage of positive responses	77/79/75	77/86/73	84/95/84	82/88/90
Average value in %	77	79	88	87

Source: own research

Table 8: Statistical calculations of ST4 by the most important sectors in the V4 countries

Z score: p-value			
CR: S/M; S/Tr; M/Tr	0.6965	0.7795	0.5687
SR: S/M; S/Tr; M/Tr	0.2150	0.5892	0.1211
PL: T/M; T/Tr; M/Tr	0.0183	0.9601	0.0349
HU: T/Tr; T/S; Tr/S	0.2380	0.1585	0.7263

Source: own research

The results of the empirical research showed that the percentage of positive responses to the ST4 statement varies from 77% (the level of agreement with the ST4 statement in the manufacturing sector in the Czech Republic) to 88% (the level of agreement with the ST4 statement in the manufacturing sector in Hungary). The average level of agreement with the

statement ranges from 77% (Czech Republic) to 88% (Poland) in the V4 countries. The average agreement rate for all V4 countries is 83%. Statistically significant differences were found in Poland, where the manufacturing sector was significantly more likely to agree with the statement that they perceive the financial performance of their firms positively compared to the trade and tourism sector. The number of p-values below 0.05 is at 17%. H4 was confirmed.

Table 9: Results of the ST5 by the most important sectors in the V4 countries

ST5: Our company will survive on the market in the next five years.	CR S/M/Tr 138/72/60	SR S/Tr/M 129/42/79	PL T/M/Tr 110/78/56	HU T/Tr/S 110/69/52
1. I completely agree	44/24/19	40/14/23	37/39/25	52/41/25
2. I agree	65/36/22	52/20/38	54/34/18	43/19/23
Total 1+2	109/59/41	92/34/61	91/73/43	95/60/48
Percentage of positive responses	79/82/ 68	71/81/77	83/ 94 /77	86/87/92
Average value in %	76	76	85	88

Source: own research

Table 10: Statistical calculations of ST5 by the most important sectors in the V4 countries

Z score: p-value			
CR: S/M; S/Tr; M/Tr	0.6101	0.1074	0.0688
SR: S/M; S/Tr; M/Tr	0.2187	0.3472	0.6312
PL: T/M; T/Tr; M/Tr	0.0278	0.3576	0.0050
HU: T/Tr; T/S; Tr/S	0.9124	0.2713	0.3472

Source: own research

The percentage of positive responses to ST5 varies from 68% (the level of agreement with ST5 in the trade sector in the Czech Republic) to 94% (the level of agreement with ST5 in the manufacturing sector in Poland). The average level of agreement with the statement ranges from 76% (Czech Republic and Slovakia) to 88% (Hungary) in the V4 countries. The average agreement rate for all V4 countries is 81%. Statistically significant differences were found in Poland, where the manufacturing sector was significantly more likely to agree with the statement that their company will survive the next five years compared to the trade and tourism sector. The number of p-values below 0.05 is at 17%. H5 was confirmed.

The results of the empirical research confirmed that the positive attitude towards the issue of financial management of the firm is above 80% in the V4 countries within the sample set of the three most important SME business sectors.

The best results were measured in Hungary, where the average value of positive responses to ST1 to ST5 was 90%, followed by Poland (88%), Slovakia (82%) and the last place was the Czech Republic (78%).

Business owners and managers declared a relatively high level of optimism in area of financial management. In the Czech and Slovak Republics, firms' optimism is lower. In Poland and Hungary, it reaches extreme values. The highest values were found in the manufacturing sector. Future research could focus on verifying these attitudes.

SMEs have shown in this empirical research that they have positive attitudes towards selected aspects of financial management. There is no doubt that the perception of financial management as an essential part of the daily managerial activities in a firm determines the increased interest in the use of financial risk management techniques. The intensity of positive attitudes of SMEs in the V4 countries can be the subject of optimistic considerations in this area and presents positive trends in the development and sustainability of these firms.

SMEs also presented a high level of trust in their ability to manage financial risks. Similar to the H1 results, we found that the results in the Czech and Slovak Republics were less optimistic than in Poland and Hungary.

SMEs demonstrated a conservative attitude when assessing the financial performance of their own firm. The rate of positive responses is lower than for previous responses. It is clear that the day-to-day business activities and the business environment in which SMEs operate determines their attitude towards this area.

SMEs' belief in the future of their own company was also assessed more carefully in all V4 countries. The best results were presented by Polish SMEs operating in manufacturing. In this sector, 94% agreed with the statement that their company will survive on the market in the next five years.

The presented results are different compared to the findings by Hudakova et al. (2018), Belas et al. (2018), Kljucnikov et al. (2016), Bilan et al. (2017), and Karadag (2015). On the other hand, the results of our empirical research follow and complement the conclusions of the study by Virglerova et al. (2016).

5. Conclusions

The aim of paper was to define important factors of financial management of SMEs and compare answers of respondent in three the most important sectors in V4 countries. The empirical research yielded some interesting findings. The results of the empirical research confirmed that SMEs in the V4 countries within the sample set of the three most important sectors have a relatively positive attitude towards selected aspects of financial management. SMEs in each country presented an understanding of the basic attributes of financial management, a correct perception of financial risk and also the ability to manage financial risks appropriately. At the same time, these firms were relatively positive about the current financial performance of their firms and showed a considerable amount of business optimism.

The best results were found in Hungary, followed by Poland, Slovakia and the Czech Republic in last place. Statistically significant differences in firms' attitudes within the most important SME business sectors were found only in Poland. The manufacturing sector was significantly more likely to agree with the statement that SMEs understand the most important aspects of financial management compared to the tourism and trade sector. At the same time, the manufacturing sector agreed significantly more with the statement that they perceive the financial performance of their firms positively compared to the trade and tourism sector. The Polish manufacturing sector was also significantly more likely to agree with the statement that their firm will survive the next five years compared to the trade and tourism sector.

This research has some limitations. The empirical research was conducted in the V4 region. Therefore, future research would need to expand the research area to more European countries. However, it can be assumed that the results of this research will contribute to a rather extensive discussion in this area.

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THE IMPACT OF DIGITAL QUALITY OF LIFE ON ARTIFICIAL INTELLIGENCE DEVELOPMENT: A CASE STUDY USING THE DQL AND AIRI INDEXES

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Abstract:

Research background: This study examines the relationship between Digital Quality of Life (DQL) and Artificial Intelligence (AI) readiness across European countries, utilizing the Digital Quality of Life (DQL) and AI Readiness Index (AIRI) as assessment tools.

Purpose of the article: The aim is to identify correlations and potential causal relationships, assessing how indicators of digital well-being, such as internet quality and e-governance, align with a nation's preparedness for AI integration. The research focuses on 39 European countries, selected for geographic diversity, economic status, and digital infrastructure, allowing for a comprehensive comparison.

Methods: Through correlation analysis and regression models, the study investigates how dimensions of DQL influence AI readiness. Findings reveal a high correlation between DQL and AIRI (0.8796), particularly with electronic governance (0.9338) and electronic infrastructure (0.8819), underscoring the importance of robust digital systems for AI adoption. Lesser but significant correlations were observed in internet quality and affordability, suggesting they contribute to digital quality but are not as directly associated with AI readiness. The regression analysis identifies key DQL dimensions (Electronic Infrastructure, Electronic Security, and Electronic Government) as significant predictors of AIRI, with an R^2 value of 0.9210, indicating high explanatory power.

Findings & Value added: These results highlight the importance of investing in digital infrastructure and cybersecurity to create an environment supportive of AI integration. The study suggests that countries with advanced digital infrastructures are better positioned for AI adoption, while those with lower DQL levels may face challenges in technological readiness. Findings emphasize the need for targeted policies to enhance DQL components, especially in regions lagging in digital advancements, to facilitate comprehensive AI integration and drive technological growth across Europe.

Keywords: digital quality of life; artificial intelligence readiness; digital infrastructure; e-government

JEL Classification: O33; O38; L86

1. Introduction

Digital quality of life (DQL) is an increasingly significant focus in today's technology-driven world, playing a crucial role in influencing a country's socio-economic environment and its capacity for innovation. This emphasis on DQL reflects a broader trend within social sciences, especially in the field of technology and development studies, where scholars highlight its growing impact on technological adoption and innovation outcomes, such as artificial intelligence (AI) advancement. According to (Silva et al., 2022) digital quality of life encompasses not only access to digital technologies but also the effectiveness of digital governance, privacy protections, and digital inclusion, all of which are fundamental for fostering an environment that supports AI development.

In examining how digital quality influences AI readiness, a recent study by Li et al. (2023) emphasizes that resistance to change can significantly impact a sector's readiness for AI, particularly in environments like the hospitality industry. This research highlights how task-oriented leadership and high-performance work systems serve as mediating and moderating factors, helping to address resistance and enhance AI readiness. While focused on a specific industry, these findings underline the importance of managing change resistance, a challenge that might also impact DQL's role in AI development at broader, societal levels. By fostering leadership and supportive systems, industries may better leverage DQL for advancing AI integration.

The goal of this study is to examine the relationship between digital quality of life and AI readiness across European countries, utilizing the DQL and AIRI indexes to assess how digital well-being indicators may align with a nation's preparedness for AI integration. Specifically, the study aims to uncover correlations and identify potential causal relationships, exploring the extent to which factors like digital infrastructure, internet connectivity, and online services contribute to AI readiness in various nations.

A deeper understanding of the relationship between digital quality and productivity has been explored in studies examining sectors like agriculture, where Soldic-Aleksic et al. (2024) demonstrate that AI adoption improves labor productivity by optimizing resources and enhancing efficiency across EU countries. Their analysis shows a positive relationship between the AI Readiness Index score and labor productivity, adding an economic perspective to the discussion of DQL.

The Digital Quality of Life (DQL) index and the Artificial Intelligence Readiness Index (AIRI) are two prominent measures employed to assess the readiness and quality of a country's digital environment and its AI infrastructure, respectively. The DQL index assesses parameters like internet affordability, electronic security, and the availability of digital government services, which contribute to an individual's experience within the digital domain. AIRI, on the other hand, measures a country's readiness to integrate AI into its economy and society, considering factors such as digital skills, technology adoption, and innovation infrastructure (2023 Digital Quality of Life Index, 2023).

Recent findings by Nzobonimpa and Savard (2023) further illustrate the complexities involved in AI adoption. They analyze how high readiness scores in AI often fail to align with responsible governance, raising critical concerns about equity, transparency, and accountability as essential components in the transition toward an AI-driven society. Their study emphasizes that true AI readiness should encompass ethical considerations, underscoring the nuanced relationship between DQL and AI development.

Recent research by Litvintseva and Karelin (2022) supports this by analyzing the impact of DQL on economic growth in Russian regions, showing that a higher digital quality of life positively influences socio-economic growth but also notes potential economic and institutional risks arising from digital transformations. Their study also emphasizes the importance of project management quality in regional digital projects, which is crucial for realizing the full benefits of DQL in economic outcomes.

Involvement of elderly populations in digital transformations has also become a pertinent focus in enhancing DQL. Barysheva et al. (2022), in a study conducted in Tomsk, highlight that while many elderly individuals show limited psychological readiness and motivation to adapt to digital technologies, their active involvement could foster inclusivity and improve digital experiences for all demographics. This is particularly important in ensuring that DQL benefits are shared across age groups, thus creating a robust digital society that supports AI advancements and broader socio-economic goals.

Moreover, Holden and Harsh (2024) analyze the socio-political impacts of data infrastructures in Africa, examining the complexities surrounding AI readiness, particularly within the labor sectors involved in AI data annotation. Their work underscores the historical and political contingencies that influence the DQL and AI infrastructure, contributing valuable insights into regional disparities in digital transformations.

Studies suggest that countries with high DQL scores typically provide fertile ground for AI development, as their environments support secure, accessible, and inclusive digital experiences. Kosasi et al. (2023) reinforce this by analyzing the relationship between digital AI technology and quality of life, using the UTAUT model to study Performance Expectancy, Effort Expectancy, and Use Behavior. Their findings indicate that digital AI has a strong influence on quality of life and underscores the need for policies enhancing both digital literacy and technological inclusivity, which may stimulate AI innovation.

In recent research, Mohamed et al. (2024) examine the role of social media in enhancing adolescents' digital life quality in the UAE, revealing significant positive impacts of social media on adolescents' DQL. Variations in social media preferences might correlate with different levels of digital experience quality, aligning with findings on DQL's influence on AI development. This suggests that digital inclusivity and accessible, engaging platforms foster higher adoption and innovation rates.

Addressing the interplay between DQL and digital security, Lebea and Leung (2024) explore risks associated with smart home devices and IoT, noting privacy concerns that may hinder broader adoption. They suggest a Smart Contracts framework for bolstering personal data protection, which may serve as a valuable model for DQL initiatives aimed at ensuring privacy and ethical data management in AI innovation.

Further research is warranted to examine how variations in digital quality impact long-term AI growth trajectories and to assess the broader socio-economic outcomes of these investments. As digital quality of life increasingly influences AI capabilities, understanding the nuances of these indices can be invaluable for policymakers aiming to enhance national competitiveness and innovation in the digital age.

2. Methodology

The presented contribution focuses on identifying the relationship between artificial intelligence readiness and digital quality of life in European countries. The AI Readiness Index and the Digital Quality of Life Index are used to examine these connections, aiming to assess

how the preparedness for AI integration aligns with indicators of digital well-being. Considering the aim of the paper, the following hypothesis was stated:

Hypothesis H1: *There is a statistically significant correlation between the rankings of European countries on the AI Readiness Index and the Digital Quality of Life Index, suggesting that higher levels of AI readiness are associated with improved digital quality of life.*

The research sample consists of 39 European countries, selected based on the availability of current data on the Artificial Intelligence Readiness Index (AIRI) and the Digital Quality of Life Index (DQL) for the year 2023. The criteria for selecting the countries include geographic diversity, economic status (developed and developing countries), and the robustness of digital infrastructure. This selection allows for a comprehensive comparison and analysis of technological readiness.

Countries such as France and Germany represent developed economies with a high level of digital infrastructure and innovative approaches in the field of AI, achieving high scores in both indices. Northern European countries, like Finland and Sweden, are characterized by innovative digital governance and internet access, contributing to their favorable evaluations. Central Europe, represented by countries such as Austria and Poland, shows varying readiness for AI and digital quality of life, with some countries striving to overcome regional disparities. Eastern European nations, including Ukraine and Bulgaria, face infrastructure challenges, but many are working to improve their digital environments. The inclusion of Balkan countries, such as North Macedonia and Albania, provides insight into the unique challenges faced by smaller nations in the realm of AI and digital skills.

To achieve the study's research goal, a correlation analysis will be conducted between various components of DQL and AIRI. This methodological approach was chosen to allow quantitative analysis of the relationship between AI readiness and digital quality of life and to identify the DQL factors most significantly influencing AIRI. By using correlation analysis, this study aims to quantify the strength and direction of associations between AI readiness and digital well-being indicators across countries.

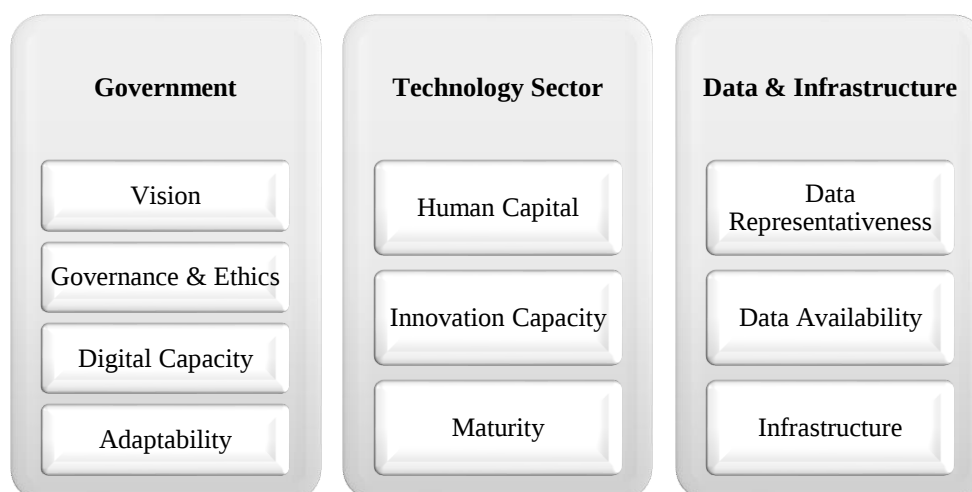
Overall, this study seeks to gain a deeper understanding of the relationship between AI readiness and digital quality of life in Europe, focusing on identifying the key factors that influence technological development in individual countries.

Two key indices were selected to explore the relationships between AI preparedness and digital well-being: the AI Readiness Index and the Digital Quality of Life Index. Each index was chosen for its recognized reliability and comprehensive methodology, providing robust insights into the technological landscape of European countries. Each index is defined by distinct methodologies and structures, providing unique insights into the technological landscape of the selected European countries.

The AI Readiness Index examines the preparedness of governments to implement artificial intelligence (AI) in the delivery of public services to citizens. The index includes 39 indicators organized into 10 dimensions, which are structured into three main pillars: Government, Technology Sector, and Data & Infrastructure (Figure 1). In 2023, the analysis was expanded to rank 193 countries, an increase from the previous 181 countries. The aim of the AI Readiness Index is to provide valuable insights for the effective and responsible integration of AI into public services. **Government Pillar** assesses the diversity and effectiveness of AI strategies across nations. Despite a decline in the overall number of AI strategies released, a significant portion of new strategies is now originating from low- and lower-middle-income countries, underscoring the growing recognition of AI's potential. **Technology Sector Pillar** highlights disparities in AI capabilities between high-income and middle-income countries. High-income nations consistently outperform their lower-income counterparts, although several middle-

income economies, such as Malaysia, demonstrate exceptional performance, placing them among the top 50 countries globally. **Data & Infrastructure Pillar** reveals ongoing challenges related to the digital divide. While generative AI presents opportunities for lower-income nations, inadequate data and infrastructure can lead to reliance on foreign technologies, complicating efforts to address local needs. Strengthening these areas is crucial for ensuring equitable access to the benefits of AI (AI Readiness Index – Oxford Insights, 2024)

Figure 1: Pillars and dimensions of Government AI Readiness Index



Source: own processing

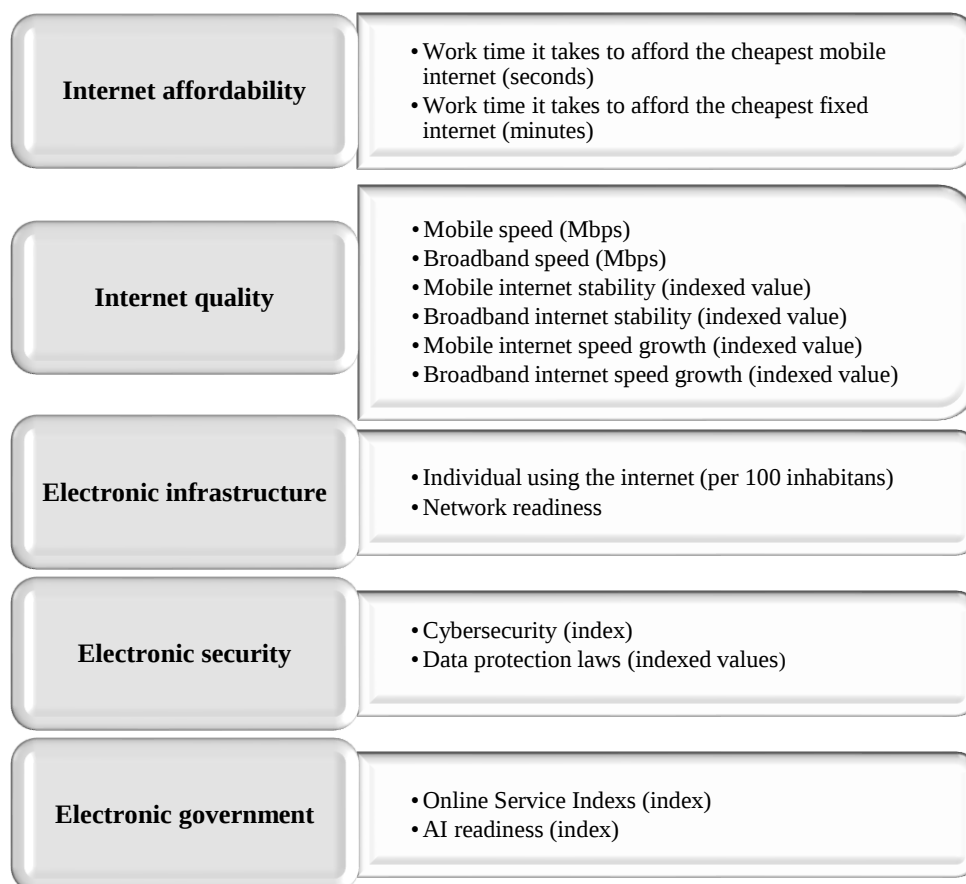
The Digital Quality of Life (DQL) Index offers insightful analysis of the factors affecting digital well-being across 121 countries. This index uniquely assesses a nation's digital quality of life through five fundamental pillars: internet affordability, internet quality, electronic infrastructure, electronic security, and electronic government (2023 Digital Quality of Life Index, 2023).

Internet affordability is a critical determinant, reflecting the amount of labor time individuals must invest to obtain reliable internet access. A lower affordability index correlates with improved digital well-being, whereas elevated costs can impede access to necessary digital resources. Internet quality, characterized by connectivity speed and stability, profoundly influences daily activities and work productivity. A higher quality of internet connectivity facilitates better communication and enhances the overall user experience. Electronic infrastructure plays an essential role in enabling daily internet usage across various domains, including education, e-commerce, and banking. A well-developed electronic infrastructure ensures that individuals can effectively engage in these activities. Electronic security evaluates the safety of online interactions and a country's readiness to counter cyber threats, thereby safeguarding user privacy and data integrity. E-government effectiveness is critical in minimizing bureaucratic hurdles and promoting transparency within public services, which ultimately enhances service efficiency and improves the overall quality of life for citizens. Collectively, these five pillars encompass 14 specific indicators (Figure 2), providing a comprehensive assessment of the overall digital quality of life in each country (2023 Digital Quality of Life Index, 2023).

The statistical programs Statistica and Gretl were used to process the research results, with methodology focusing on Pearson's correlation test and multiple regression analysis (OLS). This approach was designed to identify the relationship between artificial intelligence readiness and digital quality of life in European countries. To examine these connections, the AI

Readiness Index and the Digital Quality of Life Index were utilized, with the goal of assessing how preparedness for AI integration aligns with indicators of digital well-being.

Figure 2: Pillars and indicators of DQL Index



Source: own processing

3. Results

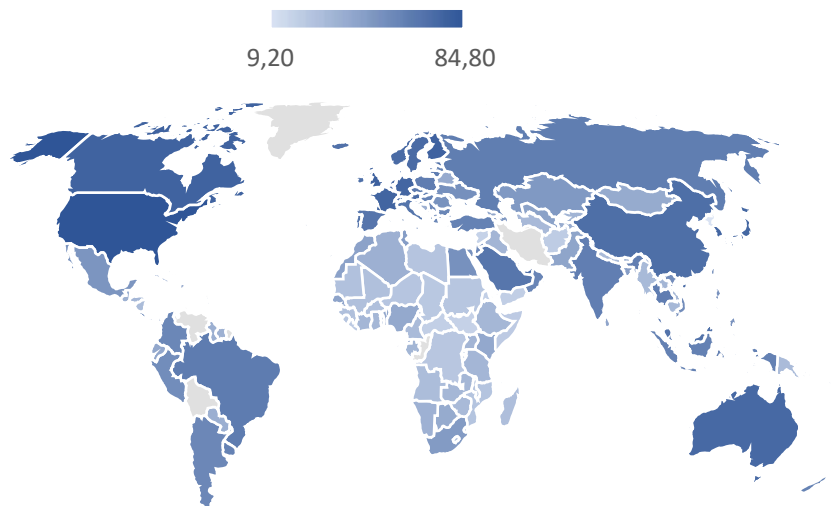
Figure 3 presents the Government AI Readiness Index values for all countries included in the analysis. The darker the color on the map, the higher the index score, indicating better preparedness for implementing and utilizing artificial intelligence. The highest-rated countries globally include the USA, Singapore, the United Kingdom, Finland, Canada, and France, while countries with the lowest scores include North Korea and Syria. For detailed information on individual rankings of European countries, refer to the notes provided below the figure.

The highest ratings among European countries were achieved by the United Kingdom (78.57), Finland (77.37), and France (76.07), indicating advanced readiness for AI integration within governmental structures and placing them as leaders in AI preparedness. Conversely, lower-rated countries include Albania (43.26), Moldova (42.97), Belarus (39.20), and Bosnia and Herzegovina (36.49), highlighting potential challenges related to technological development and the availability of skilled workers.

According to Lavrinenko et al. (2023), weaker rankings for certain countries may result from insufficient technological infrastructure and low levels of digitalization. The authors also highlight obstacles related to a lack of qualified personnel and regulatory environments, which often hinder AI development.

In the following Figure 4, the values of the Digital Quality of Life Index (DQL) are illustrated for all monitored countries around the world. The DQL indicator reflects the quality of life in terms of the availability and quality of internet services, electronic infrastructure,

Figure 3: Government AI Readiness Index – World map

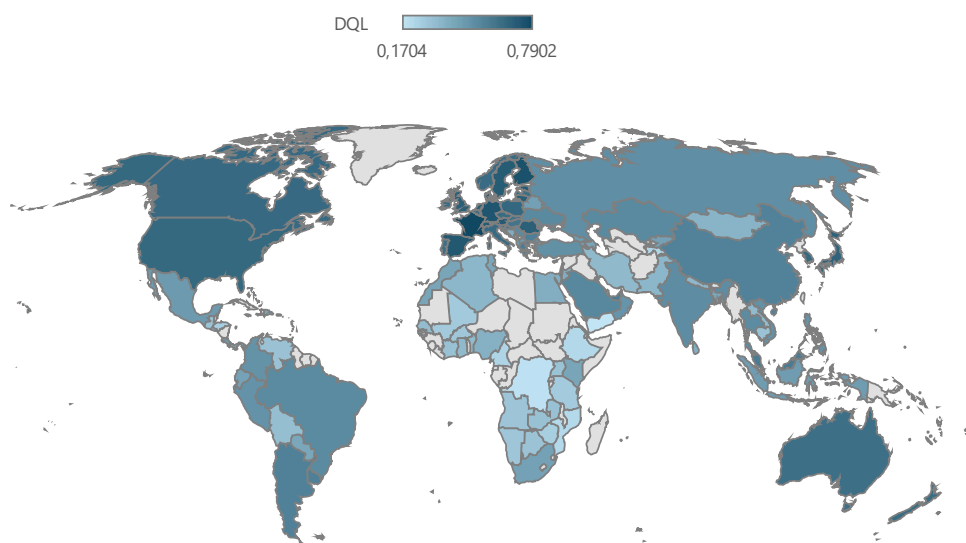


Note: Country rankings: 3rd United Kingdom, 4th Finland, 6th France, 8th Germany, 10th Netherlands, 11th Denmark, 13th Norway, 14th Sweden, 15th Austria, 17th Estonia, 20th Ireland, 22nd Luxembourg, 24th Switzerland, 25th Portugal, 26th Italy, 27th Spain, 28th Belgium, 31st Czech Republic, 33rd Malta, 35th Lithuania, 36th Poland, 39th Slovenia, 43rd Cyprus, 44th Slovakia, 45th Hungary, 48th Latvia, 51st Bulgaria, 52nd Greece, 57th Serbia, 60th Ukraine, 64th Romania, 70th Croatia, 78th Montenegro, 83rd North Macedonia, 89th Albania, 90th Moldova, 99th Georgia, 107th Belarus, 117th Bosnia and Herzegovina

Source: own processing according to AI Readiness Index – Oxford Insights (2024)

security, and e-government. The higher the DQL, the better the conditions for digital life in that country.

Figure 4: Digital Quality of Life Index – World map



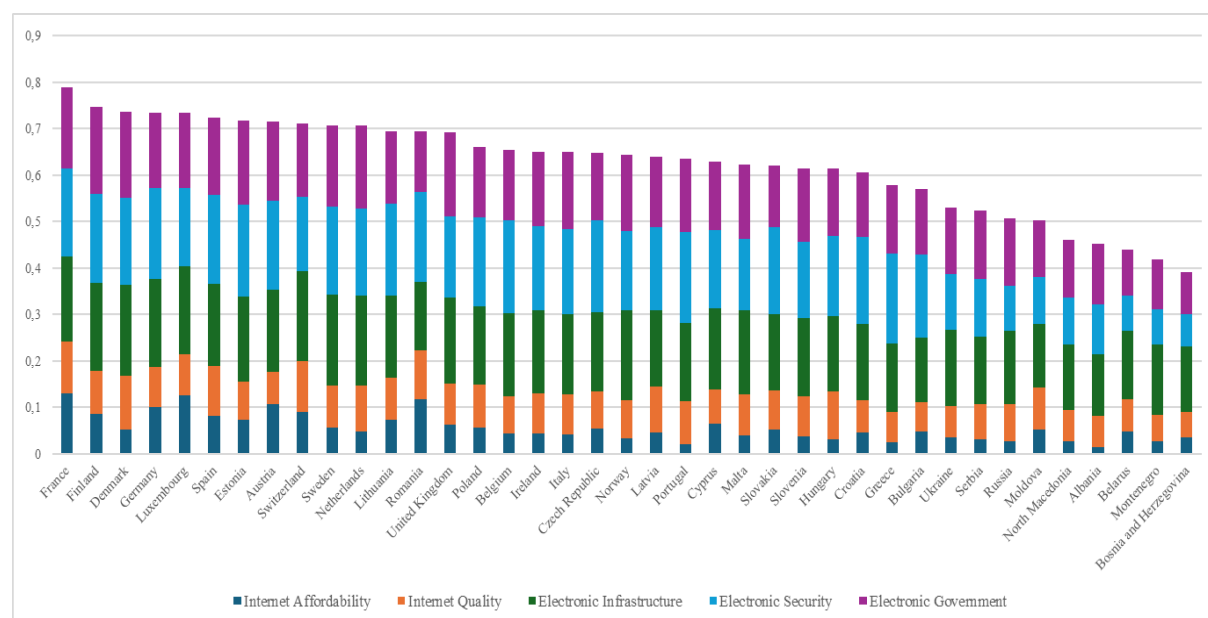
Source: own processing according to 2023 Digital Quality of Life Index (2023)

Among the countries with the highest DQL values is France, which achieved a score of 0.7902, ranking first in both Europe and all monitored countries worldwide. Following closely

are Finland (0.7482) and Denmark (0.7377), which demonstrate a high level of internet availability and quality, as well as developed electronic services and security systems. The top of the ranking is predominantly occupied by European countries, which exhibit a high quality of digital services, infrastructure, and accessibility. Among all monitored countries, European nations occupy the top 10 positions, with non-European countries appearing only at 11th place (Singapore), 16th and 17th places (Japan and Israel), and 20th (USA). At the lower end of the list, where values drop below 0.5, countries such as India and Russia are found, whose scores indicate challenges in digital accessibility and infrastructure. Among European countries with the lowest values are Bosnia and Herzegovina (0.3906), Montenegro (0.4199), Belarus (0.4407), Albania (0.4524), and North Macedonia (0.4614). These countries exhibit inadequate quality of electronic infrastructure and security. At the very bottom of the global ranking are countries like the Democratic Republic of Congo (DQL: 0.1825) and Yemen (DQL: 0.1704), where digital infrastructure and quality of life in the digital space face significant limitations.

Figure 5 present a comparison of the observed European countries in the Digital Quality of Life Index and its pillars.

Figure 5: DQL index and pillars - ranking



Source: own processing

In Western Europe, besides France, countries such as Germany (0.7357), the Netherlands (0.7064), and Sweden (0.7079) achieve the best values. These countries benefit from a high level of internet quality, electronic security, and the availability of public electronic services, thereby strengthening their digital competitiveness.

Conversely, Central and Eastern European countries, such as Hungary (0.6148), Slovakia (0.6217), and Poland (0.6614), achieve lower values compared to Western European countries, indicating the need for further development of digital infrastructure and security measures.

The graphical representation of the ratings of individual DQL pillars (Internet accessibility, internet quality, electronic infrastructure, security, and e-government) provides a more detailed view of the digital challenges and successes. For instance, the United Kingdom and Finland achieve above-average values in electronic infrastructure and internet quality, while countries such as Moldova and Serbia exhibit noticeable gaps in electronic security.

This analysis highlights significant disparities among various European regions, with Western European countries showing markedly higher DQL values than those in Eastern Europe and the Balkans.

Based on the evaluation of the graphical results, it is evident that there are significant differences in the readiness of countries for the integration of artificial intelligence and the quality of digital life in Europe. For instance, countries like France and Germany, characterized by developed economies and a high level of digital infrastructure, achieve high ratings in both indices. Conversely, countries such as Ukraine and Bulgaria face challenges related to infrastructure, but many of them are working to improve their digital environments. This raises the question of the extent to which readiness for artificial intelligence is connected to the quality of digital life.

The aim of this analysis is to investigate the relationship between the AI Readiness Index and the Digital Quality of Life Index in European countries. Based on the information presented, we have established the hypothesis H1: There is a statistically significant correlation between the rankings of European countries on the AI Readiness Index and the Digital Quality of Life Index, suggesting that higher levels of AI readiness are associated with improved digital quality of life.

To verify the existence of a statistically significant relationship between the values of the AI Readiness Index (AIRI) and the Digital Quality of Life Index (DQL) of the surveyed European countries, we employ the Pearson correlation coefficient and linear regression analysis. The resulting correlation coefficients, presented in the correlation matrix (Table 1) and in Figure 6, illustrate the strength and direction of the relationship between these two indices.

Table 1: Correlation matrix

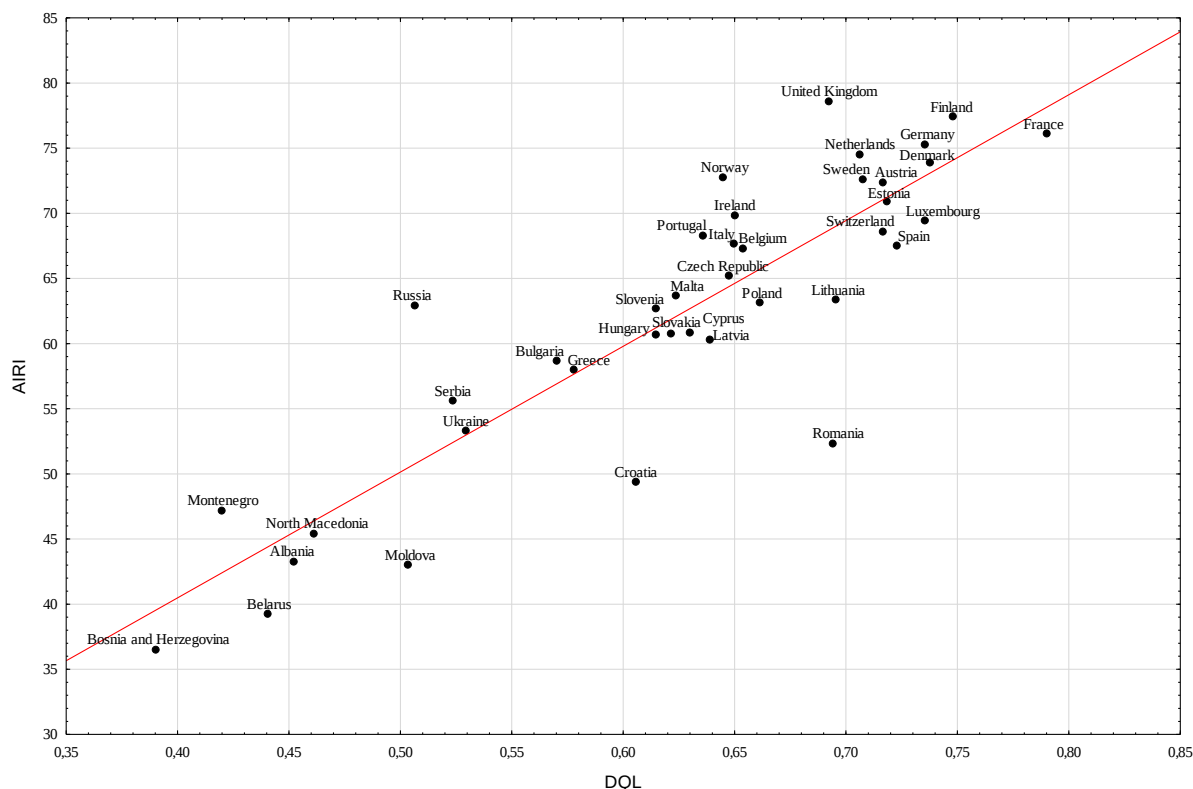
	DQL	Internet Affordability	Internet Quality	Electronic Infrastructure	Electronic Security	Electronic Government
AIRI	0.8796	0.4388	0.5861	0.8819	0.7487	0.9338
Government	0.7798	0.3268	0.5250	0.7582	0.6839	0.8967
Technology Sector	0.7989	0.4209	0.5274	0.8570	0.6499	0.8226
Data and Infrastructure	0.8580	0.5078	0.5681	0.8369	0.7302	0.8230
Vision	0.6335	0.2054	0.3822	0.5737	0.6470	0.7190
Governance and Ethics	0.6994	0.3066	0.5661	0.7398	0.5349	0.7985
Digital Capacity	0.7563	0.4429	0.5353	0.7218	0.5542	0.8877
Adaptability	0.6352	0.3621	0.4487	0.7271	0.4029	0.7593
Maturity	0.7723	0.4418	0.4921	0.8206	0.6413	0.7473
Innovation Capacity	0.8034	0.4540	0.4968	0.8862	0.6247	0.8379
Human Capital	0.6624	0.2690	0.5025	0.6860	0.5639	0.7201
Infrastructure	0.8506	0.5088	0.5944	0.8298	0.7387	0.7638
Data Availability	0.6802	0.3620	0.4555	0.6496	0.5774	0.7139
Data Representativeness	0.6842	0.4421	0.3889	0.6830	0.5564	0.6816

Source: own processing in Statistica

The correlation coefficient between AIRI and DQL is notably high at 0.8796, indicating a strong positive relationship. It is important to note that all highlighted values in bold are statistically significant at the alpha level of 0.05. This suggests that countries with greater readiness for artificial intelligence tend to exhibit better digital quality of life. Specifically, the highest correlations within the DQL dimensions are seen in Electronic Government (0.9338) and Electronic Infrastructure (0.8819), demonstrating that robust digital governance and infrastructure are closely linked with AI readiness. Additionally, dimensions such as Internet Quality (0.5861) and Internet Affordability (0.4388) also show positive correlations, although they are comparatively weaker, indicating that while these factors contribute to digital quality, they are not as directly associated with AI readiness.

The color scale of the correlation coefficients indicates that the darker the green, the stronger the correlation, while lighter colors approach a correlation coefficient of 0. A medium level of correlation, approximately 0.5, is represented in yellow. Conversely, the lower correlations between certain dimensions—such as Vision (0.6335) and Governance and Ethics (0.6994)—

Figure 6: Correlation between the AI Readiness Index and the Digital Quality of Life Index



Source: own processing in Statistica

imply that while they still relate to AI readiness, they may not play as crucial a role in influencing digital living conditions. This analysis aims to assess the extent to which improvements in AI readiness align with enhancements in digital quality of life. Thus, if a country exhibits a high AIRI, it is likely to also possess a high DQL, indicating a comprehensive digital environment that supports technological integration. In contrast, if a country shows low values in both indices, it suggests that challenges in technological readiness may be coupled with poor digital living conditions, limiting overall progress.

To verify the significance of each correlation coefficient, we decided to use a linear regression model. Table 2 presents the resulting characteristics. The results in Table 2 confirm the hypothesis H1 of the existence of statistically significant relationships between the AI Readiness Index (AIRI) and the Digital Quality of Life Index (DQL) and its dimensions for the surveyed European countries.

In this analysis, DQL is treated as the independent variable, while AIRI serves as the dependent variable. The objective of the regression analysis is to determine which factors within the DQL framework most significantly influence AI readiness. Key factors to be examined include Internet Affordability, Internet Quality, Electronic Infrastructure, Electronic Security, and Electronic Government, as these elements are likely to be critical in shaping a country's ability to integrate and benefit from artificial intelligence.

The findings presented in Table 2 indicate that the dimensions of the Digital Quality of Life Index (DQL) significantly influence the AI Readiness Index (AIRI). Each regression model

assesses the impact of DQL and its five pillars—Internet Affordability (IA), Internet Quality (IQ), Electronic Infrastructure (EI), Electronic Security (ES), and Electronic Government (EG)—on AI readiness.

Table 2: Estimation of regression models

Dependent variable	Independent variable	Const. α	Coefficient	p-value	R ²	White's test for heteroscedasticity
AIRI	DQL	1.8723	96.5345	0.0000	0.7738	0.8252
AIRI	Internet Affordability (IA)	52.8857	166.0680	0.0052	0.1926	0.8465
AIRI	Internet Quality (IQ)	25.5046	433.8860	0.0000	0.3435	0.8596
AIRI	Electronic Infrastructure (EI)	-27.3102	530.1680	0.0000	0.7778	0.0543
AIRI	Electronic Security (ES)	28.0480	208.6050	0.0000	0.56054	0.8635
AIRI	Electronic Government (EG)	-7.1506	458.4820	0.0000	0.8719	0.1866

Note: In the last column, we present the p-values of the performed White's test for heteroscedasticity with null hypothesis: heteroscedasticity not present.

Source: own processing

The analysis reveals a positive relationship between AIRI and each independent variable, suggesting that improvements in these dimensions enhance a country's readiness for artificial intelligence. Notably, the coefficient values for Internet Quality and Electronic Infrastructure highlight their critical roles in promoting greater digital engagement and facilitating AI adoption. As internet quality improves, it enables better access to information and services, which are essential for leveraging AI technologies. Moreover, the positive coefficients for Electronic Security and Electronic Government indicate that a robust digital environment characterized by effective and secure online services instills confidence in AI implementation. The statistical significance of these variables reinforces the notion that countries with stronger DQL dimensions are more likely to exhibit higher AI readiness.

Overall, these results underscore the importance of investing in digital infrastructure, security, and governance to foster an environment conducive to AI integration, ultimately supporting the development of more advanced digital economies.

The resulting regression model, which includes all dimensions of DQL, is represented as follows:

$$AIRI = -18,9056 + 13,4698IA - 24,3329IQ + 203,911EI + 35,7062ES + 278,503EG \quad (1)$$

Here, Internet Affordability (IA) and Internet Quality (IQ) do not exhibit statistical significance in influencing AIRI, as indicated by their respective p-values. Conversely, Electronic Infrastructure (EI), Electronic Security (ES), and Electronic Government (EG) show significant relationships with AIRI, supporting their importance in shaping a country's readiness for AI. The model has an R² value of 0.9210, indicating a strong explanatory power.

Moreover, the results from White's test for heteroscedasticity suggest that heteroscedasticity is not present, reinforcing the reliability of the regression analysis. These findings highlight that while the dimensions of Electronic Infrastructure, Electronic Security, and Electronic Government are crucial for enhancing AI readiness, Internet Affordability and Internet Quality may require further investigation to understand their roles better within the context of digital quality and AI integration.

4. Discussion

The findings of this study underscore the critical relationship between Digital Quality of Life (DQL) and the readiness of countries to embrace artificial intelligence (AI), as measured by the AI Readiness Index (AIRI). The strong positive correlations identified between various

dimensions of DQL, such as internet quality, electronic safety, e-governance, and electronic infrastructure, and AIRI highlight the fundamental role that digital living conditions play in determining a country's preparedness for AI adoption. This insight aligns with existing literature that posits a robust digital ecosystem as a prerequisite for technological advancement (Sui et al., 2024). According to Bruneckiene et al. (2021), competitiveness is one of the essential factors influencing the level of economic development. Moreover, recent research indicates that the integration of financial technologies, or FinTech, enhances access to digital services, further contributing to the improvement of DQL and fostering an environment ripe for AI development (Kwilinski, 2023).

Furthermore, the regression analysis further elucidates how specific elements of DQL directly influence AI readiness. For instance, the results indicate that improvements in internet quality and electronic safety are particularly significant predictors of a country's capacity to integrate AI technologies. These findings suggest that policymakers should prioritize investments in digital infrastructure and cybersecurity measures as a means to foster an environment conducive to AI development. This perspective is reinforced by studies (Aduba et al., 2023; Emuron et al., 2024) showing that FinTech advancements not only increase financial accessibility but also improve the overall digital infrastructure, which is crucial for AI integration. The notable disparity between countries with high DQL and those with lower values points to an urgent need for targeted interventions in regions lagging in digital advancements (Martincevic, 2022).

Additionally, the study reveals that enhancing e-governance and electronic infrastructure not only boosts the DQL but also creates a fertile ground for innovation and technological growth. This is significant as it implies that efforts to improve digital quality can have a multiplicative effect on a country's overall development trajectory. Investments in FinTech, particularly in emerging markets, are vital for bridging these gaps and facilitating comprehensive digital transformation (Hewage et al., 2024). Countries that invest in these areas are likely to see accelerated advancements in AI capabilities, ultimately leading to enhanced competitiveness on a global scale (Jencova et al., 2023).

In light of these findings, it becomes clear that a multifaceted approach is required to tackle the challenges faced by nations with lower DQL. Collaborative efforts among governments, private sectors, and international organizations are essential to share best practices and resources. This collaboration could help bridge the digital divide, enabling more countries to engage in AI development effectively.

5. Conclusions

This study highlights the crucial interplay between Digital Quality of Life (DQL) and artificial intelligence readiness (AIRI), revealing that higher DQL scores correspond to increased readiness for AI integration. The strong correlations and significant regression outcomes emphasize that investments in digital infrastructure, internet quality, and electronic safety are vital for countries aiming to enhance their AI capabilities.

However, this research is not without limitations. The study's reliance on existing indices may overlook localized factors that influence DQL and AIRI, such as cultural, economic, and regulatory environments. Furthermore, the dynamic nature of technology means that these findings may evolve as new developments in AI and digital technology emerge.

Future research should seek to explore the nuances of this relationship further, perhaps by conducting case studies on specific countries or regions to understand better how localized

efforts can impact DQL and AIRI. Additionally, longitudinal studies could provide insights into how changes in digital quality over time influence AI readiness.

In summary, while this study sheds light on significant trends and correlations, it also emphasizes the need for continued investigation into the barriers hindering digital advancement, particularly in developing countries. By addressing these challenges, nations can position themselves better to leverage the transformative potential of AI. These findings are consistent with previous research indicating that digital transformation plays a key role in enhancing the competitiveness of countries.

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Data Availability Statement: The data presented in this study are openly available in: <https://surfshark.com/dql2023> and <https://oxfordinsights.com/ai-readiness/ai-readiness-index/>

Conflicts of Interest: The authors declare no conflict of interest.

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RELATIONSHIP BETWEEN PROFITABILITY AND DEBT: THE CASE OF THE SLOVAK ENERGY AND MINING SECTOR

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Abstract:

Research background: Knowing the financial situation of companies and the entire sector is very important in an increasingly competitive environment. Financial indicators are used to assess the financial situation, and it is important to examine the relationships between them. Managers can use this information for better decision-making and thus improve their position in the market.

Purpose of the article: The paper deals with modelling the relationship between profitability and debt of companies in the Energy and Mining sector of the Slovak Republic. The aim of this paper is to examine the relationship between return on equity and total indebtedness of companies in the Energy and Mining sector of the Slovak Republic.

Methods: A nonlinear regression model and a threshold regression model with one and two threshold values are used to model the relationship between profitability and debt. The models are used on the data of 1,219 companies from the Energy and Mining sector in the Slovak Republic for the year 2020. The analysis is focused on the year 2020, when the entire world was plagued by the COVID-19 pandemic and other negative events (price increases) appeared that had an impact on the sector. In the case of marginal models, total indebtedness is used as a threshold variable and total indebtedness, Debt/EBITDA, profit margin, EBITDA margin, Net Debt/EBITDA are used as mode variables.

Findings & Value added: We have shown the nonlinear relationship between return on equity and total indebtedness. Knowing the relationship between financial indicators allows for more effective business management. It can be used to optimize the debt policy of the company in the industry.

Keywords: energy and mining sector; modelling; profitability; debt

JEL Classification: C24; G32

1. Introduction

Slovak industry in 2020 was marked by resistance to the corona crisis. The year 2021 also tested its resilience to influences that do not have a direct impact, when energy and input prices

rose significantly in the second half of the year. In general, however, this year was an alternation of good and bad performance across all areas of industry. Until the next period, the industry in Slovakia has quite several obstacles that individual segments will have to deal with. High energy prices without government support will shut down and dampen more and more production in the country.

In 2020, the least construction raw materials were extracted in Slovakia since 2008. However, the entire segment is suffering from unfavorable market conditions. As many as seven of the ten largest mining companies in the Slovakia in 2020 showed a decline in sales. While in 2019 almost 30 thousand kilotons of raw materials were extracted in Slovakia, in 2020 it was almost a third less. The amount of coal and lignite mined fell by as much as a third year-on-year in 2020, to around one million tons. The planned volume of mining for 2021 and 2022 is at the level of 1.1 million tons (Mato, 2021a).

The growth trend of electricity production continued in 2020, but at a slower pace than in 2019. A total of 29 terawatt-hours (TWh) of electricity were produced in Slovakia in 2020, which is an increase of approximately one percent compared to 2019. As in previous years, the largest volume of electricity was produced from nuclear fuel (53.2 percent). Fossil fuels continued to account for the second largest share of electricity production (21.5 percent). While electricity production from natural gas increased by about a fifth in 2020, the share of coal and heavy fuel oil in production continued to decline. In 2020, a new type of fuel was introduced - liquids obtained from biomass, which accounted for almost a fifth of electricity production from renewable sources. They thus ranked as traditional green resources such as biomass, photovoltaics, and biogas. The total share of renewable sources in electricity production in 2020 was eight percent. The dominant electricity producer Slovenske elektrarne and its subsidiaries were able to report earnings before interest, taxes, depreciation, and amortization (EBITDA) of 363 million euros in 2020. By comparison, in 2019 it was 342 million euros. Net consolidated profit rose to 60 million euros from 23 million in 2019 (Mato, 2021b).

In contrast to electricity, the consumption of natural gas in Slovakia in 2020 increased slightly and reached a total of 52.1 TWh. However, the volume of natural gas transport decreased significantly in 2020. The level of 57 billion cubic meters is more than seventeen percent lower than in 2019, but at the same time closer to the average of previous years. 8.4 percent of this volume went to Slovak consumers. For the monopoly natural gas carrier in Slovakia, Eustream, revenues from the sale of services reached 748 million euros in 2020, which is six percent less year-on-year. The largest gas company Slovensky plynarensky priemysel (SPP) achieved the best economic result in history. Revenues from the sale of products and services reached 1.2 billion euros in 2020, which is an increase of 88 million compared to the previous year. The company's operating profit reached 6.6 million euros, while in 2019, state gas companies made a loss of 104 million euros (Mato, 2021b).

The total heat supply in 2020 amounted to approximately 14.3 terawatt-hours (TWh), which was a year-on-year decrease of almost three percent. Of the total heat supply, 32.5 percent was used for heating and domestic hot water in households. The consumption of the average Slovak household amounted to 6.2 gigawatt-hours (GWh), which is two percent more than in 2019. The average household's annual costs for heat and hot water amounted to 625 euros, which was an increase of 3.8 percent. In terms of fuels, up to 52 percent of heat was produced by burning natural gas. Renewable sources accounted for 16 percent of the total heat supply (Mato, 2021c).

Based on data from the Statistical Office of the Slovak Republic, companies with 20 or more employees engaged in the supply of electricity, gas, and steam in 2020 achieved total sales of 12,053 million euros. Value added in this sector in 2020 was 2,747 million euros and earnings before tax (EBT) were 872 million euros. Companies with 20 or more employees engaged in

water collection, treatment, and supply in 2020 achieved revenues of 521 million euros. The value added in this sector in 2020 was 315 million euros and earnings before tax were 5 million euros.

Energy and mining sector is crucial for every economy, so this sector has been the subject of several studies, for example Horvathova et al. (2021), Melnychenko (2021), Stefko et al. (2021), Trzaska et al. (2021), Eljuri and Johnston (2014), Ghosh (2007) and Ogulata (2003).

At present, we can see increase in energy prices. The Energy and Mining sector is very important for households as well as for other industries. High energy prices without government support will shut down and dampen more and more production in the country. The corona crisis has also led to a decline in production, sales and profits in many sectors. For this reason, it is important to identify, assess and predict the financial situation in the Energy and Mining sector.

The paper deals with modelling the relationship between profitability and debt of companies in the Energy and Mining sector of the Slovak Republic. The aim of this paper is to examine the relationship between return on equity and total indebtedness of companies in the Energy and Mining sector of the Slovak Republic. A nonlinear regression model and a threshold regression model with one and two threshold values are used to model the relationship between profitability and debt. Table 1 provides an overview of the authors who dealt with the various effects of debt on profitability, while Table 2 provides an overview of studies in which a threshold and nonlinear regression models were used.

Table 1: Relationship between debt and profitability

Effect of debt on profitability	Author(s)
Negative effect	Zeitun and Tian (2007), King and Santor (2008), Pouraghajan and Malekian (2012), Olokoyo (2013), Mireku et al. (2014)
Positive effect	Ramachandran and Candasamy (2011), Goyal (2013)
Nonlinear effect	Wald (1999), Fama and French (2002), Berger and Bonaccorsi (2006), Margaritis and Psillaki (2007), Cheng et al. (2010), Ramadan and Aloqdeh (2011), Fozia et al. (2011), Kebewar (2012)

Source: own processing

Table 2: Use of threshold and nonlinear regression models

Author(s)	Object of study
Threshold regression models	
Samia et al. (2007)	plague outbreaks
Rezaei et al. (2019)	purchasing power parities in Iran using data on the US dollar, the British pound and the Japanese yen, which relate to the period 2001-2016.
Khemiri and Noubbigh (2020)	the relationship of the debt company regarding the size of the company in the period 2006-2016 in the countries of the sub-Saharan five
Wang and Wang (2021)	the non-linear effects of population aging on carbon emissions using data from 2002-2012 from 137 countries or regions
Nonlinear regression models	
Haug and Basher (2007)	long-run PPP using monthly data from the post-Bretton Woods era for G-10 countries
Sanchez-Vargas et al. (2013)	relationship between environmental regulation and manufacturing productivity in Mexico using a data set at the plant level
Omid and Jamil (2017)	the influence of inflation and operating cycle on the level of cash holding in 132 firms in the Tehran Stock exchange from 2007 to 2014
Ashrafi (2019)	how institutional investors and different types of them influence the firms' capital structure using a data including 240 the main market Iranian firms from 2012 to 2016

Source: own processing

2. Methodology

The paper deals with modelling the relationship between profitability and debt of companies in the Energy and Mining sector of the Slovak Republic. The aim of this paper is to examine

the relationship between return on equity and total indebtedness of companies in the Energy and Mining sector of the Slovak Republic. We can formulate hypothesis H1 as follows:

H1: There are statistically significant threshold values of the total indebtedness variable in the relationship between the financial indicators and return on equity of non-financial corporations in the energy and mining sector of the Slovak Republic.

2.1. Research sample

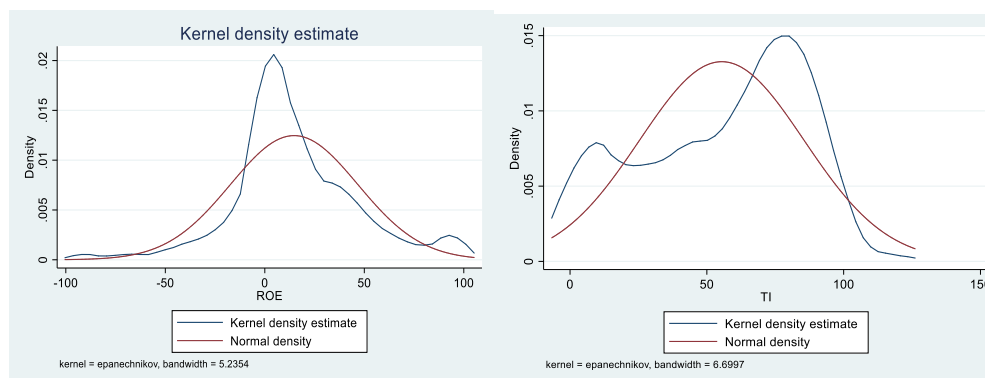
In the original database, the financial ratios of 1,520 Slovak companies in the energy and mining sector were included for the year 2020. The state indicators were obtained from the Financial Statements of the Slovak Republic and were calculated based on absolute indicators.

The energy and mining industry includes SK NACE 05 – Coal and lignite mining, SK NACE 06 – Oil and gas extraction, SK NACE 07 – Mining of metal ores, SK NACE 08 – Other mining and quarrying, SK NACE 09 – Auxiliary mining activities, SK NACE 35 - Supply of electricity, gas, steam and cold air, SK NACE 36 – Water collection, treatment and supply, SK NACE 37 – Wastewater treatment and disposal and SK NACE 38 – Collection, treatment and disposal of waste, recycling of materials.

The econometric software Stata 15.1 modules were used in the processing of this database: Kernel density estimation, Nonlinear regression and Threshold models. The financial ratios return on equity (ROE), total indebtedness (TI), Debt/EBITDA, profit margin, EBITDA Margin, Net Debt/EBITDA were used.

After omitting companies that did not have complete data (ROE, TI), 1,219 companies remained. As there were also outliers in the values of the indicators, the selection of enterprises according to the boundaries for ROE (-100; 100) and TI (0; 120) was narrowed. The omission of companies outside these limits meant that the number of companies analysed was reduced to 1,075. Kernel density estimation (Cox, 2005) was used for further data analysis. The representation of the Kernel density estimation for ROE and TI in the examined group is shown in Figure 1.

Figure 1: Kernel density estimation for ROE and TI



Source: own processing

The Kernel density estimate of ROE is far spicier than the normal distribution. The Kernel density estimate of TI has a considerably asymmetric shape with a mode slightly less than 100. The statistical parameters of the variables ROE and TI in the energy and mining sector are given in Table 3.

Table 3: Summary statistics for ROE and TI

Indicator	Observations	Mean	Std. dev.	Min	Max
ROE	1,075	15.64	31.95	-95.21	100.00
TI	1,075	55.46	30.06	0.00	119.44

Source: own processing

2.2. Nonlinear Regression Model

In the first step, we will use a nonlinear regression with a linear term and the square of the variable TI in the form:

$$ROE = cons + a.TI + b.TI^2 \quad (1)$$

2.3. Threshold Regression Model with Threshold and Mode Variable Total Indebtedness

We will use a threshold model (Stata, 2017) in which TI is a threshold and a mode variable:

$$ROE = (TI.\delta_1 + cons_1)I(-\infty < TI \leq \gamma) + (TI.\delta_2 + cons_2)I(\gamma < TI < \infty) + \varepsilon_t \quad (2)$$

where I is an indicator variable

ε_t is an IID error with mean value 0 and variance σ^2

$\delta_1, cons_1, \delta_2, cons_2, \gamma$ are the required model parameters

Our task is to determine the parameters $\beta, \delta_1, \delta_2$. Region 1 is defined as a subset of observations in which the value of TI is less than or equal to the threshold value γ . Similarly, Region 2 is defined as a subset of observations in which the value of TI is greater than the threshold value γ .

2.4. Threshold Regression Model with Threshold and Mode Variable Total Indebtedness and Other Mode Variables

To the ROE and TI indicators analysed so far, we have added other indicators: Debt/EBITDA, profit margin, EBITDA Margin, Net Debt/EBITDA.

After omitting companies where the values of indicators were missing, we were left with 605 companies. Following the analysis of Kernel density estimation, the following limits of indicators were determined: ROE (-100; 100), TI (0; 120), Debt/EBITDA (-25; 25), profit margin (-50; 100), EBITDA Margin (-50; 100) and Net Debt/EBITDA (-25; 25).

Therefore, other companies were omitted. The final state of the analysed companies is 466. Kernel density estimation for indicators with these limits is given in Figure 2.

The main statistical parameters of the variables ROE, TI, Debt/EBITDA, profit margin, EBITDA Margin, Net Debt/EBITDA in the Energy and Mining sector are shown in Table 4.

Table 4: Summary statistics for ROE, TI, Debt/EBITDA, profit margin, EBITDA Margin, Net Debt/EBITDA

Indicator	Observations	Mean	Std. dev.	Min	Max
ROE	466	17.298	29.695	-95.210	98.961
TI	466	65.590	22.176	1.586	116.49
Debt/EBITDA	466	2.655	3.151	-5.818	23.733
Profit margin	466	11.321	16.568	-48.865	59.717
EBITDA Margin	466	43.885	31.357	-40.758	109.397
Net Debt/EBITDA	466	1.5814	3.294	-17.582	21.227

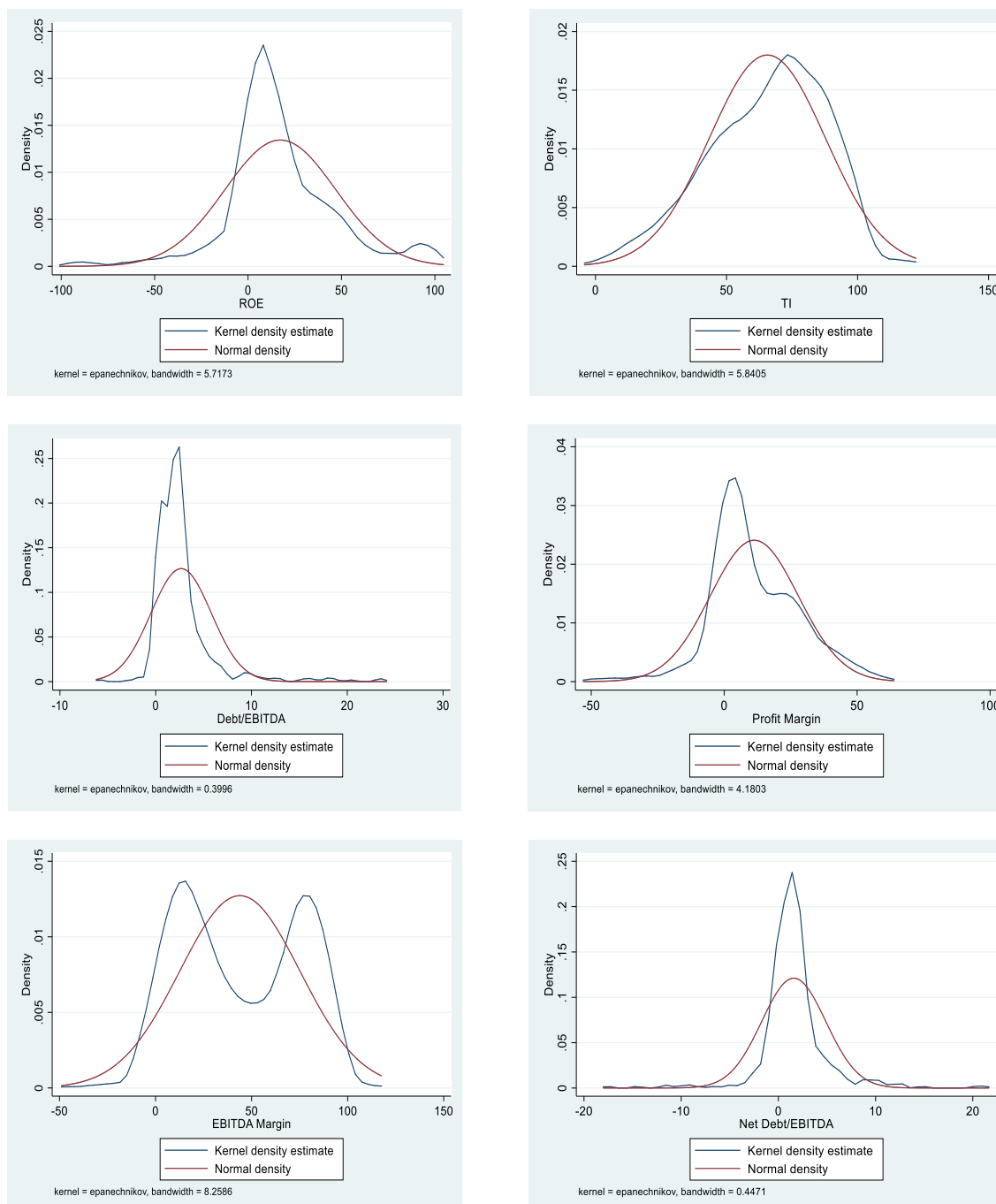
Source: own processing

3. Results

3.1. Nonlinear Regression Model

Estimates of nonlinear regression model coefficients and their significance and standardized coefficients (β) are given in Table 5.

Figure 2: Kernel density estimation for ROE, TI, Debt/EBITDA, Profit margin, EBITDA margin, Net Debt/EBITDA



Source: own processing

Table 5: Nonlinear regression model

ROE	Coef.	Std. Err.	t	P> t	β
TI	0.443993	0.1206719	3.68	0.000	0.4178
TI ²	-0.00296	0.0011697	-2.53	0.011	-0.2876
Cons	2.810577	2.7050110	1.04	0.299	

Source: own processing

The standardized nonlinear regression coefficients are comparable. The coefficients for TI and TI² are significant, in addition, the coefficient for TI² is negative. So, we can talk about the effect of inverted U. If we derive ROE according to TI we get:

$$\frac{dROE}{dTI} = 0.44399 - 0.00296 \cdot TI \quad (3)$$

We are looking for an extreme, so we set the derivative equal to zero.

$$0.44399 - 0.00296 \cdot TI = 0 \quad (4)$$

$$TI = 74.99 \quad (5)$$

This point, where TI acquires the value of 74.99, is called the "turning point", because in it the derivative changes from a positive value to a negative one.

3.2. Threshold Regression Model with Threshold and Mode Variable Total Indebtedness

The parameters of the threshold regression model with one threshold value (TI = 90.36) are given in Table 6.

Table 6: Threshold regression model with one threshold value (TI = 90.36)

	ROE	Coef.	Std. Err.	z	P > z	95 % Conf. Interval
Region 1	TI	0.1910	0.0353	5.40	0.000	0.1217 0.2602
	Cons.	5.5794	2.0499	2.72	0.006	1.5616 9.5971
Region 2	TI	-3.1690	0.4292	-7.38	0.000	-4.0104 -2.3276
	Cons.	324.069	41.402	7.82	0.000	242.28 405.3101

Source: own processing

The values of the information criteria were as follows: AIC = 7372.88; BIC = 7392.80; HQIC = 7380.42. All coefficients are significant and there is no intersection of confidence intervals. The coefficient at TI for Region 1 is positive 0.191 and the coefficient at TI for Region 2 is negative -3.169. If the value of TI is less than 90.36 (Region 1), then with the increase of TI there is an increase in ROE with coefficient of 0.191. If the value of TI is greater than 90.36, then with the increase of TI there is a decrease in ROE with coefficient of -3.169.

When analysing the model with two threshold values, the values of the information criteria were achieved: AIC = 7376.88; BIC = 7406.76; HQIC = 7388.19. The values of the information criteria are therefore slightly higher than in the case of the model with one threshold value. All coefficients of the model are significant (Table 7). The sign of the coefficient already changes at the value of the threshold variable (TI = 76.79). The intersection of the confidence intervals of the regression coefficients for Region 2 and Region 3 is non-zero. The differences between Region 2 and Region 3 are therefore small.

Table 7: Threshold regression model with two threshold values (TI = 76.79 and 90.36)

	ROE	Coef.	Std. Err.	z	P > z	95 % Conf. Interval
Region 1	TI	0.14268	.0449	3.17	0.002	0.0545 0.2307
	Cons.	6.6525	2.169	3.07	0.002	2.399 10.9056
Region 2	TI	-1.8693	0.5310	-3.52	0.000	-2.9102 -0.8284
	Cons.	180.5351	44.3124	4.07	0.000	93.6842 267.3858

Region 3	TI	-3.1690	0.4258	-7.44	0.000	-4.0037	-2.3343
	Cons.	324.0692	41.1193	7.88	0.000	243.4767	404.6616

Source: own processing

The first threshold value for the three-region model is 76.79. This value is very similar to the turning point (74.99), which we obtained from the nonlinear regression model. For Region 1 with a TI less than 76.79, the coefficient of the model is positive (0.14268). If the value of TI is less than 76.79 (Region 1), then with the increase of TI there is an increase in ROE with coefficient of 0.14268. For Region 2 with TI from 76.79 to 90.36, the coefficient is negative (-1.8693). If the value of TI is from 76.79 to 90.36, then with the increase of TI there is a decrease in ROE with coefficient of -1.8693. For Region 3 with TI above 90.36 profitability decreases much faster (-3.169). If the value of TI is greater than 90.36, then with the increase of TI there is a decrease in ROE with coefficient of -3.169. Due to the overlap of confidence intervals and the value of information criteria, we prefer a model with one threshold value.

3.3. Threshold Regression Model with Threshold and Mode Variable Total Indebtedness and Other Mode Variables

The correlation matrix shows acceptable values except for the correlation between Debt/EBITDA and Net Debt/EBITDA (Table 8).

Table 8: Correlation matrix

	ROE	TI	Debt/EBITDA	Profit margin	EBITDA Margin	Net Debt/EBITDA
ROE	1					
TI	0.191	1				
Debt/EBITDA	-0.149	0.262	1			
Profit margin	0.467	-0.031	-0.168	1		
EBITDA Margin	0.203	0.084	-0.051	0.639	1	
Net ebt/EBITDA	-0.111	0.292	0.775	-0.1328	0.077	1

Source: own processing

In further analysis, we will omit the Net Debt/EBITDA indicator and test the possibilities of using the threshold model for the threshold variable TI and the mode variables TI, Debt/EBITDA, profit margin, EBITDA Margin for one or two threshold values. When selecting a suitable model, we will use information criteria (AIC, BIC, HQIC), significance of coefficients and their confidence intervals. Estimates of the coefficients of the model with one threshold value are given in Table 9. The corresponding values of the information criteria are as follows: AIC = 2860.37; BIC = 2901.814 and HQIC = 2876.682.

Table 9: Threshold regression model with one threshold value (TI = 90.01)

	ROE	Coef.	Std. Err.	z	P > z	95 % Conf. Interval
Region 1	Debt/EBITDA	-1.340	0.391	-3.42	0.001	-2.108 -0.572
	Profit margin	1.038	0.084	12.26	0.000	0.872 1.204
	EBITDA Margin	-0.200	0.045	-4.40	0.000	-0.289 -0.112
	TI	0.368	0.056	6.54	0.000	0.258 0.478
	Cons.	-6.891	3.645	-1.89	0.059	-14.035 0.253
Region 2	Debt/EBITDA	-1.784	0.617	-2.89	0.004	-2.995 -0.574
	Profit margin	1.945	0.233	8.33	0.000	1.487 2.402
	EBITDA Margin	-0.116	0.103	-1.13	0.258	-0.318 0.085
	TI	-5.827	0.469	-12.41	0.000	-6.747 -4.907
	Cons.	582.29	44.859	12.98	0.000	494.369 670.215

Source: own processing

The coefficients are in the vast majority significant, but only in two cases there is no penetration of confidence intervals (TI and Profit margin). TI shows the same properties as in

previous cases. The coefficient at TI Region 1 is positive 0.368 and the coefficient at TI for Region 2 is negative -5.827. If the value of TI is less than 90.01 (Region 1), then with the increase of TI there is an increase in ROE with coefficient of 0.368. If the value of TI is greater than 90.01, then with the increase of TI there is a decrease in ROE with coefficient of -5.827. The profit margin has a greater impact on the return on equity in the Region 2 (TI is above 90.01).

The values of the information criteria for the two threshold values (73.458 and 90.01) are higher than in the previous cases: AIC = 2870.37; BIC = 2932.535 and HQIC = 2894.837. The parameters of this model are given in Table 10.

Table 10: Threshold regression model with two threshold values (TI = 73.458 and 90.01)

	ROE	Coef.	Std. Err.	z	P > z	95 % Conf. Interval	
Region 1	Debt/EBITDA	-1.283	0.4988	-2.57	0.010	-2.261	-0.3060
	Profit margin	0.7760	0.1016	7.63	0.000	0.5767	0.9753
	EBITDA Margin	-0.1587	0.0543	-2.92	0.003	-0.2652	-0.0522
	TI	0.2494	0.0821	3.04	0.002	0.0883	0.4104
	Cons.	-0.5477	4.1414	-0.13	0.895	-8.6648	7.5692
Region 2	Debt/EBITDA	-1.3180	0.5948	-2.22	0.027	-2.4839	-1.5207
	Profit margin	1.5163	0.1408	10.76	0.000	1.2401	1.7924
	EBITDA Margin	-0.2224	0.0793	-2.80	0.005	-0.3778	-0.0669
	TI	0.9659	0.3816	2.53	0.011	0.2178	1.7139
	Cons.	-57.435	31.2706	-1.84	0.066	-118.7249	3.8539
Region 3	Debt/EBITDA	-1.3180	0.5948	-2.22	0.027	-2.4839	-1.5207
	Profit margin	1.5163	0.1408	10.76	0.000	1.2401	1.7924
	EBITDA Margin	-0.2224	0.0793	-2.80	0.005	-0.3778	-0.0669
	TI	0.9659	0.3816	2.53	0.011	0.2178	1.7139
	Cons.	-57.435	31.2706	-1.84	0.066	-118.7249	3.8539

Source: own processing

Again, most of the coefficients are significant, but the confidence intervals of the model coefficients in each region overlap for each variable. Due to this fact and the higher values of the information criteria, we will choose a model with one threshold value.

4. Discussion

In the first stage, the relationship between return on equity and total indebtedness was solved using a nonlinear regression model. Nonlinearity is sought using an inverted U-shaped model. In nonlinear regression model, the turning point for the return on equity of the company is the value of total indebtedness of 74.99.

When using the threshold regression model, one (TI=90.36) or two threshold values (TI=76.79 and 90.36) come into play. In the threshold regression model with one threshold value, if the value of total indebtedness is less than 90.36 (Region 1), then with the increase of total indebtedness there is an increase in return on equity with coefficient of 0.191. If the value of total indebtedness is greater than 90.36, then with the increase of total indebtedness there is a decrease in return on equity with coefficient of -3.169.

If we consider a model with two threshold values, the first threshold value for the three-region model is 76.79. This value is very similar to the turning point (74.99), which we obtained from the nonlinear regression model. The sign of the coefficient already changes at the value of the threshold variable (TI=76.79). The intersection of the confidence intervals of the regression coefficients for Region 2 and Region 3 is non-zero. The differences between Region 2 and Region 3 are therefore small. Due to the overlap of confidence intervals and the value of information criteria, we can say that a model with one threshold value is more appropriate in this case.

To the return on equity and total indebtedness indicators analysed so far, we have added other indicators: Debt/EBITDA, profit margin, EBITDA Margin, Net Debt/EBITDA. We tested the possibilities of using the threshold regression model for the threshold variable total indebtedness and the mode variables total indebtedness, Debt/EBITDA, profit margin, EBITDA Margin for one or two threshold values. Threshold values close to those of previous models

($TI = 73.458$ and 90.01) were calculated. The coefficients are in the vast majority significant, but only in two cases is there no penetration of confidence intervals (total indebtedness and profit margin). Total indebtedness shows the same properties as in previous cases. The profit margin has a greater impact on the return on equity in the Region 2 (TI is above 90.01). By comparing the values of the information criteria and the confidence intervals, we can say that a model with one threshold value is more appropriate in this case. Therefore, we confirm hypothesis 1.

Our results could be generalized to the V4 countries (Poland, the Czech Republic and Hungary). These countries, like Slovakia, do not have a developed capital market and for this reason our results are comparable to the Energy and Mining sectors in these countries.

In study by Cheng et al. (2010), they use panel threshold regression model to test the panel threshold effect of debt ratio on firm value. The results confirm that a triple-threshold effect does exist and show an inverted U-correlation between leverage and firm value. Ramadan and Ramadan (2015) confirmed an inverse relationship between capital structure and return on assets in a sample of the Jordanian industrial enterprises listed at Amman Stock Exchange. Other authors who have investigated the relationships between financial indicators include Lyocsa et al. (2022) and Svabova et al. (2020). Gajdosikova et al. (2024) and Valaskova et al. (2021) also dealt with the capital structure and debt.

5. Conclusions

The paper dealt with modelling the relationship between profitability and debt of companies in the Energy and Mining sector of the Slovak Republic. The aim of this paper was to examine the relationship between return on equity and total indebtedness of companies in the Energy and Mining sector of the Slovak Republic.

A nonlinear regression model and a threshold regression model with one and two threshold values were used to model the relationship between profitability and debt. The models were used on the data of 1,219 companies from the Energy and Mining sector in the Slovak Republic for the year 2020. In the case of marginal models, total indebtedness was used as a threshold variable and total indebtedness, Debt/EBITDA, Profit margin, EBITDA Margin, Net Debt/EBITDA were used as mode variables.

This paper has several limitations. First, we did not consider all companies from Energy and Mining sector of the Slovak Republic, and we analysed only one year. Therefore, it would be interesting to repeat the analysis with more companies or for different years. Secondly, we did not use qualitative data in the analysis (size of the company, location, owners, etc.). Thirdly, it would be appropriate in further research to use other statistical methods to investigate the relationships between financial indicators.

We have shown the nonlinear relationship between return on equity and total indebtedness. Knowing the relationship between financial indicators allows for more effective business management. It can be used to optimize the debt policy of the company in the industry.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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DOES THE LABOUR FORCE PROGRESS THREATEN THE DEVELOPMENT OF SLOVAKIA INDUSTRY IN THE MEDIUM-TERM PERSPECTIVE?

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Abstract:

Research background: Population ageing is becoming a significant factor influencing technological innovation and the transformation of industrial models worldwide. However, labour supply shortages due to an aging population have led to a greater number of older workers within society.

Purpose of the article: The aim of the paper is to define theoretical approaches and options for addressing the population ageing impact on the labour market with a focus on the industrial sector. The study examines the ageing Slovakian population demographic trend, the size of the labour force and labour force projections, all with a focus on the industrial sector of the Slovak Republic.

Methods: To meet the objective, many statistical methods have been used to investigate ageing and the workforce size and structure in the industry sector. The Dynamic Economic and Reproductive Ageing Index methods were used to examine population ageing, the workforce and its volume, providing information on the dynamics of ageing in the Slovak Republic. Other methods used are the Labour Inflow, Outflow and Replacement Coefficient. They inform about the reproductive replacement of the labour force, the productive component and the projected volume of the labour force in the future. More specific future volume projections of the labour force were found based on the Boersch-Supan model.

Findings & Value added: The results suggest that the Slovak Republic is experiencing population ageing, the dynamics of ageing is accelerating, the burden on the productive component is increasing over time, the size of the industrial workforce is increasing at a low rate and the industrial sector does not show a need for a larger volume of additional labour in 2028. The increasing population share in the post-working age may lead to increased pressure on social and health systems and public finances. Slow growth in industrial workforce size may indicate a constraint in the competitiveness and innovation potential of industry. The absence of additional labour needs by 2028 may indicate that industry is able to use existing resources efficiently or that automated technologies are coming to the fore, which may reduce the need for manual human labour.

Keywords: population ageing; industry; Industry 4.0; workforce

JEL Classification: J21; O15; O25

1. Introduction

The study focuses on the analysis in the current state and evolution of the workforce in the Slovak Republic industrial sector, with particular attention to the interaction between demographic trends such as population ageing and the impact of Industry 4.0 on changes in the workforce. The main objective of the study is to define theoretical approaches and options for addressing the impacts of population ageing on the labour market with a focus on the industrial sector. It is assumed that this approach contributes to a deeper understanding of the dynamics shaping the future of the Slovak Republic labour market.

In the current macroeconomic environment, industrial development faces fundamental challenges that are reflected in labour market dynamics and population structure. One of the primary challenges is the transformation of labour supply, which has shifted from an almost unlimited surplus to a constrained and structurally deficient labour force (Cai, 2020). The population plays a key role in the modernization of the industrial structure, with its demographic characteristics fundamentally influencing economic development (Obadi et. al., 2019).

In recent years, the problem of an ageing population has become increasingly serious. With the growing proportion of the elderly population and the increasing population dependency ratio, demographic trends are reaching such a level that the potential of the demographic dividend is being exhausted (Bao, 2020). A rapidly aging population limits the viability of technological innovation and directly interferes with the economy's ability to adapt to new technologies (Liang et al., 2018). In the context of the new macroeconomic environment where we are facing an aging population and labour shortages, it is important to address these challenges to ensure sustainable and dynamic industrial development (Zheng, 2020).

The research originality lies in the application of advanced methods, the results of which provide a deeper insight and clarify the study context. The findings provide important evidence for strategic planning in the field of employment policy, labour market interventions and the creation of support systems by the State. The information obtained is also valuable for employers who are mapping the current labour market state in the Slovak Republic and forecasting its future development.

The structure of the article is arranged as follows. The theoretical part contains an overview of findings and conclusions of scientific studies related to the population ageing from different perspectives and with regard to their possible impacts in the context of industry and Industry 4.0 and 5.0. Subsequently, the objective of the research and a description of the applied methodology are presented. The third part presents the quantitative analysis results focused on the Slovak Republic. The paper concludes with a brief discussion of the findings and the main conclusions formulation.

2. Literature review

Population ageing is becoming a significant factor influencing technological innovation and the transformation of industrial models worldwide. However, labor supply shortages due to an aging population have led to a greater number of older workers within society (Su, 2021). In the context of industry in the Slovak Republic, this topic is particularly relevant as an ageing workforce requires new approaches to work organisation and technology adaptation. According

to a study by Jing and Li (2024), ageing affects technological innovation through labour supply and investment in human capital. Traditional models of modernisation are proving unsustainable, especially in China, where population ageing has become an urgent issue. In-depth analysis shows that population ageing exacerbates labour shortages and affects the modernisation of the industrial structure, highlighting the need to promote independent innovation and improve domestic consumption and exports (Shen et al., 2022).

The ageing population also poses a serious challenge to the competitiveness of countries and regions. This demographic trend affects not only the economy, but also social and political structures, requiring adaptation to new labour market conditions. With a growing elderly population, who often face health problems and limitations, it is essential to find innovative solutions to enable this group to integrate effectively into the labour market. Industrial AI, as a new development model, has the potential to contribute to deep integration of industrial and innovation chains and improve national competitiveness. Wu et al. (2022) confirm that population aging has a positive impact on the technical intensity of exports. The introduction of industrial AI tools mitigates the negative effects of aging and promotes industrial upgrading, thereby increasing the technological maturity of exports. At the same time, automation frees workers from repetitive hard work, but older workers feel threatened by new technologies (Zhang et al., 2023).

Within the challenges posed by an ageing economy, Hu et al. (2021) identified four main challenges in the ageing industry: poor adaptability to technology for older workers, mediocre quality of shared services, the concept of redundant older people and a shortage of skilled professionals. Coping with these challenges is crucial for the effective adaptation and new technologies implementation.

Regarding the older workers, physical demands are limited, which can lead to a reduction in their work capacity and motivation. Many of these workers face health problems that make it difficult to perform physically demanding tasks. Therefore, incorporating age management practices is crucial (Calzavara et al., 2020) as these practices not only allow for the adaptation of the work environment but also the optimization of work processes to take into account the individual needs and demands of older workers. The use of wearable and smart devices to analyse working time and physical fatigue could become an effective tool (Berti et al., 2021). Older workers in industry show a positive attitude towards industrial innovation (Finco et al., 2020).

In further analyses by Gao et al. (2023) suggest that eastern and central regions benefit from technological innovation induced by population aging, while western regions face the opposite trend. Similarly, Angelini (2023) reports that population aging explains almost half of the increase in new technology adoption over the period 1995-2020, while projecting a decrease over the period 2020-2045. Automation and computerisation are key factors shaping the labour market. Phiromswad et al. (2022) point out that these factors have a statistically significant impact on employment.

Social support also has a significant impact on long-term innovative capabilities. Gao and Tian (2023) report that an ageing population and child population affect scientific and technological innovation, while investment in education has a positive impact on innovation (Liang et al., 2018). In the context of workforce diversity, it is important to consider age, gender and individual capabilities in productive systems (Katirae et al., 2019). Older operators can mentor younger workers and positively influence the work environment (Berti et al., 2021).

Li and Zhao (2019) point to the long-term effects of aging on technological innovation, while at the same time suggesting that the dependency ratio of the elderly has a strong impact on scientific and technological innovation. In this regard, Zhang (2023) systematically reviews

the factors influencing older employees' attitudes toward technology, highlighting the complex relationship between their personal characteristics, technological factors, and social context.

With the advent of Industry 4.0, which requires new infrastructures and increased volumes of data, it appears that the implementation of new technologies such as robots can significantly improve efficiency and productivity in industrial processes (Mohamed, 2018). Various studies have focused on technological solutions that harness the flexibility and creativity of workers (Schlegel et al., 2017; Guo et al., 2017). The technologies associated with it are applied in complex industrial processes to increase task efficiency and productivity and can also be used to train workers (Jetter et al., 2018). An important part of modernisation is the consideration of age management, which appears to be key for older workers (Calzavara et al., 2020).

In the context of Industry 5.0, the focus is on the well-being of the human workforce and sustainability, allowing for a better integration of an ageing workforce into modern industrial systems (Aceta et al., 2022; Thorvald et al., 2021). This approach promotes the consideration of human factors and ergonomic aspects, thus ensuring a healthy and productive work environment. The combination of technological innovation and a humane approach is key to creating efficient and sustainable work systems that reflect the needs of all generations (Alves et al., 2022).

The ageing workforce in the Slovak Republic requires a comprehensive approach that combines technological innovation with a humane approach. These findings show that it is imperative to adapt industrial systems to reflect the needs of all generations to ensure sustainable and efficient growth of the industrial sector. A key element of this transformation is taking into account age management aspects, improving the quality of education and adapting the working environment to the needs of an ageing population. Attention must also be paid to innovative technologies that can improve the quality of work and living conditions of older workers, as well as their integration into modern work processes. Ultimately, sustainable and efficient growth of the industrial sector depends on a cooperation between technological progress and an approach that respects and supports the needs and preferences of all age groups.

3. Methodology

The main objective of the research was to define theoretical approaches and options for addressing the impact of ageing on the labour market, with a priority focus on the industrial sector.

Based on the method of expert estimation, the following hypotheses were formulated:

H1: We assume that the index of dynamic economic and reproductive ageing will show population ageing.

H2: We assume that labour force turnover will be reduced in the future. The average value of the replacement rate will be less than 0.900.

H3: We assume that the amount of additional labour force in industry will be lower in 2028. Industrial labour demand will be reduced by around 40,000 workers.

The empirical research includes a quantitative analysis focusing on demographic changes and transformations in the workforce. The analysis of the ageing population is extended by examining selected indicators that reflect the labour market situation and labour force availability in the context of an ageing population. The current situation and previous developments are complemented by assumptions on the development of the industrial workforce up to 2028. Eurostat and the Statistical Office of the Slovak Republic were used to obtain primary data.

The index of dynamic economic ageing of working age reflects the speed of the population ageing process. The relationship is as follows

$$I_{esd} = [O_{(0-14)t} - O_{(0-14)t+n}] + [O_{(65+)t+n} - O_{(65)t}] \quad (1)$$

where $t = 1, 2, \dots, T$ is the number of periods
 n is the size of the statistical population

The Dynamic Reproductive Ageing Index is a modification of the previous index. The change consists in examining the age structure of the population in terms of reproduction. The relationship reads

$$I_{rsd} = [O_{(0-14)t} - O_{(0-14)t+n}] + [O_{(15-49)t+n} - O_{(15-49)t}] \quad (2)$$

Polynomial trends are used in trend following and help to define a trend function that has an extreme. Its shape is

$$Y_t = a_0 + a_1t + a_2t^2 + \dots + a_kt^k \quad (3)$$

The inflow coefficient expresses the number of people aged 10-14 years per 100 people aged 15-64 years. It is denoted by the capital letters KP and expressed as a percentage. The ratio reads

$$KP_{\%} = \frac{P_{(10-14)}}{P_{(15-64)}} \cdot 100 \quad (4)$$

where $P_{(10-14)}$ is number of people aged 10-14
 $P_{(15-64)}$ is number of people aged 15-64

The labour force outflow coefficient expresses the number of people aged 60-64 per 100 people aged 15-64. It is denoted by capital letters KO and its expression is in percentages. We find the resulting value as:

$$KP_{\%} = \frac{P_{(15-64)}}{P_{(60-64)}} \cdot 100 \quad (5)$$

where $P_{(60-64)}$ is number of people aged 60-64
 $P_{(15-64)}$ is number of people aged 15-64

The coefficient of exchange is denoted by the capital letters KV, and its value is quantified as a percentage. Its relationship is

$$KV_{\%} = \frac{KP}{KO} \quad (6)$$

The average growth coefficient was used to find the average development of the indicator under study. The calculation is based on the geometric mean and its relationship is as follows

$$K_{(y)} = \sqrt[n-1]{\frac{y_n}{y_1}} \quad (7)$$

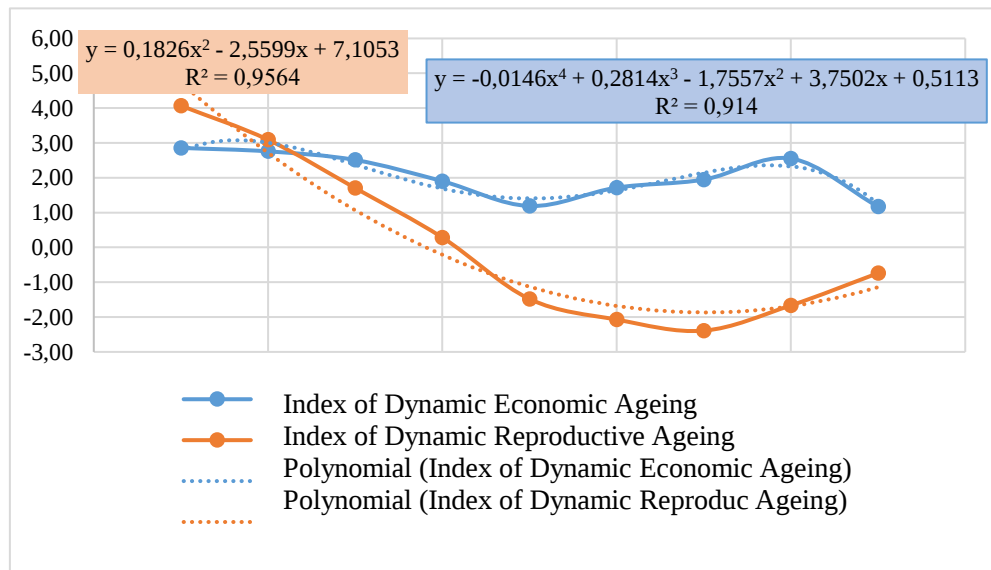
where $K_{(y)}$ is the average growth coefficient
 $n - 1$ is the number of observation periods minus 1
 y_n is the value in the last period
 y_1 is the value in the first period

The Boersch-Supan model was used to identify the additional future labour requirements in selected industries. The selected model consists of identifying the expenditures of each population age group, identifying the number of people working in the selected sectors, estimating future expenditures, identifying the total population consumption, analysing the number of people employed in the selected sectors, identifying the future population forecast and then forecasting the amount of labour force in the selected sectors. On the basis of the analysis of demographic changes and the transformation of consumer preferences, the number of employees that will be necessary to produce the required volume, based on changes in the total consumption of the population, is determined. The information and data obtained from the model quantifies the change in the structure of the workforce in the economy and the data can be used for further investigation, such as the changing skill structure and much more (Kostrova, 2019).

4. Results

The following figure and tables show the results of the research, see Figure 1.

Figure 1: Index of dynamic economic and reproductive ageing 1993-2028



Source: own processing based on the Statistical Office of the Slovak Republic (2023)

The index of dynamic economic ageing took on positive values throughout the period under review, indicating population ageing. A higher value of this index indicates a faster dynamic process. The regression coefficient also shows a positive value, indicating that the index had an increasing trend throughout the period. This indicates that the dynamics of the process is steadily increasing. Population ageing in terms of reproduction is denoted by the index of dynamic reproductive ageing, whose values change over the time frame under study. The overall assessment indicates a downward trend, which is influenced by the increase in life expectancy, the increase in the age of women at first birth and the general postponement

of family formation and family life among young people. Based on the results obtained, it has been assessed that population ageing in the Slovak Republic is ongoing and will continue to accelerate in the future. H1 has been confirmed.

Table 1 presents results reflecting generational labour turnover based on inflow, outflow and replacement coefficients.

Table 1: Projection of the KP, KO, KV to 2028 in the Slovak Republic

	2024	2025	2026	2027	2028	Average
KP	8.301	8.300	8.339	8.450	8.546	8.387
KO	9.504	9.596	9.598	9.549	9.482	9.546
KV	0.873	0.865	0.869	0.885	0.901	0.879

Reduced labour force reproduction in all periods

Note: KP Coefficient of inflow, KO Coefficient of outflow, KV Coefficient of exchange

Source: own processing based on the United Nations (2024)

The average value of the KP in 2024-2028 is detected at 8.387, which means that there are approximately eight children aged 10-14 years for every 100 people aged 15-64 years. The value of the KP increases over the projected time series, which can be seen as a positive manifestation of demographic development.

The value of the average KO for the period 2024-2028 is 9.546. The resulting value means that there are approximately nine to ten people of post-working age for every 100 people of working age. The unfavourable fact is that the average value of KO is higher than the average value of KP.

The average KV has taken on a value of 0.879. A value less than one means that the outflow is higher than the inflow of labour. We are talking about the reduction in the reproduction of the labour force, which tends to increase. These figures mean that the share of the productive and post-productive population exceeds the share of the pre-productive group. This gives rise to a situation on the labour market where there is a risk of labour shortages because there is no exchange between the post-productive and pre-productive components of the population. H2 has been confirmed.

Table 2 shows the results confirming the need for additional labour in 2028 in selected sectors.

Based on the results obtained from the Boersch-Supan model, the industries were divided into two groups. The first group includes sectors where additional labour is expected to be needed, and the second group includes sectors where the demand for workers is expected to decline. The sectors with an existing need include information and communication technology. Conversely, sectors with declining demand include industry, transport and financial and insurance services. An additional need of 12 950 persons is expected in the information and communication technology sector.

Table 2: Additional labour needs in 2028 in the Slovak Republic based on population consumption

Indicators sector	Employment in 2023	Need in 2028	Difference
Industry	480,000	440,250	-39,750
Transport	110,000	98,125	-11,875
Information and communications	55,000	67,950	12,950
Financial and insurance services	53,000	52,125	-875

Source: own processing

The second group of sectors in which the additional labour needs are projected to decrease includes industry, where a decrease of up to 39 750 persons is estimated. The decline in demand in the transport sector is attributed to the increasing number of drivers and cars, as well as to a reduced interest in public transport, which is becoming less convenient and less frequent. The

final sector experiencing a decline in demand is financial and insurance services. H3 has been confirmed.

Based on extensive data, it can be concluded that Slovakia's population is ageing, the process is accelerating, the reproduction of the labour force is decreasing and there is a shortage of labour on the labour market. Future projections are unfavourable, and labour resources are exhausted.

5. Discussion

The Slovak Republic is currently in a complex demographic context characterised by an ageing population and changes in the workforce. Based on the findings of the previous analysis, several key aspects can be identified that are crucial for the future of the industrial sector.

The first important fact is that the working age population is declining while the number of people of post-working age is increasing. This trend is consistent with the finding that an ageing workforce leads to a shortage of skilled labour (Su, 2021). The consequences of this decline are not only felt in the labour market but also in overall economic development, as the ageing population directly affects the modernisation of industrial models (Shen et al., 2022).

The dynamics of population ageing is accelerating, which is an alarming signal not only for industry but for all sectors of the national economy. In line with this observation, it is becoming increasingly evident that the demand for adaptation to new labour market conditions is becoming inevitable. A rapidly ageing population limits the scope for technological innovation and interferes with the economy's ability to adapt to new technologies (Liang et al., 2018).

The findings regarding labour force reproduction are also crucial as they reveal the challenges that the SR industry will have to face in the coming years. With labour force reproduction projected to decline by 2028, the SR industry needs to prepare for major changes in the employment structure. The upcoming changes require careful analysis and adaptation to the new conditions to ensure competitiveness. Another critical aspect is the projected reduction in the need for an additional workforce of 39 750 persons by 2028. This alarming trend not only indicates a possible surplus workforce, but also changes in the employment structure, whereby traditional positions may be abolished or transformed. It is imperative that employers begin to prepare for these anticipated developments and plan strategically for the deployment and adaptation of the available workforce. This trend corresponds with arguments that automation and technological innovation may reduce the demand for manual labour (Mohamed, 2018). With the increasing use of robotics and AI in industry, traditional jobs are becoming less and less desirable. The consequence of this is not only a reduction in the number of employees in certain areas, but also the need to retrain and upskill those who will continue to be in the labour market. This opens the debate on the need to develop new approaches to work organisation that take account of the individual skills and needs of older workers. Given the ageing population and the projected number of younger workers, it is crucial to create a working environment that is inclusive and adapted to different age groups.

The final analysis shows that a comprehensive approach that combines technological innovation with a humane approach and takes account of demographic change is essential to ensure the sustainable development of the Slovak industry. It is necessary to look for innovative solutions that effectively integrate older workers into modern work processes, thus ensuring not only their active participation but also the overall competitiveness of the industry. It should be stressed that the creation of innovation is closely linked to human capital and therefore, even in the context of a declining need for additional labour, it remains crucial

to ensure that industry has a sufficiently skilled workforce capable of generating innovative solutions.

6. Conclusions

The main objective of the research was to define theoretical approaches and options for addressing the impact of ageing on the labour market, with a particular focus on the industrial sector. The research analysed the population ageing in the Slovak Republic and the size of the workforce in the future.

The key finding is that the working-age and pre-working age population is declining, while the number of people of post-working age is increasing. This trend is a clear indicator of the ongoing population ageing in the Slovak Republic, which is characterized by accelerated dynamics. For 2023, a reduced reproduction of the labour force has been recorded and the projections for the period 2024-2028 indicate that this trend will continue. Despite the average increase in industrial employment, the need for additional labour is projected to decrease by 39 750 people by 2028.

The limitations of this research are that the analysis is based on available demographic and economic data, which can be influenced by a variety of external factors such as economic crises, policy decisions and technological innovation. In addition, the lack of specific forecasts and estimates regarding future labour market developments may affect the accuracy of the predictions.

The results of this research underline the importance and urgency of the need to develop comprehensive and sustainable employment policies that take demographic changes into account and increase the competitiveness of Slovak industry. Given that the aging of the population and the decline in the number of people of productive age create challenges for the labour market, it is necessary to create policies that not only respond to the current situation, but also to anticipated developments. These policies should include measures to support a flexible and adaptable labour market, as well as consider the needs of different age groups of employees. In connection with technological progress and the concepts of Industry 4.0 and 5.0, it is important to integrate innovative technologies such as automation, robotics and AI into work processes. These technologies can increase efficiency and productivity, while relieving workers of physically demanding tasks, allowing them to focus on more valuable and creative activities.

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LABOR RELATIONS IN DANGER: LEGISLATIVE ANALYSIS OF PATHOLOGICAL RELATIONSHIP PHENOMENA IN SLOVAKIA AND IN FOREIGN COUNTRIES

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Abstract:

Research background: Every day, many employees face discrimination at work. Work is good for your health, but it may also be dangerous and damaging. It promotes self-confidence, quality of life, and self-affirmation, all of which contribute to higher self-esteem. At the same time, it provides benefits such as self-esteem, social support, and social integration. However, we must recognize that a person can only work till his physical and mental health allow it.

Purpose of the article: In the scientific contribution, we provide a comprehensive view of the issue of pathological relationships in the workplace, their occurrence, elimination, consequences, and types. The aim of the scientific contribution is to analyse and compare the legal arrangements for pathological relationships in the workplace in Slovakia and in selected countries of the world and to create recommendations for Slovak legislation.

Methods: The methods of analysis, deduction, induction, comparison of data collection and graphic display were used in the research.

Findings & Value added: The Slovak Republic does not have specific legislation dealing with workplace bullying, similar to Russia, Kazakhstan or Turkmenistan. These countries include, for example, Italy, where, however, for a long-time scientific worker and the legal community have been warning about the absence of legislation. In Australia, there is a Fair Work Commission (FWC), which, however, already defines bullying and can even be appealed to by an employee. The organization then investigates the issue of bullying. On the other hand, we have countries like Colombia, which has had its legislation since 2006, or Romania since 2020.

Keywords: mobbing; bossing; pathological relationships; prevention of mobbing; regulation of pathological relationships

JEL Classification: O15; M50; M59

1. Introduction

Businesses should take bullying, mobbing, or bossing seriously and responsibly investigate each situation. They should not look on passively from either moral or economic aspects. They must show by every measure that they will not tolerate these phenomena. The employer cannot overlook the fact that according to labour law, he is obliged to protect the personalities of his employees and take care of them. The most important thing is to name problems of this nature and to discuss them openly. Any form of mobbing is generally very difficult to prove, but it is even more difficult to convince victims of mobbing not to give up and solve the situation. After all, the solution is not to leave the company but to learn to defend yourself (Nekoranec and Kmosena, 2015).

In terms of power, initial research identified managers as perpetrators, with such behaviour being associated with organizational structure. The defenselessness of the target results from a lack of power, or an unbalanced distribution, which is manifested in the organizational structure. However, some subordinates are able to gain enough power outside of their competence, which they then use to mob the victim in the same or higher organizational position (Branch et al., 2013). According to Naranjo-Zambrano et al. (2023), perpetrators of mobbing use the opportunities created by the corporate situation, such as reorganization, cost reduction, bureaucracy, dizzying changes, and others, to direct successive impulses of psychopathic tendencies. In their research, Safina and Podgornaya (2014) state that in up to 33% of cases, the perpetrator was a direct superior; in 30% it was a colleague; a co-worker was the perpetrator in 22%; and the director in 15% of cases. 4% of the respondents identified themselves as perpetrators of pathological relationships. Naranjo-Zambrano et al. (2023) identify women as more vulnerable to sexual harassment and bullying. In general, this assumption can be generalized to the structure of most businesses, where women are traditionally placed in a position of subordination, which makes them more susceptible to this type of violence.

Ares Camerino and Ortega Marlasca (2018) state that the most common manifestations of mobbing in the workplace are discrediting or belittling the harassed person through disruption of communication, systematic blocking of work activities, degrading the harassed person with inappropriate tasks in the form or content outside of his competences, and behaviour supporting insufficient communication within the work area, e.g., ignoring her presence, not answering her questions, refusing to speak or discrediting, or disparaging a person's personal life through criticism. Studies have shown that there are many causes of mobbing, such as company goals and objectives, employee personalities, corporate culture, and social group structure in the workplace (Erdis et al., 2021). Perpetrators may bully because of a need to protect their self-esteem or because of a lack of social competence, such as emotional control or perspective-taking (Branch et al., 2013).

According to Stefko et al. (2023), leaders have different motives for bullying and use different strategies than in the case of mobbing. Among their basic motives are jealousy of a qualified worker and fear of losing his position, creating pressure on a subordinate worker to force his obedience, and efforts to exclude this person from the work team or from the workplace as such. Also notable are anger at the company itself, hatred of superiors, and negative personality traits of the leader, which are given the opportunity to manifest themselves the moment the individual gains power or influence. Bhusal et al. (2023) consider the causes of inappropriate behaviour at the workplace to be insufficient staffing, heavy workload, and ineffective methods of prevention. The mentioned factors increase the risk of exposure to occupational violence and its harmful effects on patients and medical personnel.

A study conducted by Maran et al. (2021) investigated the impact of mobbing on witnesses of bullying by gender on 574 Italian workers. The findings showed that witnesses of both sexes

emphasized verbal, physical and psychological aggression that occurred in relationships within the company, intrusion into individuals' private lives, excessive surveillance, social isolation and destruction, all of which had an impact on their co-workers. Regarding health and work stress, it was found that men and women who witnessed psychological harassment considered their mental health problems to be more serious than those who did not witness such behaviour.

Silva et al. (2021) state as frequent consequences of mobbing, e.g., anxiety, insomnia, irritability, feelings of frustration or failure, and problems with concentration. In addition to psychological problems, they also talk about physical (cardiovascular diseases, diseases of the digestive tract, etc.), economic (loss of money due to job loss), or social (avoidance of human contact, fear of crowds, etc.).

In extreme cases, on the basis of pathological relationships, the idea of taking one's own life may arise. According to Swedish research, pathological relationships are the cause of 10–20% of all suicides. The victim requires long-term and complex treatment, the success of which is questionable (Droppa et al., 2018).

Mobbing is a major problem for businesses in developed countries. It became an important topic in Turkey as well. In this country, for example, the prime minister's circular was created and published in the official newspaper. The circular contains information on how to defend against such behaviour, who victims can turn to, etc. The reason was that the number of manifestations of mobbing and victims of this type of behaviour is constantly increasing (Saricam, 2016). What can a victim do against mobbing? It is necessary to analyse the situation and clarify the facts, or discuss the situation with someone outside the victim's workplace. Subsequently, document the facts related to these phenomena, such as the gathering of witnesses, discussion with a lawyer, etc. In the next step, it is necessary to file a complaint and a request to analyse the situation at the workplace, which should relate to the adoption of appropriate measures. The victim should not be afraid to apply laws that prohibit any kind of discrimination and thus claim their rights through the courts (Nekoranec and Kmosena, 2015).

1.1. Typers of pathological relationships

A characteristic feature of psychosocial risks is their high probability of causing significant damage. Consequences are more likely to occur and more likely to be severe (Benavides et al., 2002). The most cited psychosocial risks, which are generally more accepted, are violence and sexual harassment in the workplace or sexual harassment that threatens the physical and personal integrity, dignity, privacy, or other elements of workers' basic rights (Naranjo-Zambrano et al., 2023). Ares Camerino and Ortega Marlasca (2018) talk about hostile, repeated, and intimidating behaviour towards the worker in the framework of the employment relationship, which can be carried out by one natural person or several employees; it can be the employer himself, his representative, a leader or middle manager, or even co-workers with a de facto superior position.

It is claimed, for example, that aggression in the workplace can also be expressed in the form of sexual harassment. Nevertheless, Duffy and Sperry (2011) tend to distinguish sexual harassment from mobbing. They emphasize that mobbing is the non-sexual harassment of a co-worker by a group of other workers or other members of the company, the aim of which is to ensure the exclusion of the victim from the company. Sexual harassment has become a very popular issue in recent years in various cultural contexts. Fear of sexual harassment can limit the movement of women and other feminized or gender-differentiated subjects. The absence of harassment is a basic human right, a prerequisite for mental and physical health and well-being. Harassment can occur through threatening, degrading words and actions, but also through non-verbal signs that pass between people (Boyer, 2022).

Currently, as a result of the expansion of Internet communication and technological literacy, we encounter the term cybermobbing more and more often. This is a type of mobbing when it moves from such behaviour face-to-face to the virtual space. It is therefore mobbing, whether via email, chat, social networks, or via a computer connection, using a mobile phone or other electronic media. Cyber-mobbing is a very insidious way of mobbing because the victim is ridiculed for a short period of time. The reason may be the posting of ordinary videos or photos on a social network (Divincova and Sivakova, 2014).

Stefko et al. (2023) state that bossing is defined as regular and long-term negative interaction between a supervisor and his employees. The main feature of bossing is systematic and long-term. Exposure to such systematic, negative, or anti-social acts can be considered a kind of psychological siege. There is a term "boss syndrome" occurring in bosses who, as managers or leaders, do not know how to handle the most important resource of the company, i.e., their employees. With their approach, such bosses threaten the overall performance of work teams as well as the psychological well-being of the individuals involved (Antonyova et al., 2018). Jenco et al. (2018) define bossing as dangerous behaviour that can affect the long-term cooperation of work teams as well as the overall performance of the company. Zhao (2018) supports this by arguing that bossing or abusive supervision can not only directly reduce subordinates' performance but can also have a negative effect on performance by reducing subordinates' trust in management. Contrary to the mentioned authors is Lu (2013), who claims that bossing can, on the contrary, stimulate passion for work among employees and thus improve the overall performance of the company. For this reason, it is necessary to distinguish between bossing, symbolizing abusive supervision leading to a decrease in performance, and bossing, representing the consistent fulfilment of duties, leading to an increase in performance.

2. Methodology

In a scientific contribution, we use the methods of induction, deduction, comparison, graphic display, analysis, and others. The data is taken from the global, independent, non-profit organization WageIndicator Foundation, whose mission is to ensure improved labour market transparency for workers, employers, and policymakers worldwide. In the next chapter, Results, we will look in more detail at the legislation of selected countries of the world. These are countries such as France, Sweden, Romania, Slovakia, Ecuador, Colombia, Turkey, Uzbekistan, Hong Kong, Japan, South Korea, Australia, South Africa, Israel, and others. The given countries were selected on the basis that they are developed countries that respect basic human rights, or countries that caught our attention from the point of view of approaches to pathological relationships or the complete absence of legal regulation. Of the selected countries, only five countries have pathological relationships regulated by laws in various forms (Table 1).

3. Results and Discussion

Lanata-Fuenzalida (2018) points out the need to pay priority attention to mobbing in all types of businesses, as it is a factor that is part of psychosocial risks. It is becoming a problem that requires precise and defined regulations through laws. Some authors argue that anti-bullying legislation fills the gap left by sexual harassment legislation as well as legislation prohibiting racial discrimination.

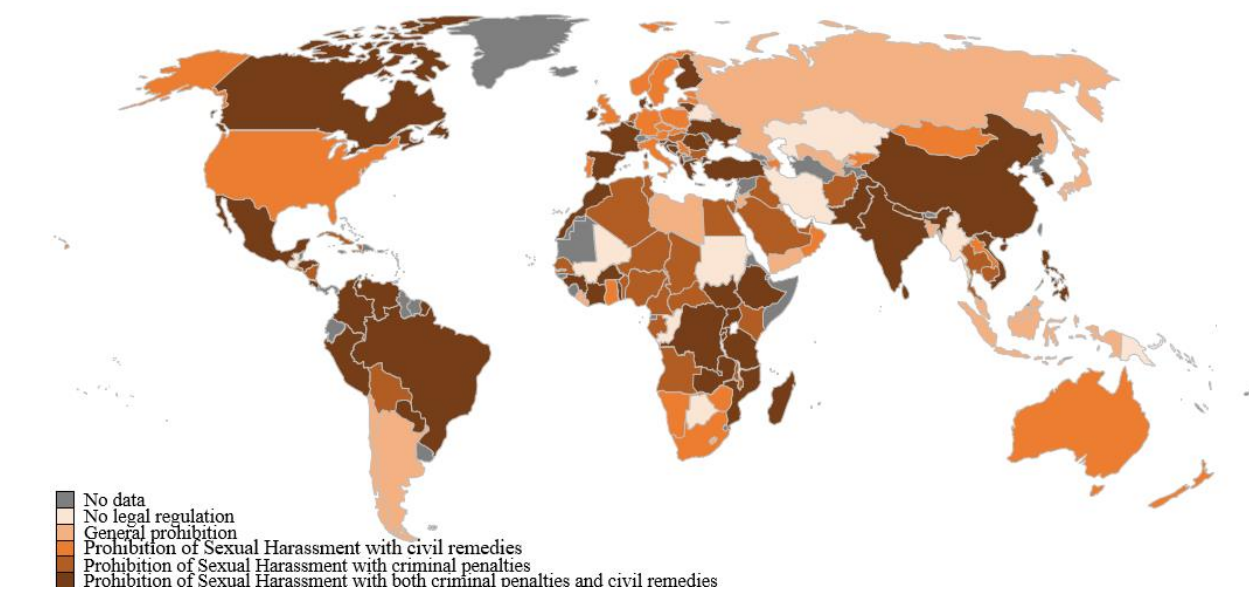
Table 1: Overview of the legal regulation of pathological relationships in selected countries of the world

Country	Form of pathological relationships	Act
France	Barcelement moral (moraal harrassment))	Loi De Modernisation Sociale
Japan	パワーハラスメント (power harrassment)	労働施策の総合的な推進並びに労働者の雇用の安定及び職業生活の充:等に関する法律
South Korea	직장 내 괴롭힘 (workplace harrassment)	근로기준법
Columbia	De acoso laboral (workplace harrassment)	Lay 1010 de 2006
Romania	Bartuire morala (moraal harrassment)	Lege nr. 167 din 7 august 2020 pentru modificarea și completarea Ordonanței Guvernului nr. 137/2000 privind prevenirea și sancționarea tuturor formelor d discriminare, precum și pentru completarea art. 6 din Legea nr. 202/2002 privind egalitatea de sanse si de tratament intre femei si barbati
Slovakia	Diskrimination	Antidiskriminacny zakon
Sweden	Victimization	Ordinance of the Swedish National Board of Occupational Safety and Health containing Provisions on measures against Victimization at Work

Source: own elaboration

While legislation against sexual harassment and racial discrimination focuses on gender or race, anti-bullying legislation focuses on the abuse of power regardless of the gender or race of the victim (Friedman and Whitman, 2002). Figure 1 specifies in more detail whether the law in the countries allows sexual harassment in the workplace.

Figure 1: Map of countries of the world reflecting legal protection against sexual harassment in the workplace



Source: own elaboration according to www.wageIndicator.org (2022a)

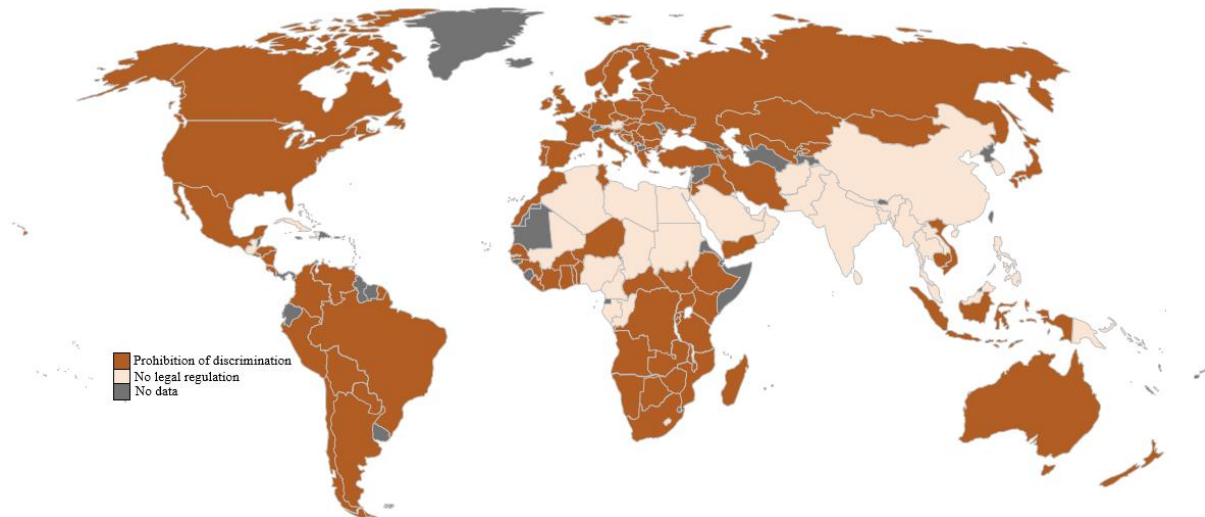
In the World:

- 54 countries prohibit sexual harassment with criminal penalties and civil remedies (Brazil, Canada, Democratic Republic of Congo, Morocco, France, Spain, China or India);
- 29 countries prohibit sexual harassment only with criminal sanctions (Bolivia, Nicaragua, Algeria, Nigeria, Bulgaria, Hungary, Afghanistan or Thailand);
- 26 countries prohibit sexual harassment with only civil remedies (United States of America, South Africa, Zimbabwe, Norway, Slovakia, Czech Republic, Poland, Sweden, Australia or Mongolia);

- 15 countries have only a general ban on sexual harassment (Argentina, Chile, Libya, Liberia, Russia, Uzbekistan, Indonesia or Japan);
- 11 countries have no measures against sexual harassment (Ecuador, Uruguay, Somalia, Mauritania, Moldova, Switzerland, Tajikistan or the DPRK).

Figure 2 specifies in more detail whether the law in the countries allows discrimination in the workplace.

Figure 2: Map of countries of the world reflecting legal protection against discrimination in the workplace



Source: own elaboration according to www.wageIndicator.org (2022b)

The world as a whole is:

- 37 countries that do not meet at least 7 out of 10 criteria for combating discrimination (Cuba, Guatemala, Egypt, Libya, Austria, Saudi Arabia, China or India);
- 98 countries that prohibit discrimination in the workplace (Mexico, Colombia, Niger, Ethiopia, V4 countries, Ukraine, Cambodia or Iran).

Sweden was the first country to pass anti-bullying legislation. It took nine years before the next country, which was France, followed by Belgium and the United Kingdom, decided to take this legislative step. The second country to adopt such legislation was France, followed later by Belgium and the United Kingdom. What is notable about the Swedish, French and Belgian legislation is the focus on mobbing as an employer issue. The Swedish and French approaches require employers to create anti-mobbing policies and place the burden of preventing mobbing solely on employers. Belgian legislation goes a step further and requires employers to employ a prevention counsellor who is trained to mediate workplace relations, including the recognition, prevention and resolution of cases of psychological and sexual harassment (Browne and Smith, 2008).

3.1. Legal regulation of pathological relationships in Europe

The first rule that applies to the prevention of mobbing was adopted in Sweden in 1993. It was the regulation on victimization at work, which applies to all activities where employees may be exposed to victimization. This document defines bullying in a way that uses the term "victimization." Thus, victimization can include periodic, repeated, admonishing, or significantly negative actions that are directed against individual employees, are expressed in an offensive manner, and can lead to his isolation and exclusion from the working community (Rodic, 2016). This document is intended for the employer to organize work and provide

conditions that will largely suppress victimization. It emphasizes its obligation to cooperate with the union. In order to effectively implement the regulation, the National Board for Safety and Health at Work (Swedish National Board for Safety and Health at Work) issued a general recommendation detailing the specific causes and consequences of workplace victimization (Browne and Smith, 2008).

In France, this term is defined as "moral harassment." In addition to criminal prosecutions, the protection of this phenomenon is also provided by labour law and a special law. These laws impose sanctions for violators of the ban on mobbing. Thus, the Criminal Code stipulates a one-year prison sentence and a fine of fifteen thousand euros for the perpetrator, while the Labor Code foresees a one-year prison sentence and/or a fine of 750 euros. The French Social Modernization Act of 2002 prohibits discrimination in the exercise of labour rights (the right to remuneration, professional development, and career advancement) as well as protection against termination of employment linked to moral harassment or the dismissal of an employee. The employer is obliged to develop a prevention plan and an annual action plan to prevent abuse. One of the solutions that significantly contributes to the prevention of mobbing in the workplace is the employer's obligation to appoint commissioners to prevent abuse. The commissioner is considered to be an internal body of the employer, which is autonomous in its work and at the same time participates, among other things, in developing the analysis of the risks of prohibited conduct and taking preventive measures. The employer is responsible for the implementation of these measures, which in this context has the obligation to carry out a "risk analysis" of mobbing in the workplace. The analysis is based on questionnaires and interviews related to the research of potential situations that can lead to behaviour representing bullying at work (Rodic, 2016).

On August 10, 2020, the first Romanian normative act explicitly regulating moral harassment entered into force. Law no. 151/2020, amends the Labor Code and, in particular, Act No. 167/7. of August 2020, amending Government Regulation No. 137/2000 on preventing and punishing all forms of discrimination. The first Romanian regulation on moral harassment, on discriminatory and abusive behaviour at work, violation of dignity, rights to equality, physical or psychological integrity, can play a determining role in the way this multifaceted complex, destructive phenomenon is perceived and respected in Romanian society. The existence of the legal framework, repressive, protective and preventive measures of the legislation should be coordinated with raising awareness of the seriousness of moral harassment, not just fighting against it. To understand how abusive behaviour manifests itself and to educate people to protect their own rights and respect the rights of others (Bejan, 2020).

According to the Labor Code, labour protection is an integral part of labour relations. The employer's duty is to ensure the safety and health protection of employees at work. Discrimination of employees is dealt with by Act No. 365/2004 Collections of laws. It defines (among other things) direct and indirect discrimination, harassment, sexual harassment, and incitement to discrimination. It also deals with ensuring equality, methods of legal protection, judicial enforcement, and accounting for non-monetary damages. He claims that the employer and the union body that concluded the collective agreements are obliged to bring the provisions of the collective agreements into compliance with the anti-discrimination law. This law also adopts the legal acts of the European Communities and the European Union. According to Act No. 9/2010 Z. z. about complaints, file a complaint to protect your rights or interests protected by law if they have been violated. The Anti-Discrimination Act provides an opportunity to seek legal remedies if it believes that these rights have been violated and the business has not taken adequate legal procedures to resolve them. The "Public Defender of Rights" institute has been operating in the Slovak Republic since 2002, where employees can also address the problem of

bossing (Droppa et al., 2018). The fulfilment of a specific form of discrimination is one of the basic conditions for violating the prohibition of discrimination. The UN Committee on the Elimination of Discrimination against Women stated that the forms of discrimination defined by the currently valid and effective anti-discrimination law do not sufficiently cover all situations that should be considered discrimination. However, this does not only apply to discrimination against women but also applies to other discriminatory grounds (Cunderlik et al., 2017).

3.2. Legal regulation of pathological relationships in Asia and Oceania

The Racial Discrimination Ordinance and Employment Code 2009 in Hong Kong prohibit discrimination and harassment of employees in the workplace. It is illegal under the law to discriminate against, harass, or condemn a person based on determinants such as race, colour, origin, national, or ethnic origin. However, this law does not cover discrimination based on religion (Akella, 2020).

The legal system of Uzbekistan does not provide effective protection mechanisms, especially when it comes to bullying and mobbing. It is therefore necessary to start from the Code of the Republic of Uzbekistan on administrative responsibility, where, for example, the penalty for slander or, for example, the protection of one's honour and business reputation in civil court proceedings is regulated. Another document that can be used as a starting point is the Criminal Code of the Republic of Uzbekistan (Vasyaev and Shestak, 2020).

In both Russia and Kazakhstan, society mostly condemns the victims of violence; the legislation ignores them and is limited to the existence of criminal law norms, which are not practically applied (Golovina and Voitkovska, 2020). For example, there is no legal definition of mobbing and bullying in the legislation of Kazakhstan or Russia. However, perpetrators of pathological relationships at the workplace in Kazakhstan can be brought to court by qualifying their actions as slander, refuting information that discredits the honour, dignity, or business reputation of a person based on the Civil Code of the Republic of Kazakhstan or the Criminal Code of the Republic of Kazakhstan (Kintonova et al., 2021).

It can be concluded that Japan has relevant legislation to prevent and address workplace harassment or bullying, including acts of physical violence, verbal abuse, intimidation, and social ostracism. They are stipulated in the Act on General Support of Labor Policy. However, these are not prohibitive provisions that can serve as a basis for civil claims for damages. Instead, they are provisions that set out the obligations of the national government, employers, and workers, and at the same time impose an obligation on employers to develop systems and take other such measures to prevent power harassment. The Ministry of Health, Labor, and Social Affairs considers bossing in Japanese workplaces unacceptable and as an expression against the dignity and well-being of the employee (Fumiko, 2021).

The Korean constitution, on the other hand, directly recognizes equality between the sexes, prohibits discrimination during maternity and childbirth, supports the workforce of women, and thereby ensures the quality of the working environment, workforce, and the working and family life of employees. In addition, the national government introduced a bill that currently imposes a criminal sanction on top management of a company for workplace harassment. All corporations in Korea are advised to review organizational policies and procedures, make appropriate adjustments, and monitor developments in the country (Seo and Hong, 2019).

The Australian Fair Work Commission (FWC) is given statutory authority to deal with complaints about workplace bullying. This is possible only on the condition that the worker is harassed while performing a constitutionally protected activity. The FWC defines bullying as repeated and unreasonable behaviour that is aggressive, intimidating, includes disparaging

comments, malicious rumours, social isolation, and assigning too much or too little work. It leads to health and safety problems for employees in the workplace. If an employee believes they have been the victim of bullying, they can apply to the FWC to stop the bullying. The FWC must then investigate the matter. If bullying has occurred, the FWC will issue an order to the employer to stop the bullying in the workplace with immediate effect. The FWC is also obliged to process the application within 14 days of receiving the complaint. This law does not apply to management control measures taken by senior employees to guide employees in organizations. Ultimately, it is necessary to rely on laws such as the Fair Work Act of 2009, the Gender Equality in the Workplace Act of 2012, or the amendments to the Health and Safety at Work Act of 2011 (Akella, 2020).

3.3. Legal regulation of pathological relationships in Africa and Middle East

In South Africa, the Protection from Harassment Act 2011 protects individuals from harassment and provides redress for victims. The Amendment to the Employment Equality Act and Employment Equality Regulation 2014 applies to all employers and workers, providing protection to all workers and potential employees from unfair discrimination. The Occupational Safety and Health Act 1993 contains legal clauses relating to the health and safety of individuals in workplaces (Langeveldt, 2023).

The purpose of the Prevention of Sexual Harassment Act of 1998, amended in 2014 in Israel, is to prohibit sexual harassment of employees in the workplace, protect their dignity and self-respect, and ensure the freedom, privacy, and equality of employees within the enterprise. At the same time, employers are obliged to develop and implement preventive measures against sexual harassment in the workplace. If the employer does not do so, he bears both criminal and civil liability. Employers guilty of sexual harassment face up to four years in prison. The Equal Employment Opportunity Act of 1988, as amended in 2014, prohibits discrimination on the basis of race, ethnic origin, age, marital status, religion, sexual orientation, and political affiliation at all stages of employment. This also includes hiring, training, working conditions, promotion, severance, and retirement benefits. Israel is taking steps to implement legal laws on workplace bullying. Recently, in 2015, a bill on the prevention of abuse in the workplace passed preliminary reading (Akella, 2020).

It can be said that the legislation is relatively new in Turkey. It can be explained by the relatively late recognition of the criminal dimension of mobbing behaviour. For this reason, mobbing in the workplace is not yet fully defined, and the legal regulations in this area are not sufficient. There is no provision in the Turkish legal system that directly deals with mobbing; such cases are assessed by some articles of the Obligation Law, Labor Law, Criminal Law, and Civil Law. However, this situation can create a gap in mobbing, and at the same time it can weaken the evidence of mobbing behaviour in the workplace and the fight against this behaviour, causing mobbing to become a problem (Donar and Yesilaydin, 2022).

3.4. Legal regulation of pathological relationships in America

In Ecuador, the Labor Code (Asamblea Nacional, Law of 2021) states in Article 1 that all labour relations between employers and employees in all modalities and working conditions are regulated and harmonized with the proposal of the International Labor Organization. He states that it is necessary to establish legal regulations that frame this activity through a contract guaranteeing the interests of both the employer and the worker. According to these definitions, work is subject to laws for the benefit of both parties involved, so mobbing is of interest because it threatens the rights and well-being of workers in the workplace. The state must take into account the psychological consequences that may occur in workers (stress, anxiety, fear, and

loneliness) as well as the physical consequences (some diseases that developed during the health crisis in the families of Ecuadorian society) (Naranjo-Zambrano et al., 2023).

Colombia is one of the first countries to legislate this phenomenon through a special law (Law 1010 of 2006, through which measures are taken to prevent, remedy, and punish bullying in the workplace and other bullying in the framework of labour relations), thus contributing to its visibility. However, according to the authors Seco-Matin and Lopez-Pino (2015), the government only tried to restore the image of the country at the international level, far from respecting human and labour rights.

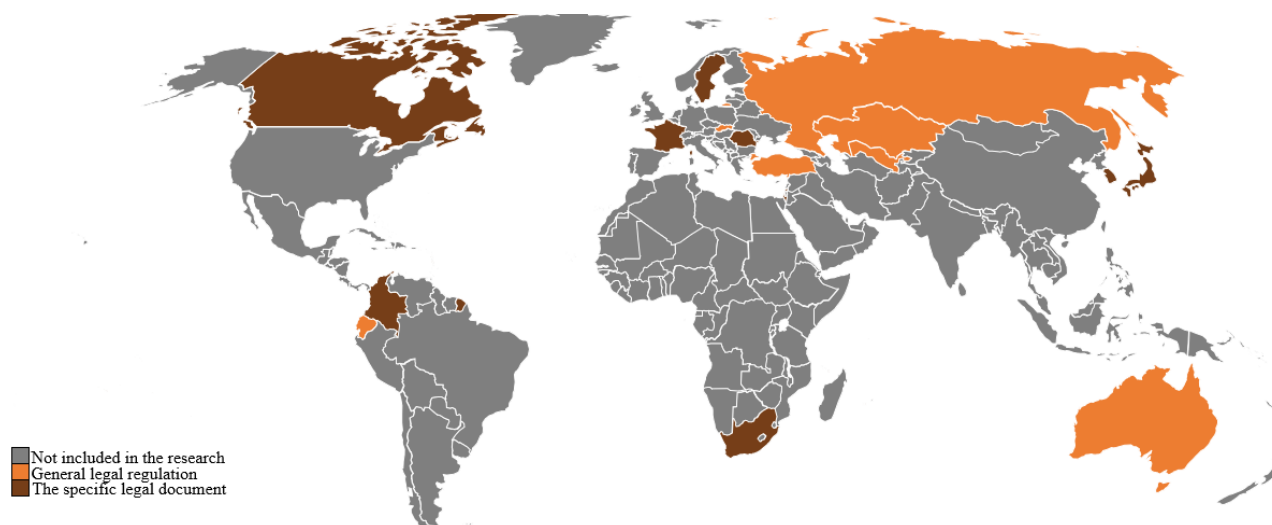
The Canadian Human Rights Act of 1985, as last amended in 2014, prohibits employers from discriminating or discriminating against employees directly or indirectly on any of the prohibited grounds of discrimination during employment. The aforementioned law applies to sexual harassment. Sexual harassment is not permitted in all workplaces in Canada. The law contains enactments dealing with equal pay for employees regardless of gender. The Canada Labor Code, as amended in 2016, consolidates all labour laws that govern work in organizations in Canada. Part XX of Canada's Occupational Health and Safety Regulations deals with workplace violence. Violence in the workplace can be defined according to the regulation as all actions, behaviours, threats, or gestures that can cause damage, injury, or illness to an employee. Unlike Canada, which has had concrete legal protections in the form of several amendments in recent years, workplace bullying has not had a strong presence in the US in recent years. Therefore, it is possible to state that the USA tends to lag behind in the addressed issue (Akella, 2020).

4. Conclusions

Based on the findings, we decided to create a comparison of the legal regulation of pathological relationships in selected countries and create recommendations for the legislation valid in the territory of the Slovak Republic. Based on the representation of the countries (Figure 3), it can be concluded that only ten countries have legislation dealing with the manifestations of pathological relationships at the workplace. However, it is possible to see that the Slovak Republic does not have a specific legal regulation dealing with workplace bullying, similar to, for example, Russia, Kazakhstan, or Turkmenistan. In Australia, there is a Fair Work Commission (FWC), which, however, already defines bullying and can even be appealed to by an employee. The organization then investigates the issue of bullying. On the other hand, we have countries like Colombia, which has had its legislation since 2006, or Romania since 2020.

Although Slovakia has an Anti-Discrimination Act, we are inclined to the opinion of Nekoranec and Kmosena (2015) that the Anti-Discrimination Act is not sufficient. This law does not allow discrimination on various grounds such as gender, race, religion, etc. However, there is no mention of workplace bullying in the law. The issue of pathological relationships, as we demonstrated in the submitted dissertation, is a complex issue that includes not only discrimination or sexual harassment but also other manifestations. For the stated reasons, we therefore consider it crucial to include in the legislation an amendment to the Anti-Discrimination Act, within which the term bullying at the workplace should be supplemented and its specific definition established, as we do not consider the term harassment, which is defined in the Anti-Discrimination Act, to be sufficient. For this reason, we recommend adopting the definition of workplace bullying according to the Australian Fair Work Commission (FWC) into the legislation, as this definition includes many manifestations of pathological relationships in the workplace and at the same time mentions the fact that the employee has health problems. The wording should read as follows: Bullying is repeated and

Figure 3: Map of countries with legal regulation of pathological relationships in the workplace



Source: own elaboration

unreasonable behaviour that is aggressive and intimidating; it includes disparaging comments, malicious rumours, social isolation, and being given too much or too little work, which leads to health, financial, social, and safety problems for employees at workplaces. This would lead to the introduction of a generally known and frequently occurring phenomenon in the world. At the same time, we consider it essential that the law, whether anti-discrimination or the Labor Code, states the obligation to directly implement measures ensuring the minimization of bullying in the workplace and its individual manifestations and to grant the employer the obligation to remove bullying at its own expense in the event of bullying and at the same time protect the employee from dismissal or reassignment to a less qualified position, similar to Sweden or France. This is mainly due to the fact that we have shown in our survey that the victim of bullying is moved to another job position or prefers to leave the organization.

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THE USE OF BANKRUPTCY MODELS IN THE CONTEXT OF ASSESSING THE MACROECONOMIC BUSINESS ENVIRONMENT

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Abstract:

Research background: Predicting economic crises and assessing macroeconomic stability are among the most important challenges of the contemporary economy. Bankruptcy models, originally developed to assess the financial health of businesses, are increasingly being used for macroeconomic analysis

Purpose of the article: The aim of this paper is to analyse the impact of selected economic and institutional factors on the stability and efficiency of the business environment through discriminant analysis.

Methods: The model includes factors such as average quality of education, amount of R&D spending, education spending, financing of the judiciary, duration of litigation, market risk, number of venture capital investors, and government debt to GDP.

Findings & Value added: The results show that high education and judiciary spending, along with a higher number of venture capital investors, contribute significantly to the positive results of the model, indicating the need to support these areas to improve economic performance. Conversely, high R&D expenditures and lengthy judicial processes emerged as factors negatively impacting the efficiency of the business environment. The presence of venture capital has proved crucial for market dynamism and growth, while government debt has had only a minimal impact. The findings provide valuable information for policy makers and investors on optimising public spending and promoting key factors that have the potential to improve economic competitiveness and the stability of the business environment.

Keywords: discriminant analysis; macroeconomic environment; bankruptcy models

JEL Classification: C02; C38; C51

1. Introduction

Predicting economic crises and assessing macroeconomic stability are among the most important challenges of the contemporary economy. Bankruptcy models, originally developed to assess the financial health of businesses, are increasingly being used for macroeconomic

analysis (Athanasios et al. 2022). These models provide tools to quantitatively assess the risk of financial distress and thus potentially help to predict the possible bankruptcy or, conversely, the prosperity of specific economies. However, with the development of globally interconnected markets and the rising debt of many countries, the identification and prediction of sovereign bankruptcy is an issue that is increasingly resonating in both economics and political decision-making (Wang and Sun, 2006).

The aim of this paper is to propose a model that would allow to classify the economies of countries into one of two categories: prosperous and bankrupt states. This model is intended to serve as a tool for early recognition of macroeconomic risks and has the potential to provide objective information for economic policy makers and financial stability institutions. Forecasting models based on a combination of financial and non-financial indicators provide valuable information that can be used to assess economic stability and predict the risk of sovereign default, thus contributing to the stabilisation of the global economic environment.

Research on this issue is particularly important because of the increasing instability of the global financial system and the rise of sovereign default risk in the contemporary world. In an environment of high country indebtedness, political conflict and frequent economic shocks, understanding the factors leading to sovereign bankruptcy is essential for designing effective economic policies. In addition, accurate prediction of sovereign default risk can help to protect investors and increase confidence in international markets. The results of this research can provide insights that will enable improved assessment of countries' economic conditions and thus contribute to a more stable and predictable macroeconomic environment. This paper therefore makes a contribution not only to economic theory but also to the practice of international finance and macroeconomic policy.

2. Literature review

The process of globalisation has helped the concept of competitiveness to move from the corporate level to the international level. However, the concept of competitiveness is not clearly and precisely defined. Ceptureanu (2016) says that competitiveness is a complex concept that is closely related to factors such as sustainable development, standard of living, productivity and economic growth. He presents a new methodological and theoretical approach to this issue, pointing to the development of competitiveness as a separate field of economics with its own tools and concepts. According to a study by Rajnoha and Lesnikova (2022), higher competitiveness of a country leads to GDP growth, which positively affects sustainability and quality of life. They proposed a mechanism for sustainable competitiveness that includes investment in research, technology and ecology for long-term growth and well-being. At the macroeconomic level, Balkyte and Tvaronaviciene (2010) point to new trends in competitiveness theory, especially in the context of global challenges such as sustainable development. According to the authors, there is a need to develop a concept of 'sustainable competitiveness' that considers economic dynamism, social progress and environmental sustainability. Ketels and Porter (2021) examine why Europe has not made more progress in increasing competitiveness despite numerous EU initiatives, identifying the main problem as the inability to adapt policy approaches to changing conditions. They propose a new role for the EU to support Member States and regions to increase their competitiveness in line with current challenges.

Aranguren and Margo (2020) examine the role of academic institutions in the competitiveness policy-making process. They argue that these organisations can play a key role in the process of adaptive implementation where they serve as founding institutions. Hrabanova

(2011) discusses the concept of the knowledge economy and its impact on competitiveness. She argues that in the current environment where information and communication technologies play a key role, information and knowledge are key drivers of competitive advantage. However, the knowledge economy can also lead to differentiation, particularly in terms of income, which can have a negative impact on social cohesion. Xu (2015) conducted a similar study, analysing the relationship between knowledge competitiveness and industry economic competitiveness, and argues that knowledge competitiveness is a key factor influencing a country's economic competitiveness.

Ruzekova et al. (2020) analyse the impact of the institutional environment on the competitiveness of the national economy, using export performance as a key indicator. Their research showed that export performance is not a universal indicator of competitiveness, suggesting the need to use multi-factor indicators to measure competitiveness more accurately. Therefore, Androniceanu et al. (2020) focused on the multidimensional assessment of competitiveness, welfare, innovation and concluded that there is a direct and strong relationship between competitiveness, innovation and welfare. Governments and organisations that invested more in research in the sense of innovation to increase the competitiveness of their products and services had higher GDP growth and higher levels of well-being of the population. Cieslik and Michalek (2018) identified the following factors increasing welfare, prosperity and economic growth: population growth, working time, technology, specialization, capital, labour and productivity, as well as various institutional factors such as the political system, economic freedom and development. Bencsik and Trunkos (2009), in turn, examined the impact of lifelong learning on quality of life and concluded that in several Western European countries, such as Denmark, Germany and Sweden, where adult education has a long tradition, a high level and quality of adult education is a determinant of quality of life. Sebo and Sebova (2010) approach competitiveness assessment from the perspective of product competitiveness. They propose the use of statistical methods, particularly multicriteria evaluation, as a tool for assessing different aspects of product competitiveness.

Climate change and global warming have forced economists and scientists to broaden the concept of competitiveness to include an environmental aspect. Recently, the term "eco-innovation" has also been used, Loucanova et al. (2017) associate this term with organizational innovations, innovative products or processes that aim to reduce environmental costs, increase social acceptance and ultimately achieve sustainable development. Xie et al. (2019) analysed 209 enterprises belonging to "polluting industries", concluding that green product innovation also has a positive impact on the financial performance of the enterprise. In contrast, Dechezlepretre and Sato (2017) argue that environmental regulations can lead to statistically significant adverse effects on trade, employment, plant location, and productivity in the short run, especially in a well-identified subset of pollution- and energy-intensive industries, because the resulting benefits do not appear to be large enough to outweigh the costs of the regulated entities. Ketels and Porter (2021) published a similar study, concluding that environmental regulation unnecessarily increases costs and thus retards environmental progress. In particular, costs increased due to the need to comply with regulations, neglecting the benefits created by innovation, and this affected the competitiveness of the industry.

3. Methodology

Discriminant analysis is a parametric method for determining which weights of quantitative variables or predictors most effectively discriminate between two or more groups of cases better than random selection (Cramer, 2003). This analysis produces a discriminant function that is a

linear combination of the weights and scores of those variables. Discriminant analysis is a frequently used statistical method in many scientific fields, especially in natural and socio-economic disciplines (Kral et al., 2009). Discriminant functions are linear combinations of variables that contribute most to the resolution of k groups within multivariate observations. Their goal is to identify a subset of variables that can discriminate groups almost as efficiently as the total set of original variables. After selecting the variables with the highest ability to discriminate between groups, the next step is to order these variables according to their contribution to group separation (Rencher and Christensen, 2012). According to Hair et al. (2014), discriminant analysis encounters a classification problem in which two or more groups are known in advance, and individual observations are classified into one of these groups based on the measured values. Linear discriminant analysis can be said to be a dimensionality reduction method, and its main goal is to project the data into a space of lower dimensionality characterized by higher separability between groups.

First, it is necessary to establish the objective of the analysis, which is to distinguish countries on the basis of the quality of their business environment and to develop a classification rule to correctly assign them to one of two groups: countries with developed business environments (code 0) and countries with underdeveloped business environments (code 1). Data on the countries is then collected, identifying variables describing the business environment. Based on the studies already carried out, the following variables have been identified as relevant for describing the business environment: average quality of education (X1), amount of expenditure on research and development (X2), expenditure on education (X3), expenditure on the judiciary (X4), average number of days to process a civil dispute (X5), market risk (X6), number of venture capital investors (X7), government debt to GDP (X8). These data are prepared for analysis, which involves standardising the values and checking the completeness and accuracy of the records. Table 1 summarises selected data.

Table 1: Summary of selected data

Countries	Country code	X1	X2	X3	X4	X5	X6	X7	X8
Netherlands	0	502.33	2.2	5.20%	0.27%	127	0.00%	0.2	52.4
Denmark	0	501.00	2.9	7.80%	0.17%	190	0.00%	0.3	36.7
Sweden	0	502.33	3.4	7.60%	0.27%	161	0.00%	0.2	36.7
Ireland	0	504.67	1.2	3.50%	0.30%	118	0.84%	0.2	56
Luxembourg	0	476.67	1.2	3.60%	0.17%	161	0.00%	1.2	24.4
Finland	0	516.33	2.8	6.40%	0.19%	300	0.39%	0.2	65.8
Germany	0	500.33	3.2	4.90%	0.35%	237	0.00%	0.1	69.3
Austria	0	491.00	3.2	5.40%	0.32%	156	0.39%	0.1	82.8
Belgium	0	500.00	2.9	6.40%	0.22%	399	0.60%	0.1	108.2
Estonia	0	525.33	1.6	5%	0.26%	135	0.70%	0.4	18.1
France	0	493.67	2.2	5.50%	0.21%	637	0.49%	0.2	112.9
Czech Republic	0	495.33	1.9	3.90%	0.32%	165	0.60%	0.0	41.9
Lithuania	0	479.67	1	3.80%	0.27%	117	0.84%	0.1	44.3
Cyprus	1	438.00	0.6	5.80%	0.27%	617	2.47%	0.1	103.6
Spain	1	482.67	1.2	4.20%	0.37%	468	1.58%	0.0	118.4
Portugal	1	492.00	1.4	5%	0.30%	280	1.88%	0.1	127.4
Latvia	1	487.33	0.6	4.40%	0.37%	239	1.19%	0.1	44.8
Slovenia	1	503.67	2	4.80%	0.45%	350	1.19%	0.0	74.7
Poland	1	513.00	1.3	4.60%	0.30%	317	0.84%	0.0	53.8
Italy	1	477.00	1.4	4%	0.30%	674	2.18%	0.0	150.8
Hungary	1	479.33	1.5	4.70%	0.40%	165	1.88%	0.0	76.8
Bulgaria	1	426.67	0.8	4.10%	0.61%	660	1.58%	0.0	34.4
Romania	1	428.00	0.5	3.10%	0.44%	168	2.18%	0.0	48.8
Slovak Republic	1	469.33	0.8	3.90%	0.43%	204	0.84%	0.0	63.1
Greece	1	453.33	1.3	3.70%	0.29%	551	3.56%	0.0	193.3
Croatia	1	471.67	1.1	3.90%	0.53%	665	2.47%	0.0	79.8

Source: own elaboration

Countries will be divided into two groups based on the International Institute for Management Development's competitiveness rankings. Discriminant analysis is applied to the data, which is carried out in the statistical software SPSS. The model calculates discriminant functions which are linear combinations of the independent variables. The significance of the individual variables is verified using Wilks' lambda and p-values. Those variables that show statistical significance are considered as key variables.

Next, the assumptions of the discriminant analysis are tested, in particular the equality of covariance matrices between groups, which is verified by the Box test. If the assumptions are met, the discriminatory ability of the model is assessed using canonical correlation and statistical tests. On the basis of the discriminant functions developed, a classification rule is constructed which allows countries to be assigned to groups based on their discriminant scores.

Finally, the model is validated using a test sample or cross-validation methods to verify its accuracy and reliability. The results of the analysis are interpreted in terms of the ability to distinguish between groups, key variables are identified and the applicability of the model to other data is assessed.

4. Results

After collecting all the data in SPSS statistics, we build the model via Analyse-Classify-Discriminant, next we consider the output of the program (Table 1).

Table 2: Comparison of the significance of input variables

	Wilks' Lambda	F	df1	df2	Sig-value
Average quality of education	0.681	11.249	1	24	0.003
Expenditure on research and development	0.550	19.649	1	24	0.000
Education expenditure (% of GDP)	0.827	5.022	1	24	0.035
Judicial expenditure (% of GDP)	0.590	16.693	1	24	0.000
Number of days to process a civil dispute	0.763	7.448	1	24	0.012
Market risk	0.375	39.946	1	24	0.000
Venture capital investors	0.763	7.448	1	24	0.012
Government debt to GDP	0.843	4.455	1	24	0.045

Source: own elaboration

To assess the significance of the input variables, we will compare the last column called sig-value. Before assessing the significance of the input variables, we will set the null and alternative hypothesis at significance level at 5 %:

H0: The input variable is statistically insignificant.

H1: The input variable is statistically significant.

By comparing the individual sig-values with the significance level, we concluded that all variables are statistically significant. The observed parameters are clearly different in countries with developed and countries with underdeveloped business environments.

This is followed by Box's test of the goodness of fit of the covariance matrices. The Box test shows that the covariance matrices can be identical. The log determinants of the covariance-covariance matrices of each group are identical.

Table 3: Box test for equality of covariance matrices

Country development	Rank	Log determinants
0	8	5.146
1	8	5.064
Grouped within groups	8	10.075

The order and natural logarithms of the determinants are from the group covariance matrices.

Source: own elaboration

Table 4: Result of the Box test

Box's M		119.272
F	Estimate	2.094
	df1	36
	df2	1,938.156
	Sig-value	0.000
Tests of the null hypothesis of equal population covariance matrices.		

Source: own elaboration

In the next section of the deliverables, we evaluate the canonical correlation of the discriminant function and its statistical significance. These correlations are used to assess the resulting quality of the model, and thus whether the canonical discriminant functions clearly distinguish (discriminate) the groups formed. We identify two groups of countries, i. e., one discriminant function. Table 6 shows the values of the correlation coefficients between the discriminant function and each of the explanatory variables; these are also used to assess which variables have the greatest discriminatory ability. Results indicates that the correlation between the discriminant function and the explanatory variables is statistically significant (Sig. < α (0.05)), the resulting canonical correlation is 0.930, i.e. very high. The absolute values of the standardized coefficients of the canonical discriminant function provided us with information about the discriminant property of the selected variables (Table 5).

Table 5: Canonical correlation of the discriminant function

Eigenvalues				
Function	Eigenvalue	Deviation %	Cumulative %	Canonical correlation
1	6.374 ^a	100	100	0.930

^a1 canonical discrimination function was used in the analysis.

Source: own elaboration

Table 6: Test of statistical significance

Wilks' Lambda				
Chi-square	Wilks' Lambda	Chi-square	df	Sig-value
1	0.136	39.959	8	0.000

Source: own elaboration

Table 7 shows that the relationship between the discrimination function and market risk and judicial spending is moderately strong. Further, the dependence between the discriminant function and the number of days to process civil litigation and the amount of government debt is weak.

Table 7: Coefficients of the discriminant function

	Function
	1
Average quality of education	0.400
Expenditure on research and development	-1.791
Education expenditure (% of GDP)	1.474
Judicial expenditure (% of GDP)	1.657
Number of days to process a civil dispute	-0.469
Market risk	0.176
Venture capital investors	0.303
Government debt to GDP	1.563

Source: own elaboration

The table shows that coefficients close to zero have a low impact on the discriminant function; at the same time, negative values of the coefficients rank countries towards alternative group membership. The indicators with the highest discriminatory power are judicial expenditure, government debt to GDP and education expenditure.

Table 8: Assessment of the strength of dependence of the coefficients

	Function
	1
Market risk	0.511
Research and development expenditure	-0.358
Judicial expenditure (% of GDP)	0.33
Average quality of education	-0.271
Venture capital investors	-0.221
Number of days to process civil litigation	0.221
Education expenditure (% of GDP)	-0.181
Government debt to GDP	0.171
Pooled within-group correlations between discriminant variables and standardized canonical discriminant functions	
Variables sorted by absolute magnitude of correlation within the function.	

Source: own elaboration

Through the non-standardized coefficients of the canonical discriminant function, the resulting discriminant equation of the prediction model for EU countries can be written, it takes the form:

$$y_M = -19,901 + 0,019 \cdot X_1 - 2,663 \cdot X_2 + 1,1316 \cdot X_3 + 19,844 \cdot X_4 - 0,003 \cdot X_5 + 0,299 \cdot X_6 + 1,404 \cdot X_7 + 0,04 \cdot X_8 \quad (1)$$

Discrimination scores (Z-scores) for each country can be computed through the non-standardized coefficients of the canonical discriminant function. On the basis of its comparison with the centroids, a decision can be made to classify a country into the group with a developed business environment or with the remaining business environment.

Table 9: Centroids for a general model for assessing the business environment of countries

Landscape development	Function
	1
0	-2.426
1	2.426
Unstandardized canonical discriminant functions evaluated at group means	

Source: own elaboration

SPSS also uses the model constant to calculate the centroids, thus making a targeted correction so that the weighted average of the centroids (weighted by the number of countries in each group) is zero. Comparing the Z-score values with zero then determines the outcome, a positive value indicates a developed business environment and a negative value indicates a backward business environment.

Table 10: Classification table

Landscape development			Expected group membership		Total
			0	1	
Original	Count	0	13	0	13
		1	1	12	13
	%	0	100	0.0	100.0
		1	7.7	92.3	100.0

96.2 % of the original merged cases are correctly classified.

Source: own elaboration

Considering the reported results, it can be summarized that the model for countries with developed business environments has 100 % classification ability. And the model for countries with underdeveloped business environment has 92.3 % classification ability. However, caution should be exercised because if the model is validated on the same data on which the model was built, its classification ability is overestimated.

5. Discussion

The results of the discriminant analysis suggest a number of interesting conclusions that are consistent or contrast with the existing literature. The average quality of education (X1) has a moderately positive effect on the observed outcome, suggesting that education plays an important role. This conclusion is supported by Ponomarenko et al. (2022) who emphasize the need to implement total quality management (TQM) philosophy in educational institutions in order to increase their competitiveness. Similarly, Iatagan (2015) highlights the importance of quality assurance and international cooperation in higher education to improve the competitiveness of universities.

On the other hand, the negative impact of R&D spending (X2) contrasts with the findings of Ravselj and Aristovnik (2019), who have shown long-run positive effects of R&D on firm performance. This difference may be explained by regional specificities or the short-run nature of the data analysed. However, Sofrankova et al. (2018) points out that in the V4 countries, higher R&D expenditures contribute to the development of innovation activities and improved competitiveness, suggesting that the effectiveness of these investments may depend on their regional and sectoral context.

The positive impact of spending on education (X3) and a quality judiciary (X4) on the outcome is consistent with the findings of Kirovska et al. (2022), who identify positive associations between the efficient functioning of the judicial system and foreign investment inflows. Conti and Valentini (2018), in turn, emphasize that an independent judiciary promotes entrepreneurship and lowers barriers to entry. Thus, judicial support is a key factor to increase economic stability and competitiveness.

Market risk (X6) and the number of venture capital investors (X7) show a significant positive impact on the result, suggesting that a dynamic business environment can support economic growth. This conclusion is in line with the work of Bobakova and Cepelova (2014), who highlight the low level of venture capital use in Slovakia and its potential as a key factor for financing innovation. Moreover, Hnoievyyi et al. (2022) stress that the development of venture capital is essential for enhancing innovation performance and economic growth. The slightly positive impact of government debt (X8) suggests that as long as debt is manageable, it may not be a major obstacle to economic growth. The findings of Kiselakova et al. (2018) show that effective public financial management and increasing R&D spending in the education sector can contribute significantly to improving the competitiveness of CEE countries.

Finally, Lysokon et al. (2024) emphasise the importance of strategic management of education and continuous improvement of the quality of the teaching process, and this comprehensive approach can inspire policies aimed at the efficient use of public resources. Habermeier (2007) points to the key role of education and technological innovation in building the macroeconomic strength of countries, reinforcing the need for investment in education quality and the promotion of innovation.

On the basis of the above, it is recommended to focus on increasing the efficiency of public spending, supporting venture capital and the judiciary, and optimising R&D spending in the long term. Future research could analyse the links between macroeconomic factors and long-term competitiveness trends at the global level.

6. Conclusions

Discriminant analysis has proven its effectiveness in distinguishing countries with developed business environments from those with underdeveloped business environments. The main findings suggest that all selected variables have a statistically significant effect on intergroup

discrimination. The most significant variables included spending on the judiciary, government debt to GDP, and spending on education, with these factors playing a key role in the quality of the business environment. The model showed high classification accuracy, with countries with developed business environments correctly classified with 100% accuracy and countries with underdeveloped environments correctly classified with 92.3% accuracy. The overall classification ability of the model was 96.2%. The canonical correlation between the discriminant function and the explanatory variables was 0.930, indicating a very strong ability of the model to discriminate between groups. This study contributes to the theory of business environment assessment by identifying the key factors influencing the quality of the business environment. The use of discriminant analysis demonstrates how statistical methods can be used to effectively differentiate countries based on their economic and institutional characteristics. The results support the importance of investments in education, judicial efficiency and public financial management in improving the business environment. For policy makers, these findings provide concrete recommendations for improving the business environment. Emphasis should be placed on increasing spending on education and research, reducing the time taken to resolve legal disputes and managing public debt efficiently. The model can be used to regularly assess countries and identify areas for improvement.

Although the model showed high accuracy, it should be noted that it was validated on the same data that were used to build it. This may lead to an overestimation of the classification ability of the model. In addition, the data used for the analysis is limited to a specific time frame, which may affect its generalizability to other periods or regions. The choice of variables was also influenced by data availability, which may mean that some important factors may have been omitted. Future research should aim to broaden the data base and include a wider range of variables that may influence the business environment. Validation of the model should be carried out on an independent test sample or through cross-validation. Another challenge is to examine dynamic changes in the business environment over time in order to track trends and impacts of policy decisions. Future research could also apply discriminant analysis in combination with other methods, such as machine learning or Bayesian models, to improve prediction ability and classification accuracy.

In conclusion, this analysis provides valuable insights into the factors influencing the business environment and provides a solid basis for further research and policy implementation aimed at improving countries' economic and institutional environments.

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CUSTOMER SATISFACTION PREDICTION: A CASE STUDY FOR ELECTRO-BIKE CUSTOMERS

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Abstract:

Research background: Customer satisfaction is one of the key factors influencing businesses' success and long-term profitability. Understanding customer needs and preferences is particularly important in the e-bike segment, which is experiencing dynamic growth. Satisfied customers make repeat purchases, and their recommendations help build a positive brand image, which is essential in a competitive market. Identifying the factors that most influence satisfaction enables companies to adapt their products and services to meet customer expectations better and thus secure a stable position in the market.

Purpose of the article: The article aims to analyse customer satisfaction with e-bikes and identify its key factors. Based on the findings, it offers recommendations for dealers while also proposing a prediction model to understand customer needs better.

Methods: Customer satisfaction with e-bikes was measured through an online survey in the form of a questionnaire. Data collection was conducted from January 2024 to the end of February 2024 and involved 388 respondents. The data collected will be used to create predictive models of customer satisfaction, the accuracy and quality of which will be subsequently compared. The analysis results will also be presented graphically, allowing for a better interpretation of the relationships and trends identified.

Findings & Value added: Five models were created to predict customer satisfaction. The logistic regression method was the most effective based on overall accuracy and sensitivity. This method identified engine brand, battery capacity, and product purchase location as significant variables. This model allows sellers to tailor their offerings better and provide goods significantly contributing to higher customer satisfaction.

Keywords: customer satisfaction; satisfaction prediction; prediction model; e-bikes

JEL Classification: C00; C02; M2

1. Introduction

Paying attention to customer satisfaction is a very key factor nowadays. A good customer experience increases the probability of repeat purchases and overall brand loyalty. A bad customer experience can very quickly damage the reputation of an entire company or brand. If customers are disappointed with products or services, they make it known through social media. Social networks and media have become a firm part of many people's daily lives. However, delivering a good experience and quality customer service is a pragmatic balance between reducing operational costs and investing additional efforts to improve the experience and drive revenue. Customer satisfaction surveys are a great way to understand how customers feel and think and discover what new customers might like about a product. A high satisfaction rate is an important indicator of retaining and winning new customers.

Customer satisfaction refers to the extent to which customers are satisfied with their experience with a given product, service or store. It is a key business metric because it directly affects their success and long-term vitality. If a customer's expectations are met or even exceeded, they are likely to be satisfied (Antonides and Hovestadt, 2021). Happy and satisfied customers mostly become repeat customers, and their recommendations contribute positively to the company's reputation. On the contrary, if the product does not meet the customer's expectations and needs, it brings disappointment, and the customer will probably not continue to purchase that business's products (Knápcíková et al., 2021). Factors that may cause customer dissatisfaction are, for example, poor quality, sub-standard service or unmet expectations. Dissatisfied customers show their dissatisfaction through negative reviews, complaints or by ceasing to be a business customer. It is very important to avoid these complaints because, in today's connected world, these complaints are quickly shared on social media, which can affect the business's overall reputation (Park et al., 2021).

Customer satisfaction results in loyalty, which is often referred to as loyalty. It is what drives a person to repeat purchases and encourages existing customers. Customer care solutions researcher Leonie Brown says: "People who have had a bad experience with a brand, but the brand has made it right, are more loyal than customers who never had a problem in the first place. This is because it involves trust."

Customers are loyal for a variety of reasons that can be grouped into the following loyalty categories (Oracle, n.d.):

- satisfied customers – this category of customers like the products or services, have shopped many times and never complained,
- price-loyal customers – this category of customers is satisfied with the low price of the product or service; if they can save money elsewhere, they will leave,
- loyal to the loyalty program – customers are not loyal to the company but to the loyalty program offered by the company,
- loyal for the benefits – the brand does not attract customers, but by the benefits offered by the company (free internet connection), they buy only sporadically,
- truly loyal customers – customers who make repeat purchases and talk about a great experience with the company.

If an organisation cannot resolve the issue of its customer and its complaints, the business can use ISO 10003 standards, which provide guidelines for both the organisation and external dispute service providers to investigate the complaints further and come to a satisfactory conclusion (Ang and Buttle, 2012).

Measuring customer satisfaction is key for businesses to understand how well they meet customer expectations and identify improvement areas. If a business measures customer

satisfaction, it can grow in the marketplace, improve its brand image, uncover its strengths and weaknesses, and gather new inspiration. Customer review data can be collected from various sources, including online platforms and social networking services. Although customer reviews vary in many data points, they generally provide information about overall satisfaction ratings, customer profiles and content. The basic measure is the overall rating, which can be further used to assess service quality, identify customer complaints and conduct detailed statistical research (Kim and Lim, 2021).

The tools that can be used to measure satisfaction are divided by Hayes (2008) into online surveys, email surveys, customer feedback forms, online reviews and ratings, customer interviews and others. The experiment is one of the most valuable scientifically based research to uncover relationships, causes and consequences of influences. However, using this method is time-consuming. A more widely used method is observation. It is the process of learning about and recording facts without interfering with them. In other words, it helps us discover what is happening. Observation is often combined with enquiry, one of the most widely used and widely used methods. It is the collection of information based on the responses of the persons under investigation using questions. This method includes questionnaires. Data collection can be carried out via face-to-face, telephone, or written questionnaires. The advantage of the online questionnaire solution is that it does not require such a high cost and burden as questionnaires sent by post or in person. It is also possible to reach a segment of the population that is difficult to contact from the company's side. From the customer's side, the advantage is that it is mostly anonymous. (Mateides, 2001a; Mateides, 2001b, Islam et al., 2021)

The aim of the research in this paper is to develop a prediction model of customer satisfaction with e-bikes. Satisfaction includes aspects such as purchase, company attitude and customer care while also considering the customer's initial preference when purchasing the product. Based on the developed model, recommendations can be formulated for manufacturers and sellers of the type of goods.

2. Literature review

Nowadays, every individual is in the role of a customer almost every day. Understanding customers' value and expectations of their treatment is the basis for customer satisfaction analysis. The term "customer satisfaction" can be defined as an emotional state resulting from a positive evaluation of a customer's experience with a company (Agag et al., 2024). In the dynamic modern environment, customers are exposed to a wide range of products and services, with their choices determined by individual preferences and needs. According to Ashworth and Bourassa (2020), customer satisfaction depends on the extent to which their needs and expectations are met. If a product or service fails to meet these needs, it may lead to dissatisfaction and a reduced likelihood of repeat purchases. The issue of customer dissatisfaction and complaints has also been addressed by Kim and Lim (2021), who emphasised the importance of effective service quality management in their research. These authors describe how using customer ratings and statistical process analysis enables businesses to ascertain customer satisfaction systematically and prevent service failure through early identification of serious problems. The combination of these methods supports the ability of businesses to respond effectively to customer complaints at optimised costs. Besides customer satisfaction, understanding consumer behaviour also significantly influences the customer's final decision. With the growing importance of a holistic approach, companies are increasingly focusing on creating emotional experiences. Vrtana and Krizanova (2023) investigated the impact of emotionally attuned advertising appeals on the purchase behaviour of Slovak

consumers. Their results showed a complex relationship between advertising with emotional appeal and purchase behaviour, with negative effects outweighing positive ones in certain age groups.

Protecting the environment is a key global priority, with companies and individuals increasingly seeking sustainable solutions for everyday life. E-bikes have become an important alternative to traditional means of transport as they combine eco-friendliness, flexibility and low cost. Their use contributes to reducing air pollution and promotes the sustainable development of urban areas. Studies by Xia et al. (2022) and Li et al. (2020) investigated the satisfaction of e-bike users in China and identified service quality as a critical factor influencing consumer choice. They found that high service quality positively impacts customer satisfaction, which is particularly crucial when introducing new products such as e-bikes. Nematchoua et al. (2020) focused their analysis on the factors limiting e-bike use, listing lack of safe cycle lanes, high procurement costs, inadequate parking infrastructure and concerns about theft as the main barriers. Despite these barriers, e-bikes scored better in several categories than conventional bicycles, cars or public transport. The e-bike sector is a dynamically growing segment that has the potential to make a significant contribution to the transition to greener cities. However, this development requires an analysis not only of the bicycle production itself but also of the organisation of the whole supply chain. Mina et al. (2024) focused on identifying factors influencing consumer preferences for e-bikes. They aimed to propose strategies to increase the attractiveness of these means of transport, thereby promoting their wider adoption in urban environments.

Customer satisfaction can be measured using various statistical methods, one of the most widely used being the questionnaire survey. According to Terek (2019), the questionnaire survey process includes questionnaire design, data collection and data analysis. In his publication, the author describes in detail the steps required to effectively conduct surveys, from the design of questions to the use of different data collection methods to the statistical processing of the results. Similarly, Patra (2019) defines a questionnaire as a systematic data collection instrument in which respondents answer a series of questions. He emphasises that the design of the questionnaire must be carefully thought out, emphasising the relevance and simplicity of the questions. According to the author, the survey's success is directly dependent on the quality of the questionnaire design, as incorrectly worded questions can skew the results. However, modern technological advances bring new challenges in data collection through questionnaires. Lebrun et al. (2024) point out the risk of automatic completion of questionnaires by artificial intelligence, which can negatively affect the quality of the data collected. Although various platforms for creating affordable and user-friendly questionnaires exist, their dependence on AI-based technologies poses potential problems. The authors highlight the need to find efficient solutions that ensure that the answers in questionnaires come from real respondents, thus maintaining the validity of the data collected.

In their research, Kamalja et al. (2024) describe the use of statistical methods such as chi-square test, tests of independence, and analysis of variance (ANOVA) to identify significant relationships between variables. In addition to retrospective analysis, data can be predicted using modern methods, including machine learning. In their study, Ulrich et al. (2023) present the use of neural networks as a prediction model, and their results confirm the high efficiency of this method in prediction and the development of business strategies. Such prediction enables organisations to understand customer behaviour better and make personalised business proposals to increase customer satisfaction. Another important prediction method is decision trees, which are often used to analyse market trends. Pitka et al. (2024) emphasise the transparency and efficiency of decision trees, which operate on the principle of partitioning data

into individual nodes and leading to accurate decisions. In their study, the authors applied decision trees to classify customer orders to identify patterns in customer behaviour. This method significantly contributes to organisations seeking to understand their market better and tailor their strategies to customer needs.

Measuring customer satisfaction requires a thoughtful approach to questionnaire design and analysis of the data collected. In addition to traditional statistical methods, modern machine learning tools are finding applications, providing new opportunities for understanding customer behaviour. These insights provide a valuable basis for improving customer satisfaction and optimising business strategies.

3. Methodology

In data science, solving the customer satisfaction prediction problem is a classification problem since customer satisfaction is the output variable of interest. For this purpose, we use overall customer satisfaction as the dependent variable. The customer himself determined its value on a 5-degree satisfaction scale. However, for the purpose of this study, we have further converted satisfaction into a dichotomous variable with values of satisfied and dissatisfied customers. We took this step because of the poor representativeness of some of the five categories, which would consequently affect the predictive performance of the models developed.

The satisfied customer group in the dataset includes 342 respondents, while the dissatisfied group includes 46 respondents. As explanatory variables, we included the place of purchase, battery capacity, accessories, brand and type of e-bike, price and the last factor, battery life, in the model.

3.1. Questionnaire survey

We used an online survey in the form of a questionnaire to measure customer satisfaction with the e-bike. The questionnaire was created using the Google Forms platform. It was published in January 2024. The data was collected through social networks. Data collection lasted until the end of February 2024. The target group was exclusively customers who own, know and use the product regularly.

The questionnaire contained 31 closed questions. Of these, the first six questions describe the respondent's position in society: i.e. gender, age, education, region, social status and net monthly income. The remaining questions were product-related and depended on various factors, such as the form of product purchase in a brick-and-mortar store or online. One of the questions was about overall customer satisfaction, and respondents had a choice of five satisfaction levels: very satisfied, satisfied, neutral, dissatisfied and very dissatisfied.

The questionnaire concludes with two questions. The first asked what attributes customers would like to see to make an e-bike more attractive. In the last question, customers could formulate their own recommendations for the manufacturer. These questions are semi-closed, where the respondent could decide whether to choose one answer to the question from the options offered or to write their answer.

3.2. Methods of creating a customer satisfaction prediction model

We then used the data collected through the questionnaire survey to create a predictive customer satisfaction model. The model uses the customer's socio-economic characteristics and preferences in purchasing and using an e-bike.

To predict customer satisfaction, we created and compared several prediction models. To create them, we used four machine learning methods: neural networks, classification trees, logistic regression, and the nearest neighbour method. We characterise these methods briefly.

Neural networks are considered one of the best machine learning algorithms and have a wide range of applications. An artificial neural network is an imitation of a real human neural network. It consists of nodes - neurons interconnected by synaptic fibers, and these connections between neurons have valuations. The neurons are arranged in layers that consist of an input layer, several hidden layers and an output layer. The most important advantage of a neural network is the high accuracy of the predictions. On the other hand, the disadvantage is the computational complexity and the very difficult to impossible interpretation of the model (Taheri et al., 2021).

Decision trees are a useful machine learning algorithm. The tree model has a hierarchical structure consisting of nodes, with the base node called the root node. In the process of decision-making, these nodes gradually branch into smaller parts, resulting in a tree-like structure. Each tree node represents a decision rule according to a selected attribute of the classified object, automatically selected by the method along with a threshold value. Thus, the whole tree model is a set of classification rules. Compared to neural networks, decision trees are more flexible and easy to understand and interpret. Their disadvantage is the need for a large sample size and the prioritization of some variables in rule generation. Different techniques are used for decision tree formation; in this study, we used CHAID (Chi-squared Automated Interaction Detection) and CRT (Classification and regression trees) type trees. CHAID is a decision tree construction technique that is designed for categorical data. It can also construct non-binary trees, meaning nodes can have more than two branches. CRT creates binary trees, meaning only two branches lead from a single node (Gunduz and Al-Ajji, 2022).

Logistic regression is a regression model that is able to predict the probability of an event occurring based on a set of input variable values. This probability can then be categorized to obtain a solution to the classification problem of predicting customer satisfaction. The advantage of logistic regression compared to other methods is its relative ease of interpretation. Limitations of this method include the requirement to meet several assumptions, such as the linearity of the relationship between the dependent variable and potential explanatory variables (Dong et al., 2022).

The nearest neighbour method is used to classify cases based on their similarity to other cases. It is one of the simpler methods to solve the classification problem. The nearest neighbours are found by calculating the distances between the vectors of values of the input variables, and this model predicts the new data cases into a class of found nearest neighbours. The advantage of this model is its ease of interpretation and efficiency for large training sets. The disadvantage of the method is computational complexity because, for each data case, the algorithm must compute distances to all other cases in all variables in the data set. The method is sensitive to missing data (Settey et al., 2021).

All statistical tests are evaluated using the p-value of the test, which is compared to the significance level, which was set at 0.05 for the purpose of this study (Labudova, 2021; Machery, 2021).

3.3. Performance evaluation of prediction models

We use evaluation statistics and the ROC curve to assess the performance of the predictions for the developed models (Maternova et al., 2023). The evaluation statistics are based on the numbers of correctly and incorrectly classified data instances in the group of truly satisfied and dissatisfied customers. These counts are reported in the so-called confusion matrix.

We can determine the overall accuracy of the model as the proportion of correctly classified customers out of all customers:

$$accuracy = \frac{TP + TN}{TP + FP + FN + TN} \quad (1)$$

where TP (true positive) dissatisfied customers are correctly predicted

FP (false positive) are customers predicted by the model to be dissatisfied but are actually satisfied

FN (false negative) are customers predicted by the model to be satisfied but are actually dissatisfied

TN (true negative) satisfied customers are correctly predicted

For this label, we consider the group of interest (hit) to be dissatisfied customers, who are indicated by the value of the dependent variable $Y = 1$.

In addition to the overall accuracy, the sensitivity of the model, which represents the proportion of correctly classified positive (i.e. dissatisfied) customers, is very important:

$$sensitivity = \frac{TP}{TP + FN} \quad (2)$$

These indicators, together with the ROC (Receiver Operating Characteristic) curve, which shows the relationship between sensitivity and specificity (specificity is the proportion of satisfied customers correctly classified by the model out of all satisfied customers), provide a good picture of the performance of the models. In general, the larger the Area Under the Curve (AUC) of the ROC curve, the better the classification ability of the model. The ideal condition is when it reaches a value close to 1.

To improve the model's predictive performance, we use sample balancing of satisfied and dissatisfied customers. We refer to unbalanced data when one category is over-represented and the other under-represented in the data. In our case, the group of satisfied customers was predominant (342), while the group of dissatisfied customers was smaller (46). This disproportion may affect the accuracy of the model. Unbalanced data can be weighted through the undersampling or oversampling technique. Undersampling means that we randomly select only enough units from the majority category to be approximately equal in size to the minority category. Conversely, oversampling means assigning a higher weight to the minority category of dissatisfied customers so that it is approximately equal in size to the majority category of satisfied customers. In this study, we used the oversampling technique.

If we want to use the model in practice, we need to test its quality on independent data, different from those used for model creation. The most common solution is randomly splitting the data into test and training sets. In this study, we use a 60:40 split of the dataset. We will use the training data to specify the model and the test data to evaluate the functionality of the model.

3.4. Data sample description

For the purpose of this study, it was possible to collect completed questionnaires from 468 adult citizens of the Slovak Republic aged 18 years and over. More men than women participated in the research. In terms of the age of respondents, the age group 26-45 years was predominant. More than half of the respondents had attained the highest secondary education level. Respondents in all regions of Slovakia were surveyed, with the Zilina Region having the

largest representation with 28.8%. On the other hand, the lowest number of respondents came from the Presov and Nitra regions (6%). This research involved mainly employed respondents, whose total percentage of the total sample was 56.4%. On the other hand, the smallest group were respondents without employment (2.4%). The respondent's net monthly income was mostly in the range of €1,001-1,500 (34.6%). Respondents with no income had the smallest representation. A detailed description of the frequency distribution of respondents in the sample is presented in Table 1.

Table 1: Distribution of respondents according to their socio-economic characteristics

Variable name	Values	Relative frequency [%]
gender	women	45.3
	men	54.3
age	19-25	19.4
	26-45	47.9
	46-65	27.4
	more than 65	5.3
education	primary	2.4
	secondary	54.3
	university	43.3
region	BA	23.1
	TT	10.9
	TN	9.2
	NR	6.0
	ZA	28.8
	BB	8.1
	PO	6.0
	KE	7.9
social status	student	12.8
	unemployed	2.4
	employee	56.4
	self-employee	20.5
	pensioner	7.9
monthly net income	no income	4.3
	lower than 500 €	9.6
	501-1,000 €	23.9
	1,001-1,500 €	34.6
	more than 1,500 €	27.6

Source: own elaboration

Of all respondents, 82.9% (388) indicated owning an e-bike. The remaining 17.1% (80 respondents) do not actually own one. We will further process the survey with a total of 388 respondents.

4. Results

To predict customer satisfaction, we created a total of 5 different models using the decision tree method (CHAID and CRT type tree), neural networks, logistic regression and nearest neighbour. In addition to the models themselves, we observe their prediction performance, which we evaluate and compare using their sensitivity and overall accuracy on a test set (Table 2).

Regarding model quality, we want the sensitivity and overall accuracy values to be as high as possible. Based on these results, the neural network has the highest overall accuracy of 89.6% on the test set (90.4% on the training set). Thus, from this point of view, we would choose the neural network model as the best-performing model, but in terms of using the prediction model in practice, it is very important to find the customers who will be dissatisfied. However, the neural network model's sensitivity on the test set is only 9.1% (25.7% on the training set). The

Table 2: Prediction performance of models for customer satisfaction prediction

Method	Sensitivity [%]	Accuracy [%]
CHAID tree	78.3	78.5
CRT tree	76.1	79.2
neural network	9.1	89.6
logistic regression	81.8	82.1
nearest neighbor	18.9	85.7

Source: own elaboration

confusion matrix of the prediction model developed by the neural network method for the test data set is shown in Table 3.

Table 3: Confusion matrix for neural networks model

Actual state / Prediction	Satisfied	Dissatisfied	Total
Satisfied	94	1	95
Dissatisfied	10	1	11
Total	104	2	106

Source: own elaboration

For the model to meet both qualitative criteria at a high level, we selected logistic regression as the most appropriate method, which achieves a sensitivity on the test set of 82.1% (84.8% on the training set) and the overall accuracy of the model on the test set is 81.8% (83.6% on the training set). The confusion matrix for the logistic regression model is in Table 4.

Table 4: Confusion matrix for the logistic regression model

Actual state / Prediction	Satisfied	Dissatisfied	Total
Satisfied	78	17	95
Dissatisfied	2	9	11
Total	80	26	106

Source: own elaboration

From the neural network model, it is impossible to say exactly what role the individual input variables play in the overall customer satisfaction or dissatisfaction. The neural network itself is very complex and uninterpretable. It consists of two input neurons (satisfied and dissatisfied customers), a hidden layer of 6 neurons, and an output layer consisting of 45 output neurons. Due to the number of connections between neurons in the model, it is impossible to interpret this model in detail.

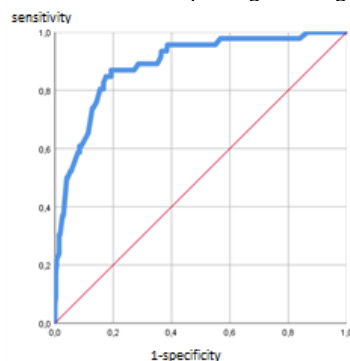
In contrast, the logistic regression model offers the possibility of interpretations of the estimated coefficients of the input variables. The model was constructed using the forward stepwise method in 6 steps. The full model is presented in Annex A.

Checking the individual variables, we find that price and e-bike accessories are insignificant variables for customer satisfaction with this product. On the contrary, battery life, battery capacity, motor brand and place of e-bike purchase are significant factors. Customers who purchased an e-bike with accessory (2) (i.e., rack) are 1.7 times more likely to be dissatisfied compared to those who purchased an e-bike with accessory (5) (i.e., locks or alarm). If the battery life of the e-bike is low (denoted as battery life (1)), customers are 82.3 times more likely to be dissatisfied compared to those who purchased an e-bike with high battery life (5). The overall effect of the battery capacity variable on customer satisfaction is statistically significant. However, within each capacity category, all are statistically insignificant in the model. Thus, the only significant category is the reference category (5), i.e. the highest battery capacity. Considering the coefficients of the other battery capacities, it is clear that all lower battery capacities increase the probability of customer dissatisfaction compared to the highest battery capacity of their e-bike.

Regarding the brand of electro-motor, if customers purchased the Eovolt brand (marked as (4)), they are 14 times more likely to be dissatisfied compared to those who would have purchased a brand other than all of the above (marked as (10)). If customers received an e-bike as a gift (marked as (2)), they are 13.9 times more likely to be dissatisfied compared to if they purchased the e-bike themselves through brick-and-mortar stores (marked as (3)).

In addition to the evaluation statistics listed in Table 2, we also evaluate the model's performance using the ROC curve and the size of the area under the AUC. The ROC curve is shown in Figure 1. The horizontal axis shows 1-specificity, and the vertical axis shows sensitivity.

Figure 1: ROC curve for logistic regression

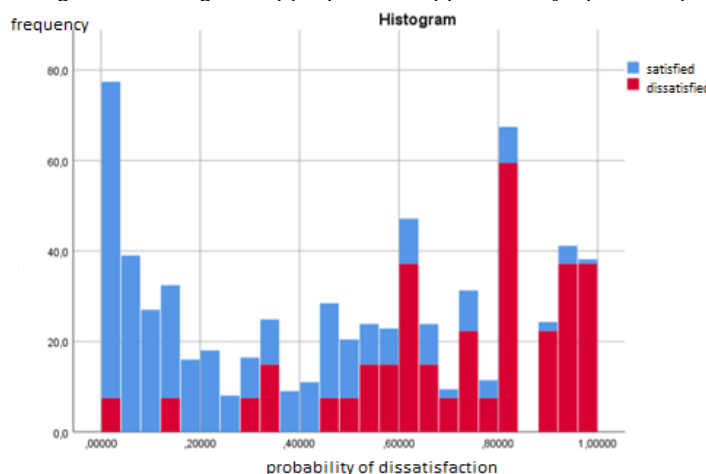


Source: own elaboration

The size of the AUC region is 0.88, which can be considered good to very good classification ability.

We can use a histogram (Figure 2) to show the frequency of occurrence of different values of the predicted probability of customer dissatisfaction.

Figure 2: Histogram of frequencies of probability of dissatisfaction



Source: own elaboration

The histogram shows that as the probability of dissatisfaction predicted by the model increases (on the horizontal axis, dissatisfaction probability values higher than 0.5), the proportion of truly dissatisfied customers increases (red). Conversely, with predicted satisfaction (probabilities lower than 0.5), truly satisfied customers predominate (blue color).

5. Discussion

Predicting customer satisfaction is a key task for businesses aiming to understand and improve the customer experience. Using predictive models, businesses can anticipate which factors affect customer satisfaction and take proactive steps to improve their services or products. By predicting customer satisfaction, businesses are able to improve customer relationships, as well as retain or increase customer loyalty, in addition to proactively solving problems. Ultimately, businesses can increase profitability by delivering exceptional experiences tailored to the needs and preferences of their customers.

In this study, we concluded that although a neural network is often a very accurate method for making predictions, the model produced tends to be complex, and its results cannot be accurately interpreted. The neural network model created had a very low sensitivity for finding dissatisfied customers, which is precisely the category that needs to be accurately predicted in order to take early action to avoid this dissatisfaction. A more appropriate model was stepwise logistic regression, whose model can also be interpreted to find significant factors for customer dissatisfaction.

When the predicted probabilities of customer dissatisfaction are plotted using a histogram colour-coded by their actual satisfaction, one can further consider shifting the threshold for categorising customers into satisfied or dissatisfied groups. The default value in logistic regression is always at 0.5, whereby customers with predicted probabilities below 0.5 are categorised as satisfied, and, in contrast, those with predicted probabilities above 0.5 are categorised as dissatisfied. According to the histogram shown, it would be possible to increase the achieved level of sensitivity of the model at the expense of its overall accuracy by shifting this threshold to, for example, 0.44. This would capture more potentially dissatisfied customers. The downside would be that more genuinely satisfied customers would be unnecessarily predicted as dissatisfied, which would mean that the firm would unnecessarily take action to reduce their dissatisfaction. In this case, however, it is worth considering whether it is costlier to encourage satisfied customers unnecessarily or to avoid losing more potentially dissatisfied customers.

6. Conclusions

Increasing customer satisfaction is essential to the success and growth of a business. By understanding the needs of their customers and offering quality products and services and quality service, dealers can build a base of loyal customers. In this study, using the data collected from a questionnaire survey and creating a prediction model using logistic regression, we found that the brand of motor, battery capacity, battery life and the location where the customers purchased the e-bike significantly impacted customer satisfaction with the product. Thus, the brand of the e-motor and the battery capacity of the e-bike, which came out as the most important factors for overall customer satisfaction, should be mainly considered when determining the firm's activities to eliminate customer dissatisfaction. In contrast, the price and accessories of the e-bike did not emerge as significant factors for customer satisfaction.

In this study, we did not use the socio-economic characteristics of the customer as a possible determinants of customer satisfaction in developing the prediction model. Thus, further study could be aimed at finding significant customer satisfaction factors both as product parameters, as implemented in this study, but also in combination with customer characteristics.

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Annex

Table A1: Logistic regression model

Variable	B	S.E.	Wald	Deg. of freedom	Sig.	Exp. B
price			11.310	8	0.185	
price(2)	1.158	0.657	3.111	1	0.078	3.184
price(3)	1.671	0.713	5.489	1	0.019	5.320
price(4)	2.051	0.792	6.698	1	0.010	7.773
price(5)	1.749	0.818	4.576	1	0.032	5.751
price(6)	0.896	0.960	0.871	1	0.351	2.450
price(7)	-0.420	1.117	0.142	1	0.707	0.657
price(8)	-18.203	8916.528	0.000	1	0.998	0.000
price(9)	1.206	0.863	1.952	1	0.162	3.339
accessories			2.674	4	0.614	
accessories (1)	-21.368	4336.553	0.000	1	0.996	0.000
accessories(2)	0.525	0.339	2.393	1	0.122	1.691
accessories(3)	0.177	0.325	0.296	1	0.587	1.193
accessories(4)	0.509	0.638	0.637	1	0.425	1.664
battery life			36.583	4	< 0.05	
battery life(1)	4.411	0.794	30.825	1	< 0.05	82.346
battery life(2)	1.226	0.325	14.268	1	< 0.05	3.407
battery life(3)	2.083	9873.947	0.000	1	0.998	8.028
battery life(4)	1.367	0.502	7.415	1	0.006	3.925
engine brand			59.452	9	< 0.05	
engine brand(1)	1.072	0.459	5.462	1	0.019	2.921
engine brand(2)	-0.514	0.484	1.127	1	0.288	0.598
engine brand(3)	-0.034	0.771	0.002	1	0.965	0.967
engine brand(4)	2.637	1.086	5.895	1	0.015	13.976
engine brand(5)	1.872	0.626	8.929	1	0.003	6.499
engine brand(6)	2.559	0.536	22.774	1	< 0.05	12.920
engine brand(7)	-0.653	0.528	1.528	1	0.216	0.520
engine brand(8)	2.377	0.853	7.771	1	0.005	10.778
engine brand(9)	1.184	0.668	3.140	1	0.076	3.268
battery capacity			38.658	4	< 0.05	
battery capacity(1)	22.819	9722.597	0.000	1	0.998	8,131,269,445.733
battery capacity(2)	21.199	9722.597	0.000	1	0.998	1,609,065,12.518
battery capacity(3)	19.451	9722.597	0.000	1	0.998	280,297,192.576
battery capacity(4)	20.212	9722.597	0.000	1	0.998	599,494,451.920
purchase place			14.126	2	0.001	
purchase place(1)	0.924	0.307	9.047	1	0.003	2.519
purchase place(2)	2.633	0.796	10.947	1	0.001	13.917
Constant	-24.913	9722.597	.000	1	0.998	0.000

Source: own elaboration

WACC IN OECD COUNTRIES (SK NACE 1920) AND SPECULATIVE TRADING VOLUMES ON THE OIL MARKET: A FIVE-YEAR CORRELATION STUDY

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Abstract:

Research background: The petroleum products manufacturing sector is a key industry in the international trade of crude oil. The activities of this sector exert a significant influence on the global economy, particularly through the production and processing of oil, which represents a vital commodity for the daily functioning of societies worldwide.

Purpose of the article: The main goal of this research is to calculate the correlations between the WACC and the volume of speculative trading positions in the crude oil market. Speculative trading in the context of this research is considered the trading volume of futures or options contracts without any direct involvement in the underlying physical commodity. The analysis primarily examines the relationship between the WACC and Brent crude oil futures prices, emphasizing the significant role of the futures price volatility in the companies' costs of capital.

Methods: The article calculates the weighted average cost of capital (WACC) for the petroleum products manufacturing sector in the member states of the OECD. Overall, 96 calculations of WACC are made for companies from 16 OECD member countries.

Findings & Value added: Country-specific disparities in WACC are identified, with Greece, Poland and Germany showing the highest values, which reflects the variable economic and market conditions. While speculative trading is proven to have no direct effect on the WACC, its indirect impact through crude oil price volatility is significant. A potential indirect effect through crude oil futures price volatility emphasizes its role as a significant factor influencing the financial environment for companies in the petroleum manufacturing sector. If we assume a continually rising trend in the traded oil futures positions, we consider further studies on the relationship between the WACC and speculative trading of great importance. The findings of this research contribute to understanding the financial implications of crude oil market dynamics and provide actionable insights for corporate risk managers.

Keywords: weighted average cost of capital; speculative trading; oil market; OECD countries; correlation analysis

JEL Classification: G12; G15; E44

1. Introduction

The petroleum products manufacturing sector is a key industry in the international trade of crude oil, which is arguably the most important commodity. The activities of this sector exert a significant influence on the global economy, particularly through the production and processing of oil, which represents a vital commodity for the daily functioning of societies worldwide. This impact is further underscored by the role of oil in ensuring a stable supply to the market. The price of oil is distinguished by a long and complex history, characterized by significant price volatility, the formation of price bubbles (Quinn and Turner, 2020), and periodic price slumps, setting it apart from other traded commodities.

Crude oil is primarily traded in the form of financial derivatives, most notably as futures contracts (Kang et al., 2020) listed on exchanges. While commercial participants, such as energy and aviation companies, utilize futures contracts to hedge against adverse price fluctuations in their future commodity purchases, non-commercial traders generally view the physical delivery of the commodity as undesirable. Historically, the demand for oil futures contracts has consistently exceeded the physical demand for oil by a factor of at least 1,16. The largest disparity between physically traded oil and oil traded as financial derivatives was observed in March 2020 (Bakas and Triantafyllou, 2020), during the peak of the global impact of the COVID-19 pandemic. During this period, the demand for exchange-traded oil derivatives surged to 2,6 times (Cepelova, 2024) the level of physical demand for oil.

The trading of oil futures contracts represents the most prevalent method of speculating on future movements of oil prices. Currently, the demand for oil, reflected in realized futures positions, exceeds the physical volume of oil traded by nearly 21 times. This trend has been increasing since 2011, with the average annual volume of Brent crude oil futures contracts traded by exchange speculators having quadrupled over this period. Speculative demand in the oil market is currently not clearly quantifiable. However, historical analysis indicates that sharp shifts in the sentiment (Umar et al., 2021) of exchange speculators during periods of high market volatility can lead to artificially inflated prices (Harrison et al., 2023) or significant reductions in oil demand.

The evolution of oil market prices and the factors influencing their development have long been a focus of research for numerous authors and scholars. Oil market dynamics serve as a critical indicator for exchange traders, including physical buyers of oil. Equally important, however, is an examination of the other side of market relations – the companies that extract, process and sell oil, which form the basis of the physical supply of this fundamental commodity. In this research, we aim to gain an insight into how the external market dynamics influence the overall financial stability of companies in the petroleum products manufacturing sector.

Generally, oil processing companies rely heavily on external financing for investments in refinery operations infrastructure and operational costs. External financing constitutes foreign capital that oil processing companies acquire through borrowing from banks or other non-bank entities. This borrowed capital incurs costs in the form of interest payments, which companies must manage as part of their financial operations. Uncertainty in oil prices can significantly influence long-term investment decisions by potential lenders (Yang et al., 2019), including banks and non-bank financial institutions. Speculative trading and oil price fluctuations can intensify perceptions of risk (Fan et al., 2021), leading lenders to view oil processing companies as less financially stable. Consequently, this elevated risk perception can increase the cost of borrowing, either through higher interest rates or stricter loan conditions.

Volatility in oil prices also has a direct impact on the profitability of petroleum products manufacturing companies through its effect on refining margins, which represent a critical source of income. Fluctuating margins weaken the financial performance of these companies,

reducing their ability to generate stable profits. For equity investors, including shareholders and potential buyers of company shares, these dynamics increase the perceived risk (Wang et al., 2021) associated with the company's stocks. As a result, the cost of equity rises due to higher expected returns demanded by investors to compensate for increased risk. The increased cost of equity can further constrain the financial flexibility of oil processing companies (Prodromou and Demirer, 2022), particularly in volatile market conditions.

Based on these theoretical foundations, we conclude that it is of importance and meaningful to evaluate the impact of oil price fluctuations and the volume of speculative trading positions on the crude oil futures market on the average cost of capital of petroleum products manufacturing companies. We note that in the issue of this research, literature is linked to oil price fluctuations, investor decisions, speculative demand or market sentiment analysis, yet the impact of the speculative transaction volume on the oil processing companies' average cost of capital in the OECD countries has not been studied to greater extent.

Research highlights the importance of market architecture and trading transparency in reducing WACC values in companies in general. Studies have shown that migrating from dealer to hybrid auction systems enhances trading information quality (Chelley-Steeley and Lambertides, 2017), reducing the cost of equity capital, especially for smaller companies with higher initial levels of information asymmetry. Similarly, information asymmetry is identified as a key driver of capital costs (Toski et al., 2020), with higher probabilities of informed trading increasing both equity and debt costs. This effect is particularly identified in ownership structures with limited information, such as family-owned companies, where the inequalities in access to the information and potential risk increase.

As part of studies on the factors influencing the cost of capital of companies, the role of institutional quality and regulatory frameworks is emphasized in the context of strong insider trading laws and high institutional quality (Kwabi et al., 2018), which lower the cost of capital by strengthening market confidence and reducing perceived risks. Higher weighted average cost of capital, on the other hand, is associated with illiquidity and highly volatile market conditions (Belkhir et al., 2020), particularly in markets with weak investor protections. Stock markets with higher illiquidity tail risk face higher equity costs, which might result in a more intensive effect during an economic downturn.

In the context of commodity markets, price volatility has been linked to the variability of financing costs in previous studies. Speculative trading is recognized as a significant contributor to price volatility, indirectly influencing WACC (Christensen and Qin, 2014) through heightened risk perceptions and market uncertainty. While not directly linking speculative trading to WACC, studies on commodity markets and volatility have consistently shown that speculative trading drives price volatility, which indirectly affects companies' cost of capital. These insights draw attention to the importance of accurate WACC calculation (Miller, 2009) for industries highly exposed to external market fluctuations, such as the petroleum manufacturing sector (SK NACE 1920).

Following on from the obtained research conclusions, the research goal of this study is set to perform an accurate calculation of the weighted average cost of capital of 96 public limited companies in the petroleum products manufacturing sector from 16 OECD member countries and additional calculations of the correlations and linear regressions of the relationship between the crude oil future prices and WACC and the volume of speculative trading positions in the crude oil market and WACC.

2. Methodology

This article defines speculative transactions in the crude oil market as the implemented positions of non-commercial traders. A non-commercial trader is defined by the Commodity Futures Trading Commission (2023) as a market participant who engages in trading futures or options contracts without any direct involvement in the underlying physical commodity. These traders do not intend to take physical delivery of the commodity but instead participate in the market to capitalize on price movements. Such traders are commonly referred to as exchange speculators.

To perform the calculations and analysis in this study, we utilize crude oil price data aggregated from daily prices of Brent crude oil futures contracts as reported by the Intercontinental Exchange (ICE). The choice of Brent crude oil prices is justified by its status as a global benchmark for oil pricing and its widespread use in economic analyses and policy discussions. Furthermore, data from ICE ensures consistency and reliability, as it represents a significant part of the international crude oil market.

The analysis focuses on the correlations between speculative demand and the average cost of capital of petroleum products manufacturing companies based in the countries of OECD. Brent crude oil is particularly relevant in this context, given its significant influence on the energy policies and economic structures of OECD member states. From the OECD member states, data for oil processing companies were analyzed based in these countries: Austria, Belgium, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal and Slovakia.

The weighted average cost of capital (WACC) serves as a critical financial metric that reflects the overall cost of financing for a company, incorporating both equity and debt. It is particularly relevant in this research as it enables assessment of the cost of capital across the analyzed countries and provides valuable insights into how differences in economic conditions, corporate structures and market dynamics influence financing costs in these regions. To compute WACC for the listed countries, we utilized the following financial and economic data over a 5-year period (2019-2023): shareholder funds, non-current and current liabilities, long-term debt and interest paid. Corporate tax rates, beta coefficients and market risk premiums were sourced from Aswath Damodaran's datasets, tailored for each country and industry. The risk-free rate is based on the 10-year U. S. Treasury bond yield, reflecting a stable benchmark commonly used in international WACC calculation.

WACC is calculated as:

$$WACC = \left(\frac{E}{E + D} \cdot r_e \right) + \left(\frac{D}{E + D} \cdot r_d \cdot (1 - t) \right) \quad (1)$$

where

E is equity

D is debt

r_e is cost of equity, calculated using the CAPM formula

r_d is cost of debt, derived from interest paid and long-term debt

t is corporate tax rate

The weighted average cost of capital formula is a fundamental concept in corporate finance (Allen et al., 2016) and does not have a single author, as it has evolved over time through collective work of academics and practitioners in this field. It is, however, widely associated

with the foundational work of Modigliani and Miller (1958). The WACC formula is now a standard tool in corporate finance.

The research goal of this study is to calculate the correlations between the WACC of 96 public limited companies in the petroleum products manufacturing sector from 16 OECD member countries and the volume of speculative trading positions in the crude oil market. To examine these relationships, correlation analysis is conducted using IBM software. Specifically, the analysis is performed using IBM SPSS Statistics, which provides robust tools for statistical computations.

The Spearman correlation coefficient is used to assess the strength and direction of the relationship between the variables. Unlike the Pearson correlation coefficient, which measures linear relationships, the Spearman correlation evaluates whether an increase in one variable corresponds to an increase or decrease in another variable, regardless of the actual linearity of the relationship. The formula applied by the software for Spearman correlation is as follows:

$$r_s = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)} \quad (2)$$

where $\bar{c}$ is constant numeric value

d_i is difference between the ranks of each pair of observations

n is number of observations

The Spearman correlation is chosen for this analysis due to the potential non-linear relationships among the studied variables, as speculative trading volumes and WACC may not always reflect a linear interaction with crude oil futures prices. This method ensures a more robust assessment of associations under such conditions.

To support the results of the correlation, linear regression analysis is conducted also using the IBM SPSS software. This approach is implemented to further investigate the relationship between the volume of speculative trading transactions in the crude oil market and WACC, as well as between crude oil prices and WACC. Linear regression allows for a deeper examination of the predictive power and significance of these variables in explaining variations in WACC, complementing the correlation analysis by providing additional insights into the strength and direction of these relationships. The regression models are designed with WACC as the dependent variable and the volume of speculative trading transactions and crude oil futures prices as independent variables, ensuring an intense exploration of these associations.

Furthermore, we set a main hypothesis to validate the present research and a hypothesis to alternate the main:

H₀: There is no significant correlation between the volume of speculative trading positions in the crude oil market and the weighted average cost of capital (WACC) of petroleum products manufacturing companies.

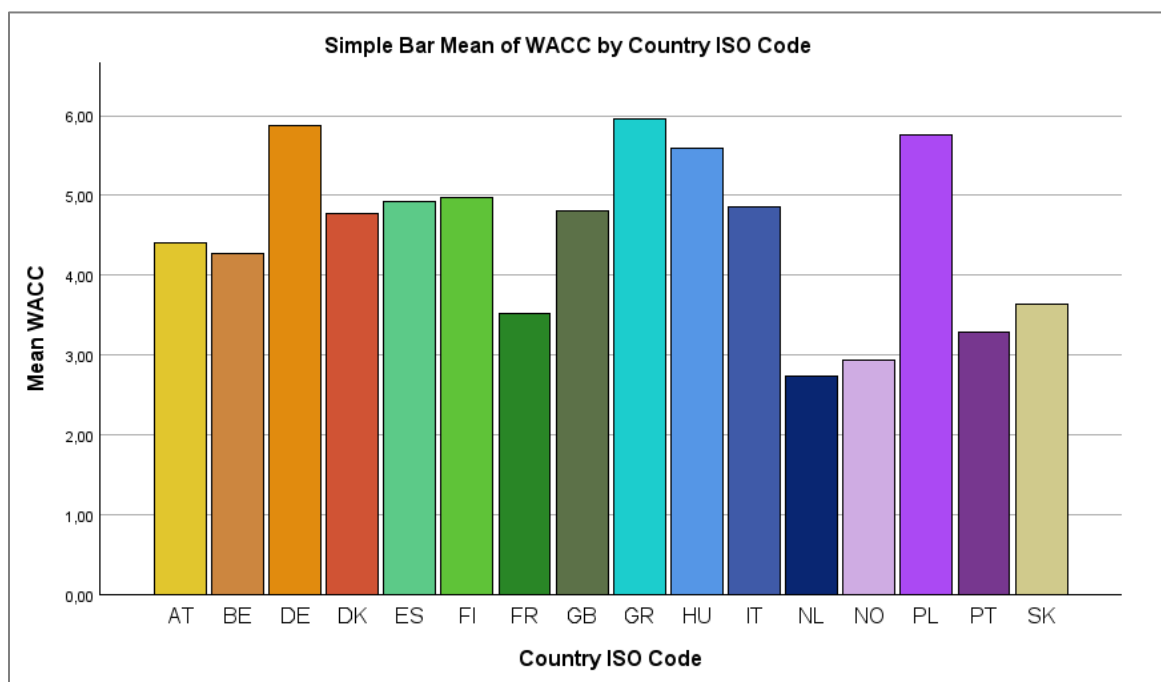
H₁: There is a significant correlation between the volume of speculative trading positions in the crude oil market and the weighted average cost of capital (WACC) of petroleum products manufacturing companies.

3. Results

First, the calculated WACC for petroleum manufacturing companies in 16 member countries of OECD is evaluated. A comparative overview of the financing costs faced by oil manufacturing companies in different national contexts is presented in Figure 1 below. The 5-

year WACC offers a high-level perspective on the variation in financial conditions across countries, reflecting differences in macroeconomic environments, risk profiles and capital structures. By visualizing this data, Figure 1 highlights the disparities in financing costs and establishes a baseline for interpreting the subsequent analysis of correlations between speculative trading, crude oil prices and WACC.

Figure 1: Histogram of average WACC by country (5-year average)



Source: own processing

Each bar represents the average WACC for its corresponding country, with variations indicating differences in financing costs across countries. The average WACC values range between approximately 3 %, at the lower end being Netherlands and Norway, and 6 %, which the higher end reached by Greece and Germany. A higher average WACC might suggest relatively more expensive financing conditions for oil processing companies. Greece exhibits the highest average WACC, which could reflect less supportive debt and equity financing conditions. Poland also shows a relatively high WACC, likely driven by macroeconomic conditions or historical market perceptions of risk. However, recent economic developments suggest a positive shift (Sultana et al., 2024), as Poland's GDP per capita has risen from 48 % to 82 % (Albert and Bienvenu, 2024) of the EU average since 2004. As these positive trends continue, it is reasonable to assume that Poland's WACC will decrease. For countries with average WACC at the lower end, this might indicate a more optimal financing environment. These are represented by the Netherlands and Norway, which might be due to their robust economy and lower perceived risk in the oil sector.

For better visualization, we also created a cartogram illustrating a geographical distribution of 5-year average WACC across European countries, presented in Figure 2. Countries included in the study of this research paper are colored blue, with a spectrum ranging from light blue, indicating the lowest values of the average weighted cost of capital, to dark blue, indicating the highest values of the observed indicator.

Figure 2: Geographical Distribution of WACC in OECD member countries



Source: own processing

Based on the regional clustering, we conclude, that Western Europe countries, such as Austria and Belgium, tend to cluster around moderate WACC values, values of 4 % to 5 % WACC. This might reflect balanced financing conditions. Southern Europe countries, such as Portugal and Spain, show slightly higher values, potentially reflecting regional economic challenges.

Next, we analyzed the correlations between speculative trading volumes in the crude oil market and the weighted average cost of capital of 96 petroleum products manufacturing companies. Spearman correlation for this relationship provided a conclusion of a weak and statistically insignificant dependence. To support these results, we also calculated linear regression based only on the relationship of these two variables. The quality of this model is lower than 0% and the relationship between the two variables has proven insignificant. The volume of speculative trades on the crude oil futures market has no direct effect on the average weighted cost of capital of oil manufacturing companies in the OECD.

Lastly, the correlations between the aggregated crude oil futures prices and the weighted average cost of capital of 96 petroleum products manufacturing companies were examined. The Spearman correlation for the relationship between these two variables is, in contrast to previous results, statistically significant. Dependence is interpreted as a weak increasing relationship. This indicates that with increasing crude oil futures prices, the WACC of crude oil manufacturing companies could have the tendency to rise. Crude oil futures prices, even though only a low portion of the transactions lead to physical delivery of crude oil, might change the

risk perception of investors in the petroleum manufacturing sector. In addition, the increase in crude oil futures may reduce consumer demand for refined products, particularly in price-sensitive regions. This reduction in demand puts downward pressure on product prices, negatively affecting the margins of crude oil manufacturing companies.

To support the results, we repeated the linear regression for the relationship between the two variables of WACC and the aggregated crude oil futures prices. The results are included in Figure 3 and show that the linear regression supported the statistical significance of this relationship. The quality of this linear regression model, according to the adjusted R squared value, interprets as the ability of this relationship to explain 11,1 % of the variability in the calculated WACC values.

Table 3: Regression Coefficients for the impact of Brent crude oil futures prices on WACC

Coefficients ^a		Unstandardized Coefficients		Standardized Coefficients	
		B	Std. Error	Beta	t
1	(Constant)	1.232	0.469		2.627
	Brent Futures Price	0.049	0.006	0.336	7.804

a. Dependent Variable: WACC

Source: own processing

The unstandardized coefficient shows that for every one dollar increase in Brent futures prices, the WACC increases by approximately 0,049 %, holding other factors constant. The positive value of the coefficient implies that higher Brent futures prices are associated with higher WACC for oil manufacturing companies of the OECD. This result underscores the importance of Brent futures prices as a key variable influencing the cost of capital, making it critical for companies and investors to monitor oil price trends in financial planning and risk management.

4. Discussion

The most important findings in the context of the research for this paper highlight the positive correlation between Brent crude oil futures prices and the WACC calculated for 96 oil manufacturing companies in 16 member countries of OECD. With increasing crude oil futures prices, the analyzed companies' WACC, in a small amount of approximately 0,049 % with a one dollar rise in the Brent futures prices, but with a statistical significance, increases. Rising Brent crude oil prices directly impact the cost of capital, possibly due to an increased market risk perception linked to the unpredictability of the crude oil futures price development, or the direct impact on the petroleum manufacturing companies profit margins, where the rising prices create a downward pressure on the petroleum products' consumer demand affecting the sales of the companies and the investor perception of the profit potential.

These findings are consistent with the conclusions of research held by Prodromou and Demirer (2022) about the relationship between oil price shocks and the cost of capital estimates from 34 global economies. According to the outcomes of the research, oil price volatility increases systemic risk, which raises the equity risk premium entering the calculations of capital costs. Higher oil price-driven equity risk translates into increased capital costs, particularly in oil-importing economies.

Our own research indicates that an increase in crude oil prices by one dollar stimulates an increase in the weighted average costs of capital by 0,049 %. The results of another research led by Ghossoub and Reed (2014) do not, however, offer the same view. According to these authors, a rise in asset prices, if driven by favorable monetary policy or increased productivity

in the capital sector can reduce the cost of capital, enhancing investment activity. These contrasting perspectives underscore the complexity of the factors influencing the cost and the importance of context when interpreting these relationships.

In the research, the country specific WACC disparities were illustrated, pointing out the highest average WACC values in countries, such as Greece, Poland and Germany. These variations reflect the influence of a country's specific economic conditions, risk profiles and market perceptions on the cost of financing for petroleum manufacturing companies. High average WACC values calculated for the companies based in Greece could be explained by the high-risk profiles due to the prolonged economic instability, elevated public debt levels and investor concerns about the financial health of its economy. These factors contribute to higher borrowing costs and greater equity risk premiums, which in turn raise the WACC for companies operating in Greece's petroleum sector.

In Poland, the high values of the average WACC calculated for the petroleum manufacturing companies appear to be primarily driven by historical market perceptions of risk, particularly in the context of the country's transition from an emerging (Afzal et al., 2023) to a developed economy. Recent economic developments such as robust GDP growth, however, suggest improved investor confidence and a positive trajectory for future economic stability. The trends indicate that Poland's WACC is likely to decrease over time as market perceptions of risk continue to diminish and financial conditions improve.

For Germany, the tendency for high average weighted cost of capital values might be linked to its heavily industrialized economy, which has faced an increasing energy transition pressures and regulatory risks. The shift towards renewable energy and the cost of capital associated with reducing reliance on fossil fuels might contribute to higher perceived risk for companies in the petroleum sector, resulting in increasing financial costs. Additionally, Germany's strong emphasis on equity financing over debt (Koch et al., 2022) could result in a higher WACC, given the generally known higher costs of equity compared to debt.

It is also important to note the role of speculative trading in the crude oil market and its potential impact on the WACC of petroleum manufacturing companies. While speculative trading itself may not directly influence the WACC, it is reasonable to suggest the possible indirect effects. Speculative trading can inflict significant volatility in crude oil futures prices, creating artificial price movements that are disconnected from supply and demand fundamentals (Christensen and Qin, 2014). This volatility in crude oil futures prices has important implications for the WACC values of petroleum manufacturing companies.

As shown in this research, there is a positive correlation between Brent crude oil futures prices and the calculated WACC, which indicates that changes in crude oil futures prices can influence financing costs. Speculative trading, by amplifying crude oil price volatility, indirectly impacts WACC by altering the risk perception of investors and creditors. Higher volatility in crude oil futures prices can lead to increased uncertainty in market conditions, prompting lenders to require higher interest rates and investors to expect greater returns on equity.

Therefore, while speculative trading might not have a direct causal relationship with the calculated WACC of petroleum manufacturing companies, its indirect effects through crude oil futures price volatility emphasize its role as a significant factor influencing the financial environment for companies in the petroleum manufacturing sector. Future research could analyze this connection greater in depth, examining how speculative driven volatility impacts not only crude oil prices, but also the broader financial indicators of companies in energy dependent industries.

5. Conclusions

This research paper analyzed the relationship between crude oil futures prices, speculative trading volume and the weighted average cost of capital (WACC) for 96 petroleum manufacturing companies from 16 member countries of the OECD organization. The research provides a country-specific perspective, showcasing significant disparities in WACC and how these variations are influenced by macroeconomic conditions, historical risk perceptions and sector specific factors such as energy transition pressures. The highest averages of the WACC values observed in Greece, Poland and Germany highlight the role of macroeconomic conditions, historical risk perceptions and capital structure factors in the capital costs development. For instance, Greece's high WACC is linked to its risk profile, while Poland's high WACC reflects persisting market perceptions of risk despite its improving economic outlook. Germany's high WACC, in the contrast of Greece and Poland, may be based on the energy transition pressures and reliance on equity financing.

The research for this paper also proves a positive correlation between Brent crude oil futures prices and WACC, underscoring the influence of crude oil price dynamics on capital costs. While speculative trading does not directly affect WACC, its role in amplifying crude oil price volatility indirectly impacts financing conditions by increasing the inability to predict its future development and risk perceptions among investors and creditors. This analysis contributes to the literature by linking Brent crude oil futures prices and speculative trading volumes with the WACC for petroleum manufacturing companies. By examining the relationship between speculative trading activity and crude oil price volatility, the study adds to the understanding of how non-physical market activities, such as the futures trading, impact financial conditions in energy-intensive industries.

The demand for oil, reflected in realized futures positions on the stock market, exceeds the physical volume of oil traded by nearly 21 times. This trend has been increasing since 2011, with the average annual volume of Brent crude oil futures contracts traded by exchange speculators having quadrupled over this period. If we assume the continuity of this trend, we consider of great importance more studies about the relationship between the WACC of companies from the petroleum manufacturing sector and the speculative trading on the crude oil market. A study aimed at different sectors linked to trading on other stock markets could be very reasonable and of high use in the context of monitoring the speculative trading on stock markets, the development of its volumes and the effects on commodities or other objects of trade.

The research bridges a gap between commodity market behavior and corporate finance by demonstrating how speculative trading indirectly amplifies financial risks for companies, enriching the dialogue on commodity-linked financial indicators. The analysis is based on 96 companies from 16 OECD member countries, which may not fully capture global market dynamics or the specific conditions in non-OECD countries. The research limitations are also found in the focus on the petroleum manufacturing sector, limiting the applicability of findings to other industries or sectors with different capital structures and risk profiles.

Future studies could explore the relationship between speculative trading, commodity price volatility and WACC in other energy-intensive sectors tied to commodity markets, such as mining, chemicals or agriculture. Expanding the analysis to include non-OECD countries would provide a more comprehensive understanding of how regional conditions shape WACC. The role of energy transition pressures, particularly in countries like Germany, also deserves further investigation to understand how regulatory and environmental policies influence WACC and financing conditions.

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INCREASING THE ECONOMIC EFFICIENCY OF TRANSPORT ENTERPRISES THROUGH TELEMATICS SYSTEMS

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Abstract:

Research background: Cost optimization in transport is a key aspect of the competitiveness of transport companies, and modern telematics systems represent an innovative tool to improve economic performance. These systems allow detailed monitoring of vehicle parameters such as fuel consumption, driver driving style, and route efficiency, providing valuable data to reduce variable costs and improve overall operational efficiency.

Purpose of the article: The purpose of this article is to explore the importance of telematics systems in cost optimization for transport companies and to highlight their potential to improve efficiency and sustainability. The article provides an overview of the benefits of implementing these systems, their cost recovery, and the economic and environmental benefits of transport. The information is intended for practitioners, transport company managers, and policymakers concerned with improving efficiency of transport.

Methods: Data from real transport companies that have implemented telematics systems were used for the analysis. The methodology includes cost structure calculations with an emphasis on variable costs as well as a comparison of operational parameters before and after the implementation of telematics. Analytical and calculation approaches were used to determine savings and return on investment.

Findings & Value added: The implementation of telematics systems has enabled the transport company to have accurate and easy vehicle tracking capabilities, thus contributing to the possibility of adjusting the driving style of the driver and thus reducing consumption. This paper highlights the importance of these systems in achieving long-term economic and environmental efficiency in transport.

Keywords: telematics systems, transport company costs, cost optimization, transport

JEL Classification: F2; L8; O4; O5

1. Introduction

Freight transport plays an important role in logistics systems and supply chains, being an integral part of each country's economy (Gajsek and Rosi, 2015). Sixta and Macat (2005) point

out the main function of transport, which is to ensure the physical movement of goods from the place of their production to the place of need or consumption. At the same time, transport serves to move products quickly and reliably, providing added value to customers if products are delivered on time, in the required quantity and quality, and without damage (Ujlacka, 2024).

Ensuring a balanced link between economic progress, social inclusion, and environmental protection is key to achieving sustainable development. Governments around the world are therefore placing emphasis on improving energy security, reducing the impacts of climate change, and improving air quality, particularly in urban areas where population concentrations are highest. One sector that has a significant impact on these priorities is transportation (McCollum et al., 2013; Erickson and Jennings, 2017).

Jeon and Amekudzi (2005) describe, that designing a sustainable transportation system requires solutions that are cost-effective, beneficial to the general public, and at the same time environmentally friendly. Such a system must promote economic stability, social progress, and natural resource conservation. Transport plays an essential role in socioeconomic development, reflecting the three fundamental dimensions of sustainability: economic growth, environmental protection, and social inclusion (Calderon-Rivera et al., 2024).

The dynamic environment of transport and logistics is increasing the pressure on transport companies, which are faced with continuously reducing operating costs while maintaining a high quality of service. Transport-related costs often form a significant part of the final price of products, thus directly affecting their competitiveness in the market (Wilmsmeier and Sanchez, 2009). To ensure long-term sustainability, companies need to focus either on maximizing performance, which allows for an efficient allocation of fixed costs, or on reducing variable costs through process optimization across all cost items (Poliak and Vrabel, 2010).

Transport costs are defined as the economic resources expended to carry out an activity that is expected to have an economic effect (Ferrari et al., 2023). These costs represent a financial expression of the consumption of production factors and are divided into fixed and variable costs (Konecny et al., 2010; Rodrigue, 2020). Fixed costs, such as vehicle depreciation or insurance, are independent of the volume of output, while variable costs, such as fuel or tolls, are directly related to the scale of operations.

Effective management of these costs is essential for the long-term sustainability and competitiveness of transport companies in an increasingly challenging global environment (Gruzauskas et al., 2018).

Cost optimization of businesses is one of the key elements of doing business. There are various costs that operators have to bear in connection with the operation of means of transport. However, fixed costs are difficult to optimize due to their immutability to short-term changes, legislative conditions, capacity constraints, or limited capacity (Mostafa et al., 2023). Changing economic conditions, as well as the impact of competition, force transport companies to optimize, to a large extent their operating costs, which are variable costs. It is important to identify the main cost items and try to find ways and measures to reduce them to the lowest possible level (Lukasik et al., 2017). Optimized fleet management requires knowledge in several areas in order to effectively control the company's costs, pursue the goal of maximizing profits, and minimize financial losses (Nagy et al., 2024). One of the key areas is fleet management, which focuses on the efficient use of the fleet in ground transportation. Real-time management coupled with data collection for detailed analysis is an important tool for reducing operating costs (Topolska and Topolski, 2016). A proper selection of a telematics system can serve as an effective support tool (Pattanaik and Goswami, 2023). It provides up-to-date information on the location and status of a specific vehicle, which allows for optimizing route planning and reducing "idling". At the same time, it allows flexible responses to unexpected

situations such as congestion or vehicle breakdowns. Tracking vehicle conditions helps prevent costly breakdowns and saves time, which is extremely important in the transport sector. In addition, the system monitors fuel consumption, which has a significant impact on the operating costs of the transport company (Pasierbski, 2020).

2. Methodology

In practice, there are several approaches to reducing costs in transport, each tailored to the specificities of particular businesses or sectors. The most commonly used methods include route optimisation, fleet management and the use of modern technologies for monitoring and analysing costs. These methods make it possible to effectively manage operating costs and improve the performance of transport companies.

Fixed costs - costs do not change with a change in output volume. The immutability of these costs is not entirely clear. A part of these costs depends on a certain range of the firm's capacity and remains the same regardless of the degree of its utilization; these are absolutely fixed costs. Part of the fixed costs is constant only within a certain range of capacity utilization (the range of output volume), but when the range is exceeded, there is a one-off increase in costs, then it is a relatively fixed cost. They remain constant over the next time span (Gnap and Poliak, 2017).

Variable costs - the value of costs varies depending on the change in the quantity of the company's output. In road transport, in connection with the operation of transport means, variable costs are divided into variable costs dependent on the amount of performance (fuel costs, toll costs, and variable costs dependent on the time of vehicle operation; e.g., driver's time wage (Konecny et al., 2010).

2.1. Methods and data

Costing of own costs in a transport company is a key process that allows to accurately analyse the cost structure and to identify the main factors influencing the economic results. This method is important not only for the pricing of services, but also for improving the efficiency and competitiveness of the company.

Similar to evaluation methods, costing also uses mathematical formulas for averaging calculations. In the case of cost in a transport company, we can consider the following formula:

$$P_i = \frac{\sum_{j=1}^n C_{ij}}{V_i} \quad (1)$$

where P_i is the unit price for the i -th type of performance

C_{ij} represents the costs for the i -th type of performance in the j -th cost item

V_i is the total volume of performance

2.1.1. Ranking method

For the cost analysis in the transport company, the costing method was applied, which divides the costs into variable and fixed costs. This method is characterized by a dynamic approach and allows to produce economically accurate results even for preliminary calculations, e.g. for calculating the price for transport. Dynamic costing is particularly useful in transport environments where vehicle performance and operating conditions can exhibit considerable variability.

The calculation was made on the basis of data collected from a real transport company. Data for one vehicle over a period of one month was analysed, with an average monthly performance of 10 000 km and an average working time of 180 hours. The average speed of the vehicle was determined based on the telematics system and was 66.1 km/h. The telematics systems allowed the vehicle's movements and performance to be accurately tracked, which significantly increased the accuracy of the calculation.

The costs had to be divided into three groups - variable costs dependent on distance travelled, variable costs dependent on time, and fixed costs that were recalculated:

$$c_{v\ km} = \frac{C_v\ (\text{€/month})}{L\ (\text{km/month})} \quad (2)$$

where $c_{v\ km}$ is variable costs dependent on distance travelled
 C_v is variable costs
 L is vehicle performance

$$n_{v\ hod} = \frac{C_v\ (\text{€/month})}{H\ (\text{h/month})} \quad (3)$$

where $c_{v\ hod}$ is time-dependent variable costs
 H is number of hours of vehicle operation

Fixed costs are independent of the output realized and are given in absolute terms.

An important parameter in the cost analysis of transport companies, which allows calculating of the average cost per kilometer of vehicle travel, is the calculation of the unit price per kilometer. It is calculated according to the formula:

$$P_{km} = \frac{C_v\ (\text{€/h})}{v_t\ (\text{km/h})} \quad (4)$$

where P_{km} is unit price per kilometre
 v_t is average vehicle speed

Another important parameter in the costing of own costs in transport companies is the calculation of the cost per hour of vehicle operation. It allows the annual fixed costs to be allocated to a specific time period of vehicle use and thus to determine their value per hour of operation.

$$P_h = \frac{C_F\ (\text{€/month})}{H\ (\text{h/month})} \quad (5)$$

where P_h is cost per hour of vehicle operation
 C_F is fixed costs

2.1.2. Data

The prices of the individual items within the transport company's costs in €/month include a wide range of expenses, which are divided into fixed and variable. These expenses are calculated based on data from the real conditions of vehicle operation, and the specific values

may depend on the type of vehicle, its use, and the region in which the company operates. Below is an expanded overview of typical items:

- Fixed costs (€/month): depreciation of vehicles, insurance, rent for premises, administrative costs.
- Variable costs (€/month): fuel, tolls, maintenance and repairs, tires, drivers' wages.
- Other costs include telematics systems and technologies and parking fees.

These items provide an outline, but the actual costs depend on the size of the company, the type of fleet, the nature of the transport services and market conditions. Properly understanding and managing these costs is key to the efficient operation and long-term sustainability of a transport company.

Table 1 provides a detailed breakdown of the costs per vehicle, the data being derived from an analysis carried out by the transport company. These costs include items related to the operation of the vehicle such as fuel expenses, maintenance costs, insurance, driver labour costs as well as other variables affecting the total operating costs of the vehicle. The data provided reflects actual operating conditions and serves as a basis for evaluating the economy of individual vehicles.

Table 1: Cost of individual items associated with the operation of the vehicle

Item	[€/month]
Fuel	3,828.00
Ad Blue	210.00
Other materials and services	23.00
Tires	345.00
Salary	1,354.40
Deductions	490.29
Reward	380.00
Maintenance/repair	299.00
Depreciation of semi-trailer combinations	1,934.24
Travel refunds SR	102.00
Collision insurance	83.19
Compulsory contractual insurance	134.42
Carrier insurance	22.70
Motor vehicle tax	45.38
Fees, GPS, phone	11.90
Parking	120.00
Directed by	780.00
Toll	1,400.00

Source: internal data of the transport company

The data collected from the transport company provides a detailed overview of the vehicles, routes and driving techniques of the drivers, serving as a basis for optimising operations and reducing costs. By implementing telematics systems, key parameters can be monitored in real time, which includes information on the length and efficiency of routes, drivers' driving styles and fuel consumption. The analysis of this data allows for improved route planning, leading to overall savings and, to a high degree, in particular, fuel savings.

Telematics also enables detailed monitoring of driver behaviour, such as acceleration, braking or cruise control use, identifying inefficient driving habits. Correcting these habits can make a significant contribution to reducing costs and improving safety. In addition, fuel consumption data enables companies to take action to optimise vehicle performance, which is particularly important when managing variable costs that directly affect economic efficiency (Kubas et al., 2021).

The overall impact of the use of telematics systems on reducing transport costs can vary. It depends on the degree of use and implementation of the systems.

Table 2 gives an overview of the data obtained by the transport company through the implemented telematics system. These data include key parameters that have a direct impact on fuel consumption and the overall efficiency of the vehicle operation.

Table 2: Costs of individual items associated with the operation of the vehicle

	Parameter	Unit	Prior to the introduction of the telematics system	After the introduction of the telematics system
Route	Distance travelled	km	9139	9,078
	Consumption	l/100 km	31.7	26.9
	Cargo weight	t	30.9	33.8
	Average gradient	%	0.51	0.42
	Number of	-	989	970
Driving technique	Average speed	km/h	64.7	66.1
	Driving time at speed > 85 km/h	%	24	0.2
	Engine running time without consumption + Ecoroll	% of total journey time	23.1	36.8
	Driving time with cruise control	% of total active engine time	28.2	64.15
	Exceeding the tensile speed	% of total active engine time	1.79	0.1

Source: author based on internal data of the transport company

In Table 3, we can see an overview of the costs associated with the implementation and use of the telepathic unit based on the offer provided by Webispečink. This offer includes the cost of the basic equipment, which includes the telematics E.V.A. unit, the cable for fixed installation, the installation of the unit including antennas, the connection to the CAN/OBD/FMS bus, as well as the connection to the tachograph card for driver identification and AETR compliance. System activation and monthly access to the Webdispečink web application with a global SIM card is an integral part of the system. These items are essential for the full functioning of the system. The total one-off cost of the basic equipment amounts to 133 €, while the monthly operating costs amount to 15.95 €. The offer also includes expansion accessories. These are optional extras that extend the system's functionality and improve its efficiency. The total cost of the extension is 555 €, with monthly fees for additional services amounting to 34 €.

The total cost of implementing the system, including basic equipment and extended services, amounts to 688 €. With full use of the extended services, the monthly operating costs amount to 49.95 €.

3. Results

Fuel consumption is a key parameter that has a significant impact not only on the economic efficiency of a transport company but also on the environmental aspects of its operations. This aspect is particularly important in the road transport sector, where the cost of fuel represents a significant item in the budget. In Figure 1 and Figure 2, we can see a comparison of the parameters before and after the introduction of the telematics system. The average fuel consumption after the introduction of the telematics system and the start of the monitoring of the driver's driving parameters decreased by 5.1 l/100 km with relatively the same, or even higher, average load weight and the same distance. Fuel consumption has fallen by 453 litres. At a diesel price (8.12.2024) of 1.216 € without VAT, the company can save up to 0.0584 € for every one kilometer of distance travelled, which at an average monthly driving performance of 10 000 km represents a saving of 584 € /vehicle.

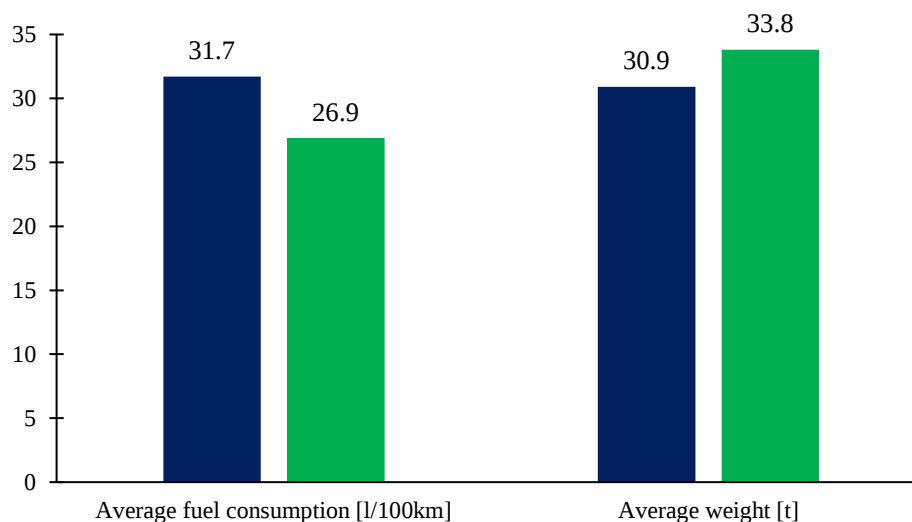
For a better idea and detailed display of individual cost items, a calculation sheet (Table 4) has been developed, which serves as a clear tool to analyse all important parameters and expenses related to the operation of the fleet.

Table 3: One-off and monthly costs for the implementation of the telematics unit

Vehicle telematics unit		
Product name	Price without VAT	Cost type
Background		
E.V.A - telematics unit	3.95 €	monthly costs
EVA - cable for fixed installation	15.00 €	one-time costs
Installation of the vehicle unit into the truck incl. antennas	65.00 €	one-time costs
Connection to the CAN/OBD/FMS bus of the vehicle (only if supported by the vehicle)	22.50 €	one-time costs
Connection to DTCO - driver identification + AETR (card-only tachograph)	22.50 €	one-time costs
System activation (Always activated during installation and reinstallation)	8.00 €	one-time costs
Access to the WEBDISPEČINK web application incl. SIM GLOBAL	12.00 €	monthly costs
Summary of total one-off costs	133.00 €	one-time costs
Summary of total monthly costs	15.95 €	monthly costs
GPS monitoring expansion accessories (not a necessary part of the system)		
SW Package Forwarding - one-time fee for the whole company	320.00 €	one-time costs
SW Package Trailers - one-time fee for the whole company	40.00 €	one-time costs
Activate remote download of the tachograph and driver card	6.00 €	one-time costs
Business card reader for remote reading of the tachograph and driver card	104.00 €	one-time costs
Trailer ID - tool/carrier identification - without mounting	75.00 €	one-time costs
Trailer ID mounting	10.00 €	one-time costs
WEBDISPEČINK Extension Monthly Fees		
Tachograph and driver card archiving service - monthly fee for one vehicle	6.80 €	monthly costs
Perfectdrive for a detailed record of the vehicle's driving style from the FMS bus - monthly service	6.20 €	monthly costs
Package - Lenovo Tablet + WD FLEET 3D + Sygic Navigation + holder and charger + SIM card GLOBAL + Sygic traffic - monthly fee with 36 months commitment	21.00 €	monthly costs
Summary of total one-off costs	555.00 €	one-time costs
Summary of total monthly costs	34.00 €	monthly costs
Total one-off costs	688.00 €	
Total monthly costs	49.95 €	

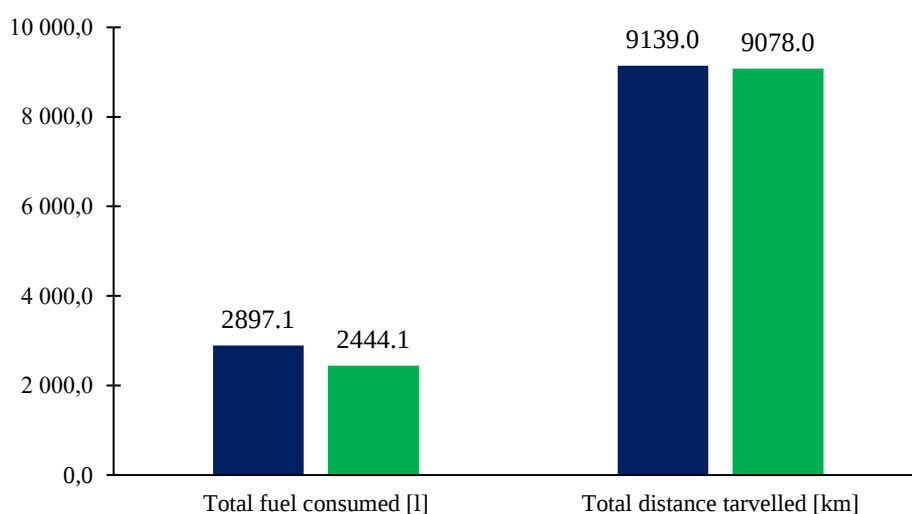
Source: author based on the quotation from Webdispečink

Figure 1: Comparison of average fuel consumption and average weight before and after the telematics system



Source: author

Figure 2: Comparison of total fuel consumed and total distance travelled before and after the telematics system



Source: author

Table 4: Costing sheet before the introduction of the telematic unit

Item	Value [€/month]	C _{v km} [€/km]	C _{v h} [€/h]	C _F [€/year]	P _{km} [€/km]	P _h [€/h]
Fuel	3,828.00	0.3828	-	-	0.3828	-
AdBlue	210.00	0.0210	-	-	0.0210	-
Other materials and services	23.00	0.0023	-	-	0.0023	-
Tires	345.00	0.0345	-	-	0.0345	-
Salary	1,354.40	-	7.5244	-	0.1138	7.5244
Deductions	490.29	-	2.7238	-	0.0412	2.7238
Reward	380.00	-	-	380.00	0.0319	2.1111
Maintenance/repair	299.00	0.0299	-	-	0.0299	-
Depreciation of semi-trailer combinations	1,934.24	-	-	1934.00	0.1625	10.7444
Travel refunds SR	102.00	-	0.5667	-	0.0086	0.5667
Collision insurance	83.19	-	-	83.19	0.0070	0.4622
Compulsory contractual insurance	134.42	-	-	134.42	0.0113	0.7468
Carrier insurance	22.70	-	-	22.70	0.0019	0.1261
Tax on motor vehicles	45.38	-	-	45.38	0.0038	0.2521
Fees, GPS, phone	11.90	-	-	11.90	0.0010	0.0661
Parking	120.00	-	0.6667	-	0.0101	0.6667
Directed by	780.00	-	-	780.00	0.0656	4.3333
Toll	1,400.00	0.1400	-	-	0.1400	-
-	-	-	-	-	1.0693	30.3238

Source: author

The reduction in fuel consumption has a direct and positive impact on the overall operating costs of the transport company, specifically the costs associated with fuel and additives such as AdBlue. These costs are classified as variable, which means that they are directly dependent on the amount of kilometres driven and the consumption of the vehicle.

A specific calculation shows that a reduction in fuel consumption of 5.1 litres per 100 kilometres can reduce the cost of operating the vehicle by 0.0586 € per kilometer. This value is based on the assumption of a constant price for fuel and AdBlue.

In Table 5, we can see that the cost per kilometre of travel is reduced by 0.0586 €.

Table 5: Costing sheet for the introduction of the telematic unit

Item	Value [€/month]	C _{v km} [€/km]	C _{v h} [€/h]	C _F [€/year]	P _{km} [€/km]	P _h [€/h]
Fuel	3,244.00	0.3244	-	-	0.3244	-
AdBlue	208.00	0.0208	-	-	0.0208	-
Other materials and services	23.00	0.0023	-	-	0.0023	-
Tires	345.00	0.0345	-	-	0.0345	-
Salary	1 354.40	-	7.5244	-	0.1138	7.5244
Deductions	490.29	-	2.7238	-	0.0412	2.7238
Reward	380.00	-	-	380.00	0.0319	2.1111
Maintenance/repair	299.00	0.0299	-	-	0.0299	-
Depreciation of semi-trailer combinations	1,934.24	-	-	1934.00	0.1625	10.7444
Travel refunds SR	102.00	-	0.5667	-	0.0086	0.5667
Collision insurance	83.19	-	-	83.19	0.0070	0.4622
Compulsory contractual insurance	134.42	-	-	134.42	0.0113	0.7468
Carrier insurance	22.70	-	-	22.70	0.0019	0.1261
Tax on motor vehicles	45.38	-	-	45.38	0.0038	0.2521
Fees, GPS, phone	11.90	-	-	11.90	0.0010	0.0661
Parking	120.00	-	0.6667	-	0.0101	0.6667
Directed by	780.00	-	-	780.00	0.0656	4.3333
Toll	1,400.00	0.1400	-	-	0.1400	-
-	-	-	-	-	1.0107	30.3238

Source: author

The cost saving opportunities are not limited to savings per kilometre and savings per month, but have also been quantified for standard annual driving performance of 80 000-120 000 kilometres in Table 6. This view offers an even more detailed overview of the potential savings, especially for vehicles with higher annual driving performance.

Table 6: Overview of cost savings for annual driving performance

Savings at 80 000 km (€)	Savings at 90 000 km (€)	Savings at 100 000 km (€)	Savings at 110 000 km (€)	Savings at 120 000 km (€)
4,669.44	5,253.12	5,836.8	6,420.48	7,004.16

Source: author

In addition to the savings the company can make on fuel, the introduction of a telematics system and the monitoring of driver driving style will also add to lower brake and tyre costs, which can contribute significantly to the company's overall savings and improve its financial situation. At the same time, they can increase vehicle safety and reliability, which is key to the efficient operation of a transport company.

4. Discussion and Conclusions

In order for a transport company to remain competitive, it is crucial for carriers to analyse cost items carefully and strive to optimise them. One effective way to do this is to use telematics systems that provide the detailed data needed to improve management and reduce operating costs.

The return on investment in a telematics system is extremely fast in the optimistic scenario, making it an effective tool for improving the economic performance of a transport company. At a saving of 584 € per month per vehicle, the initial investment in the system, including basic equipment and enhanced services, which represents a one-off cost of 688 € and a monthly operating cost of 49.95 €, can be repaid in just 38 days. This fast return on investment underlines the high efficiency of the system in real operating conditions.

While the overall cost of deploying and operating the system will increase when the system is expanded to more vehicles in the fleet, the cumulative cost savings increase significantly. In the case of a multi-vehicle fleet, the savings can amount to several thousand euros per year, which has a major impact on the overall economic performance of the company. These savings allow the transport company to invest in innovation, fleet modernisation or improving the quality of services provided, thus increasing its competitiveness in the market.

In addition to the financial benefits, telematics also provides non-financial benefits such as better traffic management, improved driver and vehicle safety, reduced administrative burden and better monitoring of compliance (Elander et al., 1993; Truby et al., 2024). In the context of large fleets, the introduction of telematics is a strategic step that not only brings direct economic savings, but also promotes sustainability and long-term business development. In this way, telematics systems are becoming an integral part of modern transport company management (Hamidi et al., 2016).

Based on these findings, carriers can take concrete steps to optimize the use of their resources and minimize negative impacts on operations. Overall, this example and the related recommendations show that a telematics system can be an important tool for a transport company to achieve the goals of efficient management and cost optimization.

Research in the field of telematics systems can make a significant contribution to monitoring and reducing negative externalities associated with transport, which include environmental, social and economic impacts. From an environmental perspective, telematics systems can help to minimise emissions of greenhouse gases and other pollutants.

From a social point of view, telematics systems promote road safety. Continuous monitoring of driver behaviour and the technical condition of vehicles can reveal potential risks such as driver fatigue, speeding or wear and tear on important vehicle components. Reducing the number of road accidents not only saves financial costs, but above all protects human life and health.

The economic aspect of negative externalities is equally important. Traffic congestion causes not only lost time but also increased fuel consumption and higher emissions. Telematics systems allow dynamic route planning based on the current traffic situation, leading to smoother operation and lower economic burden.

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