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CONTENTS

Foreword	7
1. Inna BALAHUROVSKA – Innovation synergy for the transformation of organizations in the digital era	9
2. Robert BANAS , Anita PERSKA , Adam WEINERT – Logical framework matrix as a means of program evaluation – a case study of pre-incubation program	19
3. Alina CZAPLA – Dynamic capabilities in a high-velocity environment: the emergence as a reaction to threats	33
4. Eugenia CZERNYSZEWICZ – Food safety concerns from the view of Gen Z students in Poland	45
5. Anita FAJCZAK-KOWALSKA , Daniel TOKARSKI – Analysis of transport efficiency in Poland on the example of cargo transport	57
6. Anita FAJCZAK-KOWALSKA , Daniel TOKARSKI – Level of sustainable consumption in households in Poland according to non-income factors	75
7. Malgorzata FIALKOWSKA-FILIPEK , Anna SALAMACHA , Katarzyna TWOREK – The influence of e-leadership on products and services quality and organizational performance during black swan event	87
8. Sandra GRABOWSKA , Mochammad FAHLEVI , Marta KADLUBEK – Talent management in the era of the fourth industrial revolution	109
9. Dorota GREGO-PLANER , Katarzyna GADOMSKA-LILA , Mirosława ŻUREK , Monika KLEMPKE-PITEK – The link between perceived organizational support, job satisfaction and organizational citizenship behavior – does employee age make a difference?	125
10. Aleksandra GROBELNA , Ewa WYSZKOWSKA-WRÓBEL , Patrycja KRUPA , Paulina MIKUŁA – Generation Z's attitudes towards tourism studies and careers vs. its tourism activity	159
11. Adam GUMIŃSKI , Katarzyna DOHN , Enioluwa OLOYEDE – Advantages and disadvantages of traditional and agile methods in software development projects – case study	191
12. Robert HILDEBRANDT , Ryszard MARSZOWSKI , Zbigniew LUBOSIK , Luis JORDA BORDEHORE , Mishel Tatiana GARCIA VELA – Application of virtual and augmented reality in flipped classroom – teaching and training in underground engineering: museum mines and experimental laboratories	207
13. Robert HILDEBRANDT , Aleksandra ZGÓRSKA , Agnieszka KLUPA , Tomasz PINDEL , Adam SMOLIŃSKI , Ryszard MARSZOWSKI – A new method of coronavirus virion detection – innovative method of identification transforming	221
14. Joanna IWKO , Dorota KUCHTA , Oksana YAKIVETS – Metrics based project time management – application of linear programming	243

15. Agnieszka KURDYŚ-KUJAWSKA, Aleksandra WOJTKOWSKA – To be or not to be... an entrepreneur: what motivates and what limits students' entrepreneurial initiatives?	259
16. Aleksandra KUZIOR, Mariya SIRA, Paulina BROŻEK – New technologies as tools supporting innovation management	279
17. Aleksandra KUZIOR, Jan ZOZUL'AK, Inna BALAHUROVSKA – The evolution of leadership styles during the industrial development of society	299
18. Branislav MIČIETA, Honorata HOWANIEC, Ľuboslav DULINA, Ján ZUZIK, Vladimíra BIŇASOVÁ – Indication, solution, prevention: a holistic approach to financial, industrial engineering, and business problem analysis	313
19. Mateusz MIERZEJEWSKI, Justyna TOMALA – The evolution of profit margins in the mining and extraction industry	327
20. Kamila MIGDAŁ-NAJMAN, Krzysztof NAJMAN – Identification of key aspects of building the image of the Tricity Agglomeration based on the platform users' entries X	343
21. Paweł NOWAK, Nabi IBADOV, Jerzy ROSŁON – Educational and didactic tools development – modern construction management projects	359
22. Marta NOWAKOWSKA – Enhancing communication competences for military leaders through equine-based learning	383
23. Józef OBER, Anna KOCHMAŃSKA, Charli SITINJAK – The effect of the form and level of study on the type of pro-environmental actions taken by students of higher education institutions in Poland	399
24. Katarzyna OLEJKO, Izabela EMERLING – Internal audit as an element of the internal audit system and its disclosure in non-financial reports	425
25. Katarzyna OLEJKO, Ewa WÓJCIK – Social capital and its reporting – case study of selected Polish companies listed on the Warsaw Stock Exchange	439
26. Anna OLKIEWICZ – Rules of restructuring and bankruptcy in Poland and their impact on the situation of creditors and debtors	455
27. Marcin OLKIEWICZ – The impact of economic macroenvironment on shaping foreign trade during the Covid-19 pandemic in Poland	471
28. Zbigniew ORBIK, Bogdan PLISZKA – Basic ethical problems related to the development of artificial intelligence as a management tool	485
29. Aleksander PABIAN – The need and process of generating innovations by corporate museums – cultural exhibition units of organizations	501
30. Beata PALIŚ, Matylda SIWEK, Kasper PRZENZAK – The management of the global village in Dubai as a shopping tourism attraction	515
31. Szymon PAWLAK – The impact of implementing selected lean manufacturing tools on the failure rate of machines – case study	531
32. Magdalena PAŹDZIOR – Consumer segmentation using cluster analysis as a source of data to improve product quality	541
33. Kornelia PIKIEWICZ, Dorota KUCHTA – Project scheduling under consideration of team-based dependencies between project activities	555

34. Anna M. PLATTA, Anna T. MIKULEC, Monika RADZYMIŃSKA – Women’s emotions and food choices – a study of Gdynia city residents, Poland	571
35. Konrad ROJEK, Jarosław CWYL, Anna BORCUCH – The impact of macroeconomic stabilisation on the development of non-life insurance markets of the Visegrad Group IN 2004-2020	589
36. Kinga SMOLIŃSKA-BRYZA, Karolina JÓZEFOWICZ – Socio-economic development and urbanization in the organization of African, Caribbean and Pacific states	605
37. Katarzyna SZUPER – Post-IPO innovative firm performance	621
38. Tomasz WĘGRZYN, Bożena SZCZUCKA-LASOTA, Feng CHEN, Katarzyna TUROŃ, Piotr CYBULKO – Dissimilar welding of ferritic steel H17 with DOCOL 1100 for the automotive application	635
39. Magdalena WINIARSKA, Joanna KIZIELEWICZ – The essence of process management through the methods and techniques used in IT	643
40. Radosław WOLNIAK, Wies GREBSKI – The usage of benchmarking in Industry 4.0 conditions	665
41. Radosław WOLNIAK, Wies GREBSKI – The usage of kaizen in Industry 4.0 conditions	677
42. Radosław WOLNIAK, Wies GREBSKI – The usage of smart cameras in smart home	687
43. Radosław WOLNIAK, Wies GREBSKI – The usage of smart voice assistant in smart home	701
44. Małgorzata ZAKRZEWSKA, Mariusz SIKORA, Żaneta STASIENIUK – Voluntary fire departments (VFD) in Poland as an entity of the non-governmental sector (NGO) on the example of the Western Pomerania VFD	711
45. Dariusz ZDONEK – The influence of extraversion and temperament on motivational factors for learning	725
46. Urszula ZEMLIŃSKA-SIKORA, Alina KOZARKIEWICZ – IT project managers’ competencies required on the market – generative AI enhanced analysis ...	741

FOREWORD

Presented number of Silesian University of Technology. Scientific Papers. Organization and Management Series. Contemporary management. Presented papers contain result of researches conducted by various universities from Poland. The number consists of 43 papers.

The papers presented in the number concentrate on many topics connected with organization and management. There are in the number papers about: changes management, tourism management, knowledge management, information management, logistics, supply chain management, Industry 4.0, production management, Corporate Social responsibility, quality management, human resource management, sustainable development, e-commerce, economics, public management, knowledge management, Smart City, business analytics, lean management, and innovation management.

Radosław Wolniak

INNOVATION SYNERGY FOR THE TRANSFORMATION OF ORGANIZATIONS IN THE DIGITAL ERA

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Purpose: The purpose is to study and understand the processes related to integrating extended intelligence into organizational practices and research the role of leadership 4.0 in the formation of strategies, adaptation to technological innovations, and supporting the organization in the digital environment. The work examines the interaction of leadership 4.0 and extended intelligence; the authors found out how these concepts can interact to achieve synergistic effects and improve organizational management.

Design/methodology/approach: The work analyzes modern theoretical approaches to extended intelligence and leadership 4.0, a review of practical cases of real examples of the integration of extended intelligence into organizational practices. The use of analytical methods (Friedenthal et al., 2008) for studying the characteristics of the studied systems contributed to forming a conditional formula (Hájek, 2011; Pollatsek et al., 1987) for expressing the synergy between developed extended intelligence and leadership 4.0. The scope includes research on the impact of concepts on organizational practices and strategic management.

Findings: Integrating extended intelligence into organizational practices opens up new opportunities for efficient use of resources and strategic decision-making. Leadership 4.0 is becoming a key component of digital transformations, requiring flexibility and innovative management. The interaction of leadership 4.0 with extended intelligence creates a synergy that increases efficiency and promotes innovation. The proposed formula reflects the concept of synergy, which can be a success factor in the digital era.

Research limitations/implications: The proposed formula is general and does not consider all aspects of the interaction of extended intelligence and leadership 4.0. It is logical in a conventional form, does not consider specific contexts, and requires empirical research for accurate models.

Originality/value: The study analyzes approaches to integrating extended intelligence into organizational practices and considers leadership 4.0 a key component of digital transformations, focusing on their interaction. The study introduces a conditional formula to conceptualize the synergy between extended intelligence and leadership 4.0. The study can be helpful for managers, leaders, and researchers interested in optimizing organizational processes and achieving competitive advantages in the era of digital transformations.

Keywords: leadership 4.0, extended intelligence, synergy.

Category of the paper: Research paper.

Introduction

Extended intelligence (extended mind) originated in cognitive science and philosophy. The idea suggests that intelligence is not limited to the boundaries of the human organism but can be expanded with the help of tools, technology, and other external resources (Clark et al., 1998). The concept of extended intelligence is based on the idea that intellectual functions can be distributed between the brain (internal space) and external objects (external space) (Barack et al., 2022). Human intelligence and tools form a system that solves tasks and problems together. A classic example of extended intelligence is notebooks, computers, or other means of storing information, which expands the possibilities of memorizing and processing information.

Extended intelligence in the context of artificial intelligence development refers to intelligent systems using large amounts of data and algorithms and interacting with other technologies and external sources to achieve better results (Trakadas et al., 2020). To achieve exceptional results, intelligent technologies use their data and algorithms and actively interact with other technologies and external sources of information. In artificial intelligence development, systems can use vast data for training and analysis. Such data can be obtained from both the organization's internal and external data from various sources, expanding the capabilities of artificial intelligence models.

Extended intelligence also emphasizes the importance of using a variety of algorithms and techniques to achieve optimal results (Bostrom, 2014; Kuzior et al., 2023; Bloom et al., 2016). The importance of interaction with other technologies and systems through integration into organizational processes through intelligent or automated solutions can create additional opportunities to optimize and improve productivity.

Today's leaders use extended and artificial intelligence capabilities to create an innovative environment where technology encourages creativity and solving complex problems (George et al., 2009). This trend promotes the continuous development of staff by providing them with the necessary training and professional development tools. The integration of technologies makes the organization more flexible and adaptable to changes. Leadership can use artificial intelligence and extended intelligence to respond to market and organizational changes quickly, ensuring sustainable competitiveness.

1. Integration of extended intelligence into organizational practices

Integrating extended intelligence into organizational practices is essential in improving cognitive functions and decision-making in modern organizations. Such a process involves using intelligent analytical tools, automation, and other technologies to optimize the organization's work (Ziegler, 2020; Kuzior et al., 2022). Implementing extended intelligence creates opportunities to improve communication and collaboration within an organization. Extended intelligence makes it possible to increase the speed and accuracy of analysis of large volumes of data, which helps to make informed decisions. Artificial intelligence, machine learning, and other analytical tools allow the automation of repetitive tasks, freeing up resources for strategic thinking and a creative approach to tasks.

Integrating extended intelligence into organizational practices defines new standards of efficiency and competitiveness. It helps the organization adapt to the rapid pace of changes in the environment, making it more flexible, reactive, and ready for the challenges of the digital age (Anthony, 2008). Automating routine tasks reduces the burden on workers, allowing them to focus more on their work's creative and strategic aspects. This approach promotes productivity and creates conditions for maintaining a balance between professional and personal aspects of life, improving the quality of working life.

The impact of extended intelligence on organizations' daily activities is directly related to the social integration of artificial intelligence (Abbass, 2019). Implementing innovative analytics tools and automation helps create a more accessible and inclusive environment for all team members. Artificial intelligence can support the adaptation of work processes to the needs of people with different abilities, ensuring a comfortable environment for all employees (Kuzior et al., 2019). The application of intelligent systems promotes the recognition and development of unique skills of each team member, regardless of their social group or specific characteristics.

The social integration of artificial intelligence in organizations is determined by an attempt to combine the power of technology and human capital to achieve common goals. In a certain sense, intelligent systems also play a role as an assistant for leaders in making strategic decisions, providing the necessary analytical basis and forecasts (De Jaegher et al., 2010; Kuzior et al., 2021). Therefore, the social integration of artificial intelligence in organizations contributes to increased efficiency and creates a new level of cooperation and mutual understanding in the team and the interaction of intelligent machines with people (Rupert, 2009).

Extended intelligence allows us to use intelligent analytical tools that help make informed strategic decisions. This enhances the ability to analyze large volumes of data and predict trends, providing the organization with the tools to respond to changes in the internal and external environment flexibly.

2. Leadership 4.0 as a component of digital transformations

Leadership 4.0 is marked by using the latest technologies and management strategies that meet modern challenges and opportunities. The concept of leadership 4.0 provides a new approach to management, considering the impact of digital transformation and modern technologies on organizations (Behie, 2023; Kuzior et al., 2020; Kuzior et al., 2023). Figure 1 visualizes the four main components of this concept.

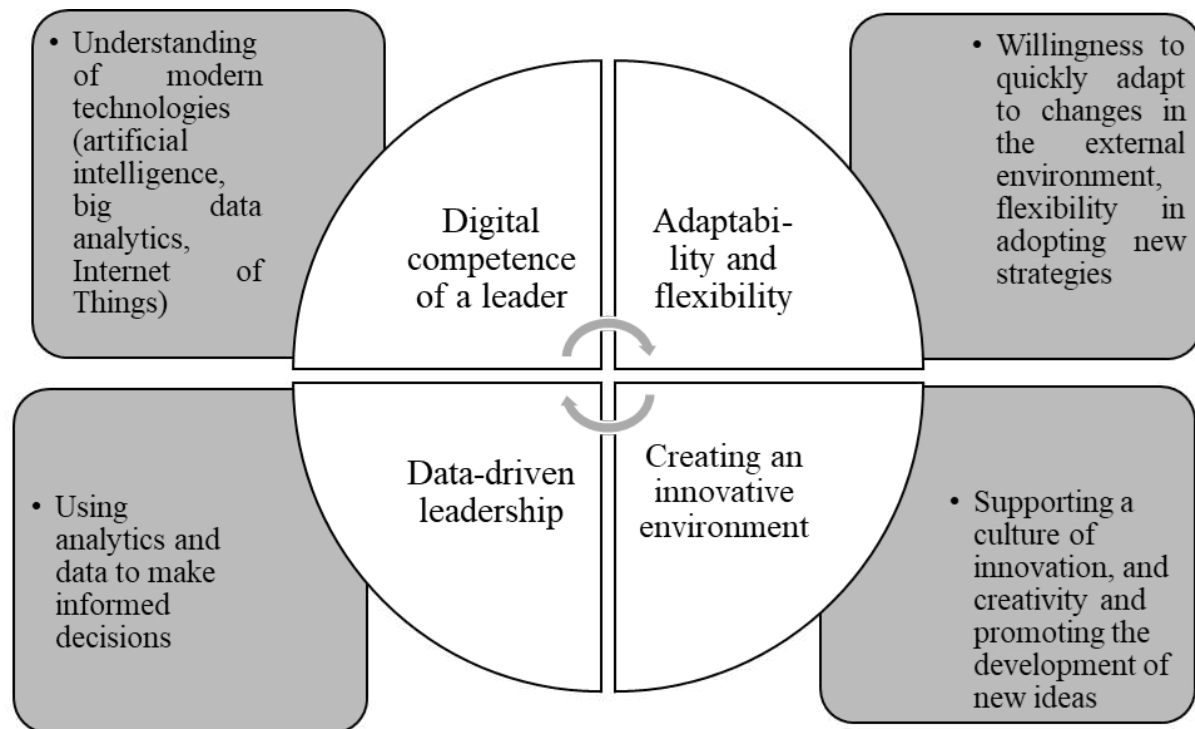


Figure 1. Components of leadership 4.0.

Source: developed by the author.

The described components are separate elements and the main pillars on which the modern concept of leadership 4.0 is based. In the era of rapid technological development and global transformations, leadership 4.0 becomes necessary for effectively managing organizations (Oberer et al., 2018; Bolte et al., 2018). A leader's digital competence determines his ability to understand modern technologies and implement them to improve organizational processes and achieve strategic goals, which means constant updating of knowledge and readiness to integrate innovations. The adaptability and flexibility of a leader are essential qualities in the face of uncertainty and change. The 4.0 leader must be ready to adopt new strategies and respond to real-time changes, ensuring stability and efficiency in all circumstances. Data-driven leadership goes beyond gathering information. Using analytics and data for decision-making makes the manager responsible for processing information and strategically using data to achieve a competitive advantage. Creating an innovative environment supports the development of the organization and stimulates creativity. The 4.0 leader acts as a catalyst for innovation, helping the team to go beyond conventional solutions and implement innovative ideas.

The analyzed components interact to form an integrated leadership strategy 4.0, which is aimed at the effective use of technology, data analysis, and creating an innovative environment, thus ensuring the organization's success in the modern business environment.

Extended intelligence is an essential tool of the 4.0 leader, which adds a new level of intellectual abilities and capabilities to the leadership arsenal in the age of digital transformation. (Luoma-aho et al., 2023) Considering the main components of Leadership 4.0, where it is essential to use advanced technologies and strategies to achieve success in the organization, Extended intelligence becomes a catalyst for realizing the tasks of Leadership 4.0.

3. Interaction of leadership 4.0 with extended intelligence

Studying the effectiveness of different leadership models and their ability to adapt to a dynamic digital environment, considering the factors of extended intelligence. In today's market, several firms successfully exploit the innovative relationships between extended intelligence and leadership 4.0. The companies in Table 1 implement intelligent technologies for effective management and strategic development.

Table 1.

Practical examples of the implementation of advanced intelligence for the development of organizations

Organization	Extended intelligence	Leadership 4.0
Google (Forbes, 2023)	To improve its search algorithms and analytical tools	Active implementation of data in strategic decision-making, based on the analysis of large volumes of data
Amazon (Statista, 2023)	To personalize services, forecast demand, and automate logistics processes	Emphasis on strategic development, taking into account intellectual solutions
Tesla (Forbes, 2022)	For the development of autonomous cars and optimization of production processes	Active support for the introduction of innovations and technological development
IBM (Statista, 2023)	To analyze data, solve complex tasks, and develop strategies for clients (Watson system)	Encouraging internal innovative culture
Microsoft (Forbes, 2023)	To develop its products, including accounts, cloud services and enterprise products	Determination of the development strategy with the active implementation of technological innovations

Source: developed by the author.

The given practical cases demonstrate how modern firms successfully combine extended intelligence and leadership 4.0 to achieve strategic goals and create competitive advantages in the conditions of digital transformation.

The synergy between extended intelligence and leadership 4.0 is determined by the complex interaction of these concepts in the context of effective management and strategic development in the digital transformation era. To simplify the visual transmission of the idea of synergy between extended intelligence and leadership 4.0, such interaction can be conventionally expressed by the following formula:

$$S = (EI + L4.0) \times E$$

where:

S - synergy between Extended Intelligence (EI) and Leadership 4.0 (L4.0).

Synergy is the result of the interaction of extended intelligence and leadership 4.0. In this context, synergy refers to the mutual reinforcement and improvement of the interaction of these two factors, which leads to joint additional efficiency in the organization.

EI - extended intelligence.

Extended Intelligence includes using various technologies, tools, and external resources to improve cognitive functions and decision-making. It may include artificial intelligence, analytical platforms, and other innovative tools.

L4.0 - leadership 4.0.

Leadership 4.0 represents a new approach to management where leaders actively use technology and innovate to adapt to organizational changes. Such leadership includes flexibility, adaptability, and the development of strategies that consider digital opportunities.

(EI + L4.0) - defines the interaction or sum of extended intelligence and leadership 4.0 contributions.

E - efficiency of the organization.

Effectiveness in this context is determined by the organization's success in achieving its goals and objectives using extended intelligence and leadership 4.0. Performance can include financial performance, customer satisfaction, innovation, and other aspects of successful operations. E takes into account the effect of overall efficiency on this interaction.

The proposed formula indicates that the synergistic effect arises from the interaction of extended intelligence and leadership 4.0, and this amount is multiplied by the level of the organization's performance. In the context of this formula, synergy is not simply the sum of the individual elements. However, it can reinforce and mutually support each other, leading to higher effectiveness. The logic of the proposed formula is determined by conceptual convention. It is a generalized analytical model that can be used for theoretical or conceptual description of systems and interactions between their components.

Therefore, the proposed conditional formula expresses the idea that the synergy that arises from the interaction of extended intelligence and leadership 4.0 multiplies the level of organizational performance, emphasizing that these two factors together can provide more significant influence and success in a digital organizational environment.

In the context of the proposed formula, S - can be a critical quantitative indicator since synergy can be measured in percentages or other numerical values that indicate the increase in efficiency due to the interaction of advanced intelligence and leadership 4.0. EI - can be

a qualitative and quantitative indicator, for example, the number of technologies used (the number of artificial intelligence tools) and the quality of their impact on cognitive functions and decisions. L4.0 - indicators can include the number of implemented innovations and the level of flexibility and adaptability of leadership, and it is also possible to measure the number of successful strategic decisions that were made using leadership 4.0 approaches. E – can be a quantitative indicator, such as financial indicators (profit, turnover), but can also include qualitative aspects, such as the level of customer satisfaction, an index of innovation, or indicators of corporate sustainability. It is crucial to consider both indicators (quantitative and qualitative), as they can provide a comprehensive view of the impact of the synergy of extended intelligence and leadership 4.0 on organizational performance.

4. Conclusions

Integrating extended intelligence into organizational practices defines a new stage in business development. Such a process opens up many opportunities for more efficient use of resources and improved strategic decision-making. By providing the organization with intelligent tools operating based on artificial intelligence, it is possible to achieve significant positive changes that contribute to optimizing work processes, increasing personnel productivity, and creating a competitive advantage in the market. In general, the integration of extended intelligence becomes a strategic step in the direction of modern and competitive management of the organization.

Leadership 4.0 acts as a response to digital transformations and a key component determining their success. In a world saturated with technological innovation, it is essential for leaders not only to adapt but also to implement innovative management strategies. Leadership 4.0 involves flexibility, openness to change, and active participation in digital initiatives. Such leaders are critical leaders who guide their teams through transformational processes, ensuring sustainability and innovative development in the digital age environment.

The interaction of leadership 4.0 with extended intelligence creates a solid synergistic effect aimed at achieving high efficiency and innovative development in organizations. Leaders 4.0, showing flexibility and openness to innovation, actively implement advanced intelligence in strategic management and decision-making. Extended intelligence, in turn, gives leaders insight into deep analytical data, contributing to more informed and accurate strategic decisions. Such interaction not only provides the organization with a competitive advantage but also contributes to creating innovative and adaptive leadership to achieve success in the digital transformation era.

The conditional formula $S = (EI + L4.0) \times E$ reflects the concept of synergy between extended intelligence (EI) and leadership 4.0 (L4.0) in terms of overall effectiveness (E). The proposed conditional formula is designed to reproduce and understand the interaction between these critical management and organizational development elements. By combining intellectual capabilities and strategic leadership with a favorable impact on overall efficiency, such a formula indicates the potential for achieving synergistic effects and achieving high results in a dynamic organizational environment.

Such a conditional formula is a simplified abstraction for understanding the meaning of the concept of synergy between extended intelligence and leadership 4.0, and it is also logical in a conditional form. In further studies to build more accurate models and predict fundamental interactions, there is a need to use the obtained specific data and results of empirical studies.

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LOGICAL FRAMEWORK MATRIX AS A MEANS OF PROGRAM EVALUATION – A CASE STUDY OF PRE-INCUBATION PROGRAM

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Purpose: The purpose of the article is to describe and explain the logical framework as a tool for a systematic and analytical process of planning, monitoring, evaluating and managing a pre-incubation program, which is a key component of the process of supporting and developing entrepreneurship and innovation.

Design/methodology/approach: The research method used is a case study. The scope of the subject concerns the evaluation of program management using the example of a pre-incubation program implemented by the Foundation and the Enterprise. Indicators with definitions, sources of information and assumed values (level I and II) are provided.

Findings: The usefulness of the logical framework matrix as a tool for a systematic and analytical process of planning, monitoring, evaluation and management of the pre-incubation program was confirmed. Attention was paid to the continuous adaptation of the matrix in view of the changing conditions of the project environment.

Research limitations/implications: Future research may address the identification of factors influencing the attitudes of participants in pre-incubation programs in terms of increasing their involvement, with the goal of settling program outcomes.

Practical implications: Practical solutions involve improving pre-incubation programs and concern the process of their planning, monitoring, evaluation and management. Progress in this area can contribute to an increase in the efficiency and effectiveness of incubation programs, and ultimately to the development of enterprises and the intensification of inter-sector cooperation.

Social implications: Social implication refers to the promotion of attitudes based on building inter-sectoral relationships, with the goal of creating shared value.

Originality/value: The novelty of the article is the reference of the logical framework matrix as a useful tool for planning, monitoring, evaluation and management of the program on the example of a pre-incubation program (the matrix has so far been used in practice to evaluate development projects). The considerations can contribute to the improvement of pre-incubation

programs and inspire the development of initiatives of this type. The addressees are enterprises, non-profit organizations, universities and leaders in their fields.

Keywords: Project Management, Program, Project Portfolio, Pre-incubation Program, Logical Framework Matrix.

Category of the paper: Case study.

1. Introduction

The dynamics of the modern world impose on organizations the need to constantly adapt to change, which poses challenges to the effective and efficient management of projects, programs and project portfolios. The paper presents selected aspects of project management, looking in particular at program structures and considering measures of program success captured as a group of projects. The study begins with an analysis of the essence of a project, program and project portfolio based on foreign and domestic literature on the subject. It then focuses on the role of program management as a response to dynamic changes in the environment. The next step presents a diagram of the logical framework matrix as a tool that enables decision-makers to comprehensively evaluate a program. The matrix was described and explained to identify key indicators of efficiency and effectiveness, which are the foundation of success in program management. The theoretical content served as an introduction to the scope of the developed case study, which shows the practical application of the concepts discussed in the context of an example of a program implemented based on the pre-incubation model. The case study presents specific challenges and achievements that can inspire other ventures in organizations. In this way, not only the theoretical basis of program management is discussed, but also the practical implications of these concepts on actual organizational successes are presented. The purpose of the article is to describe and explain the logical framework using the example of a pre-incubation program, in the implementation of which it was used as a tool for a systematic and analytical process of planning, monitoring, evaluation and management of activities undertaken in the framework of cross-sector cooperation. Special attention is given to selected indicators for program evaluation by defining them, identifying sources of information and optimal levels from the perspective of marketing, recruitment, program implementation, deployment and participant satisfaction.

2. Project, program, project portfolio - comparison of scope and measures of success

Today's business environment is characterized by turbulence, complexity and uncertainty, and the social and economic changes taking place are constant, requiring a flexible approach, dynamic action, but also creative thinking. Increasing uncertainty resulting from the intensification of the changes taking place forces the creation of new approaches adapted to organizational conditions. Organizations, including business entities, must respond more quickly to customer needs, react more quickly to the actions of competitors, spot market opportunities and eliminate non-value-adding work. As a result, unique activities are becoming increasingly important in the activities of modern organizations. Projects occur in all areas of the organization's activity, and they are carried out for the benefit of the environment, as well as to solve internal problems. As is known, the importance of projects in the modern world is constantly growing. This is due to the increasing diversity, complexity of problems and the projects required to solve them (Trotsky, 2012; Sadowska, Chmielewski, 2014; Kerzner, 2019; Geraldi et al., 2022; Aghajani et al., 2023). At the same time, the progressive complication of the processes of the environment and the functioning of organizations of various types influences the observed growing demand for professional knowledge in the field of project management (Trocki, Buklaha, 2015; Banas et al., 2023).

A project is a temporary activity undertaken to achieve a unique result, produce a unique product or provide a unique service of high complexity, for the implementation of which the commitment of significant resources (e.g., material, human, financial) is required. The implementation of projects occurs relatively independently of repetitive activities and is associated with risks (among others: technical, organizational, economic), using special methods, techniques and tools of project management. Increasingly, the implementation of multiple projects is observed in organizations. Thus, a multi-project environment is emerging, also referred to as project portfolio management, project program management, corporate/organizational project management, strategic project management, systems approach in project management, multiple project management, project-oriented organization or management by projects (Brzozowski, 2014; Derakhshan et al., 2019; Pinto, 2020; Trocki, Juchniewicz, 2022; PMI, 2019). In the Scopus database, one of the most important literature databases, one can find a total of as many as 387,384 publications that contain the term "project management" in the title, abstract, keywords, and 516,566 containing "program management" ((in turn, limiting the search to the social sciences, the numbers are 57,513 and 71,212, respectively). Narrowing the search of publications to the area of general business, management and accounting, the number of publications referring strictly to project management is greater than the number of publications referring to program management alone (51,852 versus 31,372). Due to the increasing complexity of the functioning of organizations, it is assumed that

there will be a growing interest in project program management in organizations (Papadakis, Tsironis, 2020; Marnada et al., 2022).

The implementation of projects can occur separately or they can be grouped into programs and portfolios. The basis for the scientific discussion of programs is the theory of organization, strategic management, as well as product development, production and change management. In the literature we can find many definitions of program of programs, and they are united by the understanding of them as a group of projects that make up a common, higher order, goal (Pinto, 2020; Sońta-Drączkowska, 2022; Juchniewicz, Trocki, 2022). A program is a set of product-differentiated projects that are linked by the pursuit of a common higher-order goal that would be impossible for individual projects to achieve separately. Project portfolios, on the other hand, are ensembles of projects and programs executed simultaneously in a single organization, managed to achieve its strategic goals. The programs and projects included in a project portfolio need not be interdependent and interrelated. An organization may have multiple project portfolios, created within its organizational units (Figure 1). While projects have defined objectives and their scope is gradually concretized during the project life cycle, programs have a larger scope than projects and more significant benefits can be achieved. Portfolios, on the other hand, have a business scope that varies according to changes in the organization's strategic goals. Project success is measured by the quality of the project's product, customer satisfaction, budget maintenance and timeliness, while program success reflects the degree to which the needs and benefits for which it was undertaken were met. The success of a portfolio is determined by meeting the requirements set for the portfolio components (IPMA, 2015; PMI, 2018; Cabala, 2018; Trocki, Juchniewicz, 2022).

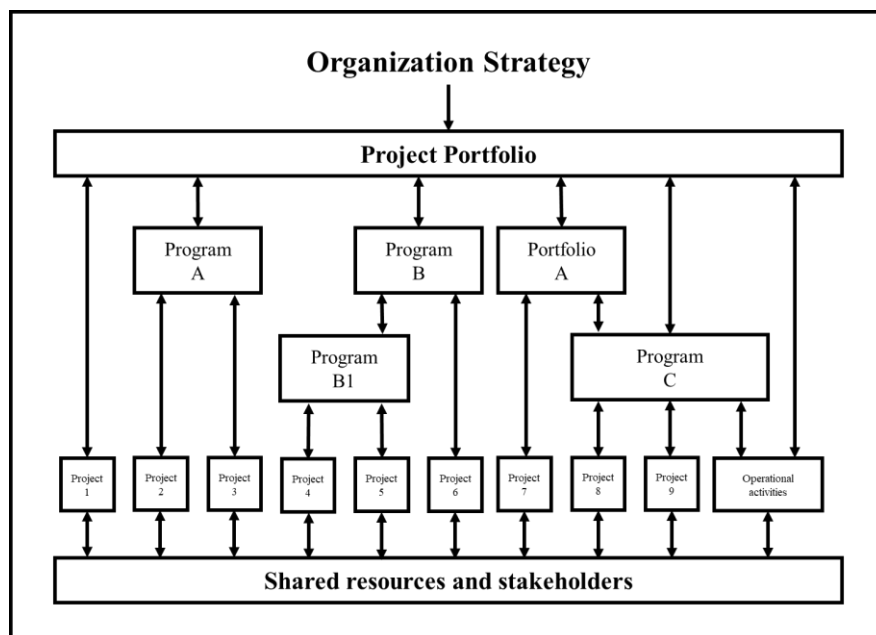


Figure 1. Relationship between projects, programs and project portfolio.

Source: PMI, 2021, p. 12.

The most important criterion for evaluating the success of a project is assumed to be the achievement of the assumed overarching goal, within the planned time, within the assumed costs, corresponding to the assumed quality parameters of the project, which refers to the consideration of the criteria of the so-called golden triangle, which include: time, budget and project goals. Researchers note that the stakeholder perspective is increasingly being taken into account, and the determinant of success, depending on the type and nature of the project undertaking, will be how the product of a given project is perceived by the customers for whom it was carried out. Examples of measures of success will be the level of customer satisfaction, the improvement of the company's competitive ability, the increase in market share, as well as the profits made possible by the company through the completion of the project. The value that is generated by the project's product for the customer is also an important factor in assessing the success of the project as a whole. The above description of success applies to the implementation of projects of an internal nature, when the organization implements a project for its own needs, being both the initiator, principal and contractor of the project. When an organization implements an external project, its interest is in the realization of the project's objective and the collection of payment, and it is not important what the further effects and results of using the project product will be (Kandefer-Winter, 2015; Agbejule, Lehtineva, 2022; Carujo et al., 2022).

3. Project program management as a response to business changes

Program management is a form of organizing project activities that helps address the problem of translating strategy into operational activities. By incorporating components of organizational change management and focusing on vision and business benefits, programs are much more able than projects to reflect an organization's long-term strategic goals. Projects tend to focus on performance goals related to delivering project deliverables within specific project constraints: budget, time, scope, required quality criteria. Programs, on the other hand, encompass the organization's long-term development vision and strategic goals, as well as the need to change and transform ways of doing things. The implementation of programs is accompanied by a great deal of ambiguity and uncertainty. They require a strategic perspective in decision-making, incorporate a systems view and represent a learning approach, reducing ambiguity over the course of the program. The popularity of program management has been on the rise in recent years due to the fact that organizations need to implement business changes in an efficient and effective way and to direct ongoing projects to benefit the organization (Sońta-Drączkowska, 2018; Pinto, 2020; Aghajani et al., 2023).

Programs in an environment characterized by a relatively high level of uncertainty and ambiguity are identified as a particularly useful form of organizing activities, so that constant validation of goals and established assumptions is needed, with the implementation of changes in the organization often causing resistance and not being easy. In the face of reluctance and resistance to change, this should be accepted as a natural trait of people, who treat change as something unknown. In the case of a very significant, strategic and organization-wide change, the management structure of the program should be adapted and thought out, and the organization of the project could take place in the form of a top-down controlled program. On the other hand, for changes of an incremental and streamlining nature, it is reasonable to implement, for example, in the form of a goal-sharing type program (Cabala, 2018; Derakhshan et al., 2019; Kerzner, 2022; Sońta- Drączkowska, 2022).

4. Logical Framework Matrix as a means of program evaluation

The Logical Framework Approach (LFA) is a systematic and analytical process for planning and managing goal-oriented projects. The approach was developed in 1969 for U.S. government agencies and is based on a worldwide study conducted by Leon J. Rosenberg in 1970 and 1971. The Logical Framework Approach is one of the more ubiquitous project management tools that has been widely used for project planning and evaluation in international organizations. The logical framework approach provides a series of tools and methods that are used at various stages of project work. Their task is to show the interactions and consequences between the key elements of the project, that is: problems, objectives, actors, activities. This is served by methods such as project stakeholder analysis, problem tree, selection of objectives and strategies for proceeding. Hence, the role of LFA is to think about the project with the goal of structuring the process of working on it, including by pointing out weaknesses and strengths, as well as the rationale for initiatives (Hosseinzadeh et al., 2019; Martinez, Cooper, 2019).

LFA supports project planning, monitoring of project implementation strengthening periodic project evaluation. The main result is the Logical Framework Matrix (LFA), which summarizes in one structure the main features and specifications of the project, including the indication of measurement, becoming a suitable tool for the process of monitoring the implemented activities and evaluating the results achieved. The method is applied throughout the project life cycle, from initiation through planning and implementation, to project closure. The logical framework approach can also be used to plan, implement and evaluate programs implemented by organizations. The matrix consists of four columns and four or more rows (Figure 2), which summarize what and how the project plans to accomplish, what the key assumptions are, and how outputs and outcomes will be monitored and evaluated (wikis.ec.europa.eu).

Narrative summary	Objectively verifiably indicators	Means of Verification	Assumptions
Program goal:			
Project purpose:			
Output: Results 1 Results 2. etc.			
Inputs: activities & resources Activity 1.1 Activity 1.2 Activity 2.1 Activity 2.2 etc.			

Figure 2. Logical framework matrix.

Source: Martinez, Cooper, 2020, pp. 1239-1253.

The vertical axis contains the project narrative or hierarchy of objectives, at the very top of the hierarchy of objectives we find the goal, which defines the program objective to which the project contributes. The project objective describes the expected outcome, and outputs are the results achieved as a result of activities. Activities/resources include the processes carried out and inputs used. The horizontal axis is used for project monitoring and evaluation. This means that each project is monitored through objectively verifiable indicators and means of verification (Martinez, Cooper, 2019).

The project should be evaluated according to the logical framework matrix at the start of its implementation, and the matrix itself should be evaluated, as it should be revised and updated on an ongoing basis. As the name suggests, it serves to assess the logical consistency of individual project areas and is an intermediate tool between its verbal description and mathematical and financial description. Despite the significant application value of the logical framework, there are criticisms that indicate that the meaning of the logical framework is sometimes overvalued. The matrix is used primarily as an evaluation tool in development projects. In addition, the focus on the provisions of the logical framework can be the basis for the selection of means and methods to achieve project objectives that are closer to the objectives of the contractors than to those assumed by the principal. Moreover, the search for linear relationships that exist between the problem and its solution influences the way the project is planned, the selection of indicators, the tools and methods of project implementation used, as well as their evaluation. Isolating the solution to a given problem from other factors (e.g., political, social, economic) is not possible, which is why, when referring to development projects, the necessity of using extensive evaluation tools and putting projects in a broader context is emphasized (Metelski, 2013, pp. 162-163).

The Logical Framework Matrix was used at the stage of formulating, organizing, implementing and evaluating the Pre-Incubation Program. A prerequisite was the willingness of the Enterprise to take action in cooperation with the academic community, involving them in solving the identified business challenges. The assumptions of the logical framework matrix were translated from the level of a single project to the level of the organization's program and strategic goals, considered as the main objectives. The framework developed by Leon J. Rosenberg was used at the stage of planning activities in a form adapted to the conditions of intersectoral cooperation and later used at the stage of evaluation and assessment of activities undertaken. Below, the authors presented the effects developed on the basis of the logical framework in the form of indicators, which were successfully used at the stage of program evaluation.

5. Case study - pre-incubation program

The pre-incubation program was established in connection with the prolonged changes in the Polish education system. The enterprise, in cooperation with the foundation (Program Coordinator), took the initiative to create a corporate pre-incubator based on intersectoral relations (business, science, third sector) wanting to increase the level of its openness to change and innovation, as well as its relations with external and internal stakeholders, while creating a positive image of the enterprise as an innovative and engaging organization in the development of the academic community and the startup idea. The activities were also inspired by the desire to seek innovation in selected functional areas of the Company, through the active involvement of students, experts and tutors.

Participants in the Program were students of Poznan University of Technology, Poznan University of Life Sciences, Poznan University of Economics and Adam Mickiewicz University in Poznan. The Program was aimed at people who were interested in the development of innovative projects and startup thinking, and who wanted to gain practical knowledge of entrepreneurship, and who intended to test the developed solutions in corporate practice.

At the stage of defining and planning the Program, representatives of the Enterprise and the Foundation determined how the program would generate value, defined internal and external goals and a schedule of activities, created a structure to support the implementation of the program and defined key performance indicators. These were used to monitor the degree of implementation of the defined objectives, at the various stages of project delivery in the Program. Two levels were defined for each indicator, a lower level and a higher level, which formed the basis for the payment of additional compensation to the Foundation, in accordance with the adopted Program budget.

The tables below define and describe the key performance indicators for the Pre-Incubation Program from the perspective of marketing (Table 1), recruitment (Table 2), program implementation (Table 3), implementations and participant satisfaction (Table 4).

Table 1.

Marketing for the pre-incubation program

Indicator	Definition of measure	Source of information	Value-Level I	Value-Level II
Number of accepted applications to the Program	The number of accepted applications sent by those with active student status who answered the open-ended questions in the questionnaire, attached a resume, and consented to the processing of personal data by the Company for the purpose of recruiting for the Program.	Data generated in the form of a report from the <i>erecruiter.pl</i> system	75	125
Foundation's social media reach and user engagement	Number of audiences, activity, reactions and comments for publications posted on social media and the Foundation's website. Summary prepared by two phases, i.e.: recruitment of participants and program implementation.	Report prepared based on information from social media and the Foundation's website	10k 10k	15k 15k
Publications of the Company and external organizations	Number of publications posted in social media and on the website of the Company, Poznan universities, student circles and organizations, and in professional media.	Report prepared on the basis of published materials on the Program	20	40

Source: own elaboration.

Adopted values for the indicator of enrollment in the Program, were determined on the basis of previous activities carried out for the benefit of the Poznań academic community by the Company and the Foundation.

Table 2.

Recruitment of participants to the pre-incubation program

Indicator	Definition of measure	Source of information	Value-Level I	Value-Level II
Number of participants accepted into the program	The number of participants, selected from the accepted applications, on the basis of interviews held with representatives of the Foundation, according to the adopted questionnaire, which allowed the selection of personae that meet certain criteria.	Signed declarations and consents by program participants	20	30

Source: own elaboration.

In the recruitment process, it was assumed that the candidate-student for the Program, should be entrepreneurial, open to new challenges and willing to work in a team. The student should want to develop interpersonal skills to be able to communicate efficiently and effectively with other team members, mentors and industry experts. Also important to develop was the ability to make decisions and work under time pressure. In addition to the aforementioned qualities, it was also important to the Program's authors that the participant be motivated and committed. This required the right attitude and determination, but also a willingness to learn from mistakes and continuously improve one's skills. The recruitment efforts undertaken

included activities aimed at recruiting at least 20 students to the Program, meeting the predefined criteria.

Table 3.
Implementation of the pre-incubation program

Indicator	Definition of measure	Source of information	Value-Level I	Value-Level II
Number of projects created under the program	The number of projects that were presented in front of a group of experts, during the meeting crowning the implementation of the first stage of the Program (Gate I)	Report prepared by the Foundation from the Gate I meeting	5	8
Number of completed projects	Number of projects that were presented in front of a group of experts, during the culminating meeting of the Program (Gate III)	Report prepared by the Foundation from the Gate III meeting	4	6
Number of implemented solutions in the enterprise structure	The number of solutions or products that, following the Gate III meeting, by decision of the top management, have been implemented or will appear in the Company's future offerings	Report prepared by the Foundation on the meeting of the top management	2	3

Source: own elaboration.

Participants in the program, following a FRIS survey conducted by a certified trainer, were divided into interdisciplinary teams based on their thinking and acting styles. The individual teams were assigned real business challenges, developed by a group of experts from selected functional areas of the Company. The students, over the course of three stages, with the support of the Enterprise's staff and experts from the Foundation, developed a solution to their assigned business challenge by following an imposed workflow, which included: Gate I - problem identification and research; Gate II - options for solving the problem; Gate III - selecting the best solution.

Table 4.
Implementation of the pre-incubation program

Indicator	Definition of measure	Source of information	Value-Level I	Value-Level II
Degree of satisfaction of Program participants	Degree of satisfaction and satisfaction of participants with participation in the Pre-incubation Program, examined using an online survey consisting of Likert scale questions and open-ended questions	A survey conducted by the Foundation	4 <	4,5 <

Source: own elaboration.

Conducting evaluation surveys allowed us to find out students' opinions about the Program. This indicator made it possible to assess the degree of satisfaction with the Program, as well as to identify areas for improvement in case of program renewal.

The pre-incubation program analyzed in the article, to the authors' knowledge, was the first program of its kind in Poland based on the concept of a corporate pre-incubator. In its assumptions, it functioned on the LAB studio concept, developed and implemented in 2012 at Oulu University of Applied Sciences in Finland, and currently used in Belgium, Nepal,

Austria or Slovakia, among others (Bielicki, Stevenson 2020; Bielicki, Weinert 2021). LAB studio is an interdisciplinary education model aimed at training skilled professionals and self-organized teams focused on establishing startups in specific economic sectors (Heikkinen et al., 2015).

6. Summary

The presented case study describes and explains the possibility of implementing a program as a group of projects in the Polish economic conditions in the context of ventures of an initial nature - pre-incubation. Knowledge of program management issues is important in the era of a dynamic environment, which forces the constant search for competitive advantage and the combination of strategic management issues with project management, which can be successfully used to implement the strategic objectives defined by the organization. The authors described and explained the possibility of using the logical framework in planning, implementation and evaluation of the project program, which is not commonly used (application primarily in so-called development projects), to the detriment of program effectiveness and efficiency. A practical case study was provided - a pre-incubation program implemented in cross-sector cooperation. Reference was made to the identified indicators and their impact on the achievement of the program's goals. At the same time, the applicability of the logical framework matrix in programs, used so far primarily by international organizations for investment projects, was confirmed. The authors recommend applying the logical framework approach by adopting the logical framework matrix as a tool for program evaluation at program initiation, implementation and renewal. In addition, it is essential to evaluate the matrix itself and adjust it on an ongoing basis.

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DYNAMIC CAPABILITIES IN A HIGH-VELOCITY ENVIRONMENT: THE EMERGENCE AS A REACTION TO THREATS

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Purpose: The study aims to investigate the emergence of dynamic capabilities (DCs) of enterprises that have appeared as a result of threats caused by high-velocity environments.

Design/methodology/approach: In the qualitative research, DCs of Polish companies were examined, to answer the question of how companies responded to turbulence in the business environment caused by the pandemic crisis. In-depth interviews with managers of 20 outstanding companies were conducted to explore the specific processes and activities, companies undertook to survive the crisis.

Findings: The emergence of dynamic capabilities for distressed enterprises in a high-velocity environment referred to both lower- and higher-order DCs, companies from various industries, also small and medium-sized enterprises. Radically innovative actions by companies during the crisis were aimed mainly at survival, but also at protecting employees, customers, and society.

Research limitations/implications: The study has some limitations. Firstly, only Polish enterprises were studied, and therefore the results cannot be directly applied to other countries. Second, this is an exploratory study that requires follow-up to deepen the topic to enable future quantitative research.

Practical implications: Companies may use the results of this project as an incentive for developing their DCs. They can also use the examples discussed as guidance for future actions, especially in a turbulent business environment.

Originality/value: The paper notes the importance of a non-routine approach to dynamic capabilities. This is important for management as a scientific discipline, but also for managers, as it indicates various possible paths for DCs' development.

Keywords: dynamic capabilities, high-velocity environment, crisis, threats.

Category of the paper: Research paper.

1. Introduction

The dynamic capabilities perspective (Teece, Pisano, Shuen, 1997; Eisenhardt, Martin, 2000) has been the center of interest for many researchers since the end of the last century. These change-focused capabilities can help companies deal with the dynamism of business environments (Hine et al., 2014).

Until recently, these capabilities were primarily considered in medium-velocity markets. Large, innovative enterprises, often related to modern technologies, were studied mainly. The prevailing view in the literature was that these capabilities are based on routines, or at least on simple rules (Andreeva, Ritala, 2016; Ritala, Heiman, Hurmelinna-Laukkanen, 2016). The actions of companies that were not based on such foundations were called ad hoc activities (Winter, 2003).

Research has shown that DCs are the basis for the development of ordinary capabilities (Winter, 2003). They also help achieve competitive advantage (Fainshmidt et al., 2019), and usually have a positive impact on company performance (Teece, 2014; Kolbe, Calderon, Frasquet, 2022), which is why companies were recommended to develop DCs.

However, in the high-velocity environment we have experienced during the pandemic crisis, the importance of DCs has changed. Companies needed DC and the resulting innovations not to be better than their competitors or achieve exceptional results, but to survive. During this period, DCs could also be observed in small local companies from various industries. DCs emerged in companies that did not need to introduce innovations before the crisis, and that had not previously developed innovative routines or rules (Khurana, Dutta, Ghura, 2022; Li et al., 2022)

This shows that DCs should be considered not only from the perspective of routines, but also from other perspectives (Teece, 2023; Zhang et al., 2023), and moreover, they can be examined in small and medium-sized enterprises from various industries. Although the number of papers on how companies fought for survival during the pandemic is very large, this research perspective is used very rarely. Hence the emergence of DCs in high-velocity environments has been identified as a research gap.

This study aims to partially fulfill this gap, by cross-sectional exploring innovative activities of Polish enterprises during the pandemic crisis from the perspective of non-routine-based dynamic capabilities.

In the qualitative study 20 in-depth interviews with managers of outstanding Polish companies were conducted to explore the specific processes and activities, companies undertook to survive the crisis. They were asked how their companies responded to turbulence in the business environment caused by the pandemic crisis.

2. Dynamic capabilities in a high-velocity environment

The answer to the dynamism of the business environments is the dynamic capabilities view (DCV) (Teece, Pisano, Shuen, 1997; Eisenhardt, Martin, 2000). This is nowadays one of the most influential schools in management theory (Schilke, Hu, Helfat, 2018; Mitreğa, 2019). It is also one of the most dynamic topics in the strategic management field (Kaur, 2019) and in firm-based performance-focused theory (Arend, Bromiley, 2009; Vogel, Güttel, 2012; Tseng, Lee, 2014; Wang, Senaratne, Rafiq, 2015). DCV has become one of the most important, but also controversial theoretical frameworks.

Dynamic capabilities (DCs) are defined in various ways, for instance as *the firm's potential to systematically solve problems, formed by its propensity to sense opportunities and threats, to make timely and market-oriented decisions, and to change its resource base* (Barreto, 2010, p. 271). They are a kind of abstract, more advanced capabilities, that allow to sense and seize opportunities and anticipate threats (Teece, 2007). They are change-focused and create not only new resources but also routines and operating capabilities (Verreynne et al., 2016). Companies use their DCs to build and adapt their resources to maximize the organization's fit with its environment (Schilke, 2014b). They gain and hold a competitive advantage in the market thanks to DCs (Teece, Pisano, 1994). DCs play an important role in reconfiguring the company's knowledge to create new knowledge resources as a response to market changes (Falasca et al., 2017).

Dynamic capabilities that a firm deploys depends on the velocity of the business environment (Verreynne et al., 2016). It should be noted that although the nomenclature may suggest something different, in both medium-velocity and high-velocity environments, changes can occur very quickly. The difference is that in a medium-velocity environment changes are predictable and linear, while in a high-velocity environment, we are dealing with uncertainty and non-linear changes (Eisenhardt, Martin, 2000). These changes may concern various aspects of the company's functioning, not only changes in technology, but also e.g. in product, demand, legal regulations, or competition activities, and not only the pace of changes but also their direction is important (McCarthy et al., 2010).

The difference between DCs in medium- and high-velocity environments can be explained based on the evolutionary theory, often used to explain economic processes. In nature, some species of animals or plants can change their environment, grow stronger, and gain an advantage. However, in crises, usually, not the strongest of them can deal with a rapidly changing environment (e.g. dinosaurs), but those that can adapt to sudden changes. In economic terms, this explains the difference between needed DCs in medium- and high-velocity environments. In a relatively stable business environment, companies can sense and seize opportunities, change their environment, and gain a competitive advantage. However, when the environment changes rapidly, DCs to deal with the threat take their value.

Before the pandemic, empirical studies on DCs have usually focused on rapidly changing technological sectors, on big innovative companies. The researchers' attention was focused mainly on the dynamic capabilities to generate market changes, rather than DCs to respond to changes in the environment. A large group of enterprises, especially small and medium-sized ones, did not need to develop DCs at that time, especially since, if underlying costs are taken into account, in a medium-velocity environment the costs of developing DCs may outweigh the benefits, and the positive impact of dynamic capabilities on the efficiency of operating routines can be observed mainly in high-velocity environments (Wilhelm et al., 2015).

The situation changed a bit during the last crisis when a lot of papers appeared on how companies fought to survive (Abubakar, 2020; Rahman et al., 2022). However, the empirical research on specific activities companies undertake concerning the changing business environment from the dynamic capabilities perspective is still limited. Some papers study the relationship between DCs and companies' survival (Chi, Ho, Lin, 2022; Weaven et al., 2021), and others the connection between DCs and new technology adaptation (Liu, Yang, 2021; Li et al., 2022; Ye et al., 2023).

Usually, DCs studies concern one specific capability, e.g. international marketing agility and its linking with new technology adoption (Thoumrungroje, Racela, 2022), multichannel integration and innovation capability in SMEs (Kolbe, Calderon, Frasset, 2022), resilience capability by the adoption of digital technologies (Khurana, Dutta, Ghura, 2022). There is a lack of a broader view of dynamic capabilities. According to the above the non-routine perspective of dynamic capabilities in high-velocity environments, has been identified as a research gap.

3. Methodology

Twenty in-depth interviews with managers of Polish companies were conducted. Purposive sampling was applied (Etikan, 2016). The main criterion for the companies' selection was their interesting and varied ways of dealing with the pandemic crisis. The representatives of companies diverse in terms of size, age, and the nature of business were invited to participate in the interviews. Snowball sampling was used, because some respondents were able to point out examples of interesting activities of other companies. In the vast majority of cases, interviews took place in person, taking into account a previously prepared scenario. In two cases it was not possible, so online interviews were conducted. The general questions from the protocol constituted the framework for the conversations and they were supplemented with detailed questions on an ongoing basis. One interview with a key manager was conducted in each company. In total, it was almost 12 hours of interviews, and the average length of a single conversation was 35 minutes.

Informants were asked about their experiences with the pandemic crisis, how their companies responded to turbulence in the business environment, and how they reoriented their companies to adjust to the high-velocity environment. The aim of this study was to explore the specific processes and activities, companies undertook in the high-velocity business environment to survive. The company names have been anonymized, and the most important information about the respondents is provided in Table 1.

Table 1.
Companies description

Code	Company Type	Size	Market	Key Informants
I-1	Manufacturer of layettes for babies	Micro	B2C national	Partner/manager
I-2	Paint manufacturer	Big	B2B international	Member of the board
I-3	The organizer of fairs and conferences	Medium/big	B2B international	Director of the organizational and legal department
I-4	Seed producer	Medium	B2B international	Sales director
I-5	Tool manufacturer	Big	B2B international	Sales director
I-6	The restaurant	Small	B2B/B2C local	Manager
I-7	Language school	Micro	B2C local	Owner/manager
I-8	Chain of grocery stores	Medium	B2C local	Owners/managers
I-9	Investment support company	Medium	B2B international	Vice-chairman of the board
I-10	Cosmetology services	Small	B2C local	Manager
I-11	Pharmacy chain	Big	B2C national	Pharmacy manager
I-12	Event company	Micro/small	B2B	Owner/manager
I-13	Producer of event lighting installations	Small	B2B/B2C	Partner/manager
I-14	Legal and tax company	Medium	B2B	Member of the board
I-15	Wine company	Small	B2B national	Chairman of the board
I-16	Audit company	Small	B2B national	Manager
I-17	Consulting and training company	Small	B2B national	Manager
I-18	Manufacturer of snacks	Big	B2B international	Marketing director
I-19	Speech therapy and neurology clinic	Micro	B2C local	Head of the clinic
I-20	Construction company	Small	B2B/B2C national	Chairman of the board

Note: In the rest of the text, references to statements from individual interviews were made in the following way: e.g. (I-7/p6) - interview no. 7, page 6

Data was collected in two stages, the first stage included interviews 1-14 and lasted from November to December 2022. This series of interviews was then pre-analyzed. The second series of interviews (15-20) was conducted in March 2023 to confirm theoretical saturation. As the results of these studies were in line with previous findings, it was concluded that the collected data is sufficient. All twenty interviews were transcribed and they were subjected to the final analysis.

4. Research results

All informants, regardless of industry and company size, claimed that the pandemic was associated with uncertainty and threats:

... persisting in such uncertainty (I-12/p5),

... when the pandemic began, well, a little fear looked into our eyes (I-14/p1).

Their primary goal during this period was not competitive advantage or performance, but the survival of the company:

... we wanted to do something and have anything, to earn any money to ... survive (I-12/p4).

But then we were thinking about how to survive (I-14/p5).

However, other higher goals also appeared, such as employee care, customer care, and social care, which mobilized entire teams to intensify unconventional activities during this difficult period:

... we have never had an intention to reduce the level of employment on a large scale. We wanted to keep it at any cost... (I-3/p2),

... we took care of them (...) just not to leave these people. (...) We took care of our customers (I-10/p5);

... there was an action of masks. (...) We did it for charity (I-6/p2).

All surveyed companies introduced radical innovations at the enterprise level. There are three categories of change here: the introduction of a new product or service, a new or radically innovative process, or even a new business model.

New products and services were often related to the fight against the pandemic, for example, the production of masks (I-1; I-6), protective clothing (I-6), disinfection liquids (I-15), performing vaccinations (I-3, I-11), and opening a temporary hospital (I-3) or related to needs resulting from the pandemic, e.g. delivering shopping to people in quarantine (I-8), support in obtaining public aid (I-14). The second group of new products and services was the result of partial or complete blocking of the company's current operations due to lockdowns and other legal regulations. The company dealing with the organization of fairs, conferences, and promotion events opened a car cinema and started furniture production (I-3), the restaurant started food production (I-6), the organizer of corporation events started to provide digital

marketing services (I-12), the producer of event lighting installations started the production of interior business and private light decorations (I-13). The third group of new products and services resulted from the emergence of demand for them e.g. enabling online shopping in a network of local rural grocery shops (I-8). Of course, some of these products and services may be classified into several of the above categories.

New or radically innovative processes were most often related to remote work, transfer of activities to the Internet, or the use of modern technologies. Remote work was used both in quite typical situations, e.g. conducting training (I-14, I-17), working of sales representatives (I-2, I-4), less typical situations like running an office at a language school (I-7) or providing construction supervision (I-20), and in completely non-obvious ones e.g. performing accounting audits (I-16), or providing neurological and speech therapy for disabled people (I-19). Moving activities to the Internet was often necessary due to the restrictions introduced. The organizer of stationary corporation events quickly decided to transfer them to the Internet and involve the participants by home-delivered parcels with themed gadgets (I-12). The investment support company, based primarily on direct meetings with clients from around the world, immediately began operating mainly online (I-9). In turn, the adaptation of modern technologies has allowed the tax company to apply automated accounting processes (I-14) and a snack manufacturer to automate its production plant (I-18). A change in the business model was observed the least frequently. An example here is a restaurant that was transformed into a store selling its food products during the lockdown (I-6).

During the data collection, it was noticed that the surveyed companies could be divided into two groups. About half of them stood out from the rest in several respects. This was already visible during the interviews. This group of informants seemed to be much more engaged in the conversation and showed emotional involvement in the company's actions during the crisis. The interview itself flowed more smoothly and the interlocutors knew perfectly well how to answer the questions asked. What was surprising, although initially, the managers were reluctant to agree to the interview, after it ended they behaved like my good friends, for example, they told me about their private matters and showed me family photos. It seemed like they needed this conversation to share their emotions about their fight for survival

Since the above thread is more about psychology, the challenge was to determine how these companies differed from others in terms of management. The analysis showed that these companies not only introduced radical innovations at the company level but that these innovations were unique compared to other companies:

... we were surprised that very few firms have had similar ideas ... (I-10/p5),

...there appeared new products, which we are proud of because they have absolutely no equivalents on the international market (I-13/p6).

Even when the actions taken were theoretically identical, this distinction could be made because, for example, the sewing of a mask by a seamstress (I-1) is less outstanding than sewing masks by restaurant employees (I-6). The same applies to remote work, all schools worked

remotely, so for them, it was rather a new norm, but remote work in the case of the event company (I-12), cosmetology services (I-10), or speech therapy and neurology clinic (I-19) was already something special. The moment of initiating such activities was also important. Companies that were pioneers, even only among local competitors, should be assessed differently, than companies that started these activities much later (I-17).

5. Discussion

Research has shown that in a high-velocity environment, the emergence of dynamic capabilities can be observed. This applies to companies from various industries, including small and medium-sized ones, which previously had no motivation or need to develop these capabilities. This shows that viewing DCs solely from the perspective of routines (e.g. Winter, 2003) is a wrong approach.

Moreover, as a result of the threat, various types of DCs appeared in companies. The two groups of enterprises indicated in the previous chapter can be referred to the hierarchy of dynamic capabilities. Researchers agree that DCs have a hierarchical structure (Ambrosini, Bowman, Collier, 2009; Collis, 1994; Hine et al., 2014; Schilke, 2014b; Winter, 2003). DCs are divided into lower-order DCs (change-focused dynamic functional capabilities) and higher-order dynamic capabilities (HDCs), which are also called dynamic learning capabilities and contribute to creating new and radically innovative routines and resources (Hine et al., 2014). HDCs are defined in this study as the organization's ability to move beyond its current strategic orientation and utilize resources in unconventional outstanding ways. Therefore, it should be noted that outstanding companies demonstrated their HDCs (they are marked with a darker background in Table 1). Other companies also demonstrated the ability to adapt to changes in the business environment, but due to the nature of the innovations they introduced, they should be considered lower-order DCs.

According to Khurana, Dutta, and Ghura (2022), dynamic capabilities may emerge in a high-velocity environment. This study shows that these may be both lower- and higher-order capabilities.

The issue of organizational goals also deserves attention. Although the literature focuses mainly on the financial results of enterprises (Teece, 2007; Tseng, Lee, 2014; Wang, Senaratne, Rafiq, 2015) and on achieving competitive advantage (Teece, Pisano, 1994; Li, Liu, 2014; Schilke, 2014a), in a high-velocity environment these goals become secondary. It turns out that in an uncertain environment, during non-linear changes in the operating conditions of the organization, survival becomes the main goal. But an organization does not operate in a vacuum, so when a threat also affects its employees, customers, and society, it also aims to protect them.

6. Conclusion, limitation, and further research agenda

Environmental dynamism has a significant impact on the DCs of enterprises. When changes occur quickly and in a non-linear manner and companies feel threatened, the situation does not provide the opportunity to build DCs based on routines. Nevertheless, the DCs are also observed in such high-velocity environments, and their emergence refers to both lower- and higher-order DCs, not only big high-tech companies but also small and medium-sized enterprises from various industries. Companies then take radically innovative actions not to improve their results or gain a competitive advantage, but to survive and also take care of employees, customers, and society.

This study makes theoretical contributions by pointing out the importance of a non-routine approach to dynamic capabilities and exploring the phenomenon of DCs emergence in high-velocity environments. As a practical implication for managers, this study points out various possible paths for DCs' development, what can be used as an incentive for developing them. Managers can also use the examples discussed as guidance for future actions, especially in turbulent business environments.

The study has some limitations. Firstly, only Polish enterprises were studied, and therefore the results cannot be directly applied to other countries. Second, this is an exploratory study that requires follow-up to deepen the topic to enable future quantitative research.

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FOOD SAFETY CONCERNS FROM THE VIEW OF GEN Z STUDENTS IN POLAND

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Purpose: This paper aims to identify sources of concern in food safety. Achieving this goal will help determine the extent to which food safety concerns are related to various sources of food information. Such information can help build Gen Z students' confidence in food safety.

Design/methodology/approach: The research was examined in 2022 using a face-to-face survey among students of a major university in Poland. The survey questions were divided into two sections including metrics questions describing the respondents. Individual food concern sources were rated on a 5-point scale from "does not matter" to "to a very great extent". Descriptive statistics were used to describe the characteristics of the sample of respondents. A factor analysis was conducted using the principal components method to simplify and reduce the number of sources of concern in food safety identified in the study.

Findings: The research showed that the main sources of concern of Generation Z consumers about food safety are related to food safety tools and supervision, in addition to the producer and the place of production and purchase of food, and also stem from the situation and factors related to the external environment of the food industry.

Research limitations/implications: Only students in Poland were surveyed. In the future, comparing students' opinions from other countries and social groups would be interesting.

Practical implications: The information obtained from the research can help build Gen Z consumers' confidence in food safety and reduce illnesses from the consumption of unsafe food.

Social implications: The information from the research can help public policy build on food safety among Gen Z consumers. On the other hand, they can help prevent illnesses from consuming unsafe food through more effective public food campaigns.

Originality/value: The study's contribution to the literature is to point out the importance of different food concern sources. This helps build Gen Z consumers' confidence in food safety.

Keywords: food safety, concerns, trust, students, Gen Z.

Category of the paper: surveys, scientific research.

1. Introduction

Safety is the most important attribute of food product quality, as it affects human health and life in all spheres (Lakner, 2021). Its importance is growing as consumer knowledge and awareness increase. Food safety means the absence of hazards and negative impacts on the health and life of the consumer when food is prepared and/or consumed as intended (ISO 22000:2018). The global organizations FAO and WHO even state that there is no food security without food safety (FAO). The issue of food safety is particularly relevant under conditions of globalization and regionalization of the food sector and food trade (FAO, Michalczyk, 2017; Liguori et al., 2022; Kowalczyk, 2017). As a result, the wave of illnesses caused by the consumption of unsafe food has been rising since the 1980s (Food Safety, 2020). This causes large losses and economic risks and thus harms the economy, businesses, and society. These phenomena in the food sector also affect consumers' attitudes, choices, and eating patterns (Hanus, 2018), and food safety problems publicized in the media undermine consumer confidence in the food they buy and increase concerns about food safety (Thanh Mai Ha, Shamim Shakur, 2020). Adulteration and other food safety incidents are focusing public attention and causing a crisis of confidence in food companies and regulators (Bánáti, 2011; Myoung Su Park et al., 2017). FAO report advocates the need for a major shift in the perception of food safety The FAO report advocates the need for a major shift in the perception of food safety from "response and action" to "anticipation and prevention" (FAO).

With this in mind, this article aims to identify the sources of food safety concerns and determine whether the demographic and social characteristics of Generation Z students affect the validity assessment of these sources. In doing so, achieving this goal will help determine the extent to which food safety concerns are related to various food issues. Such information can help build Gen Z consumers' confidence in food safety.

2. Literature review and research question

Trust is a ubiquitous feature of interpersonal relationships (Schwerter, Zimmermann, 2020). Trust in food, especially food safety, is an important issue because it influences consumer choices and eating patterns (Hobbs, Goddard, 2015; Nguyen-Viet et al., 2017). These issues are an important factor in influencing consumer attitudes and behavior (Hanus, 2018). Consumer confidence in food, its safety, and quality are shaped by many factors, including country of origin and culture (Barbarossa et al., 2016; Ariyawardana et al., 2017; Thøgersen, 2023), availability of detailed product information (Macready et al., 2020; Whitworth, 2021, Thøgersen, 2023) and the manufacturer (Wu et al., 2021; Thøgersen, 2023), the existing food

system (Lang, Conroy, 2022; Liu Jie et al., 2023) or the socioeconomic environment, including the activities of consumer organizations and other external circumstances such as a pandemic (Kubatko et al., 2023). Trust varies according to consumers' needs, expectations, attitudes, and experiences. In some situations, institutional trust prevails, while in other situations trust in individuals, leaders, suppliers, competencies, and relationships that occur between different levels of government (Bugdol, 2010; Rapp, Wilson, 2022). There are many different definitions of trust, and taking into account the OECD guidelines, trust can be viewed as a belief in the trustworthiness of other people, i.e. how others are likely to behave toward one another. Lack of trust prevents mutually beneficial cooperation. People's trust also depends on their belief in how well institutions function (Latifah, Amin et al., 2013; Fan Yang, Zili Huang, 2021). Institutional trust includes "trust in the competence" of those working in government and "trust in intentions" (Nooteboom, 2007). If people are convinced that there are strong enforcement mechanisms to discourage socially harmful behavior then they will be more willing to trust others (Mengmeng Guo et al., 2021; Liu Jie et al., 2023), but it depends on an individual's previous social experiences (Schwerter, Zimmerman, 2020), as well as the type of information and communication style (Fan Yang, Zili Huang, 2021). Willingness to trust is substantially higher after a positive social experience relative to a negative social experience (Schwerter, Zimmerman, 2020). Trust shapes consumer attitudes toward new food technology, production, and processing methods, and food origins, and influences food policy (Hobbs, Goddard, 2015), as well as can help make decisions in the absence of knowledge, experience, and familiarity with companies, processes, or products (Janssen, Hamm, 2014). In contrast, a lack of trust can negatively affect the adoption of new technologies, and products, generate resistance to policies, and hinder behavioral changes (Hobbs, Goddard, 2015).

Lack of trust in people or institutions, their competence, and intentions gives rise to all sorts of concerns. Concern is a feeling of uneasiness or uncertainty about the outcome or consequences of something. It is a mental state that occurs when we are unsure of what will happen and think it will be unfavorable to us (Żmigrodzki et al.). Taking the above into account, fear can be genuine, real, legitimate, irrational, subconscious, continuous, excessive, widespread, serious, or unfounded. In this context, we may fear the loss of health or life, pain, illness, security, war, or terrorism. Fears can accompany or accrue to something. Fears can be had, shared, felt, expressed, nourished, gloated about, evoked, aroused, heightened, overcome, dispelled or calmed. Something can be done, eaten, drank, enjoyed, or used without fear, but it can also be trembled, kept silent, hidden, huddled, fled, or withdrawn for fear of something. We can also look for the cause or source of fear (Żmigrodzki et al.). Concern may be a consequence of prolonged stress, an unpleasant event that happened in the past, suggesting that it is related to our past experiences or lack thereof. Feelings of anxiety can also arise for no particular reason. Importantly, consumers' concerns reflect their moods and influence their behavior and diet (Zhang Huan et al., 2018; Thanh Mai et al., 2020; Liguori et al., 2022). Concern may be a consequence of prolonged stress, an unpleasant event that happened in the

past, suggesting that it is related to our past experiences or lack thereof. Feelings of anxiety can also arise for no particular reason. Importantly, consumers' concerns reflect their moods and influence their behavior and diet (Bánáti, 2008; Miao Peng et al., 2020). What is significant and worrying is the expression of mistrust and concern by a significant portion of consumers even as experts declare food safety. Perhaps this is a side effect of the food-related scandals and epidemics of recent decades. Concern can be amplified by inaccurate or erroneous information provided by the relevant control authorities, or by the media disseminating information that is not based on sound science or that wants to create sensationalism and draw attention to itself. Such a situation was encountered during the COVID-19 pandemic. Currently, only 2% of Poles perceive the COVID-19 pandemic as a major source of their concern (McKinsey & Company, 2022).

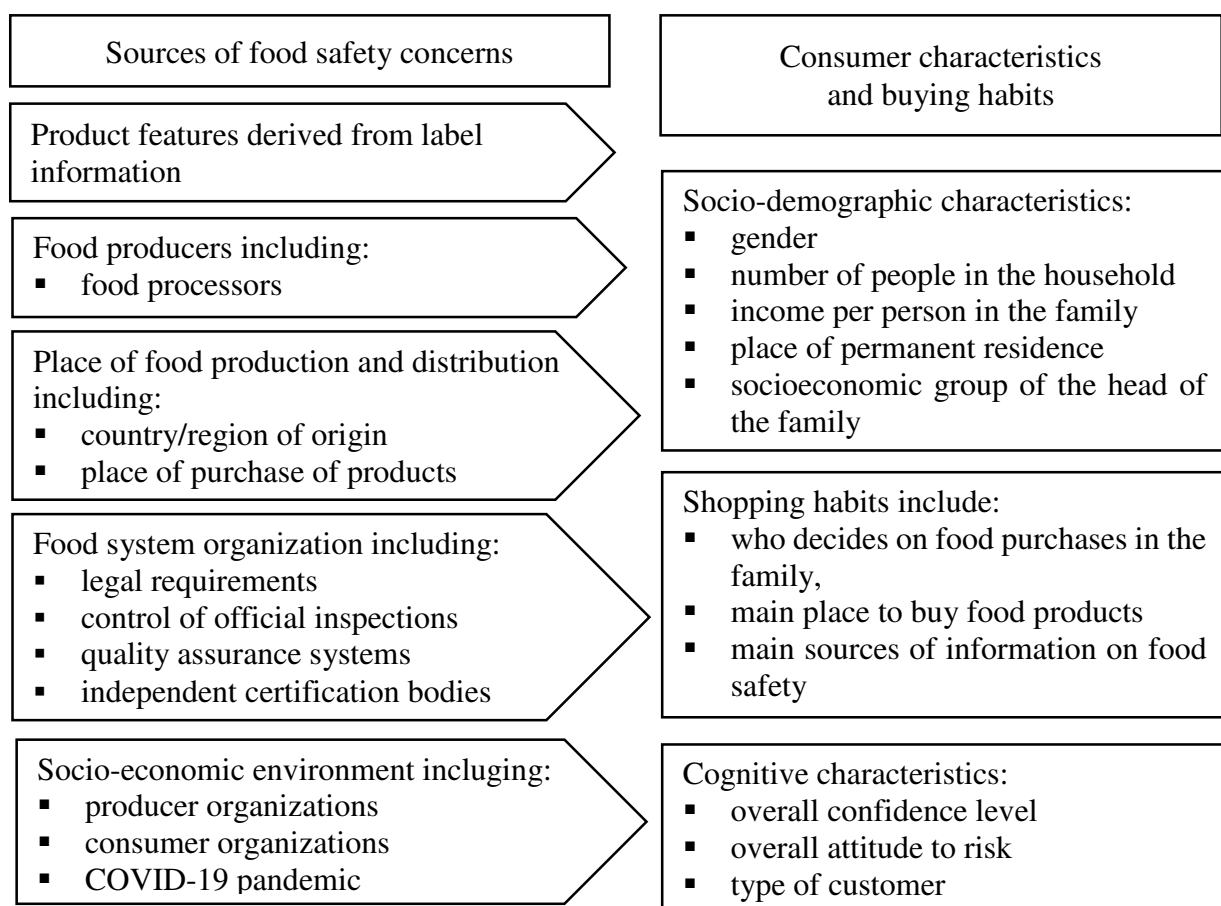


Figure 1. The conceptual framework of food safety concerns.

Source: own elaboration.

Thus, we may be concerned about change, new technologies, responsibility for actions and products offered, or the impact of purchased food on health and life. However, concerns about food safety do not always translate into avoidance of unsafe foods (Liguori et al., 2022). Many other factors have been investigated as possible predictors of risk perception, including political beliefs, sources of information, trust in institutions, inspection and certification procedures, and information (Nam Su-Jung, 2019; Simoglou, Roditakis, 2022). With the above

in mind, it was assumed that the source of concern about the food safety of Generation Z students in Poland could be the characteristics of the products, their producers, where they are produced and distributed, elements of the organization of the food system or the socioeconomic environment (Fig. 1). Taking into account the above, the following research questions were formulated:

- RQ1. Are factors related to tools and supervision an important source of concern for food safety among Generation Z students?
- RQ2. Do factors related to the manufacturer and place of production or purchase significantly affect Generation Z students' concerns about food safety?
- RQ3. Do selected elements of the socioeconomic environment, including the activities of consumer and producer organizations, affect Generation Z students' concerns about food safety?

Consumers' risk perception and response to food safety risks are influenced by sociodemographic factors, as confirmed by studies by Dosmana et al. (2001), Simoglou and Roditakis (2022), Moumita Deb et al. (2023). These factors include gender, age, education, income, number of people in the household, and place of residence, as shown in studies including Zhang Huan et al. (2018), Nam Su-Jung (2019) and Simoglou, Roditakis (2022).

3. Material and Methods

Generation Z students were surveyed. Generation Z includes people born between 1995 and 2010, and they are expected to make up the largest group of consumers by 2030 (Ozdemir-Guzel, Bas, 2021). It is believed that Generation Z people are generally less trusting of various products (Pradhan et al., 2023), and more sensitive and cautious in their purchasing decisions and spending (Squires, Ho, 2023). It is thought that with the rise of global connectivity, generational changes may even play a more important role in determining behavior than socioeconomic differences (Francis, Hoefel, 2018). Students represent a significant group of Generation Z people who are already making or will soon be making food-purchasing decisions. The students participated in the survey voluntarily. The participation was in no way related to their studies and was not evaluated for this reason. The study involved 379 students from five departments of a university in Poland.

The sample was predominantly female (76.9%). The age of the respondents ranged from 19 to 28 years old and averaged 22 years old. 62.2% of the respondents were from 4-person households. More than 82% of the respondents had per capita family incomes of more than PLN 1000, including nearly 41% with incomes of 2000 or more. The largest group of respondents lived in small towns with up to 1 thousand residents (37.7%), nearly 24% in towns with 1-10 thousand residents, and 15% in cities with more than 100 thousand residents.

Nearly 43% of the respondents came from the families of workers in the labor force. 42% of the respondents were those who decide on their family's food purchases. The majority of respondents (76%) buy food products mainly at the supermarket. The main sources of information on food safety are labels for one in two respondents (52.5%), family for 42%, and social media for 41%. The largest percentage of respondents (54%) said they "neither trust nor distrust," and more than 30% described themselves as trusting. More than 61% of respondents expressing their general attitude toward risk said they avoid risk, and more than 20% like risk, while more than 10% dislike risk. Of the 11 customer types listed, respondents most often described themselves as frugal (53%), independent (47%), balanced (45%), analytical (39%) or determined (34%). They were least likely to describe themselves as impulsive (18%), sensitive (18%), insecure (19%) or profligate (19%) customer.

The survey was conducted using a face-to-face survey method from March to May 2022. The questions in the questionnaire were divided into two parts, including metric questions describing respondents in terms of gender, age, family size, income per family member, place of residence and socioeconomic background of the head of the household, who decides on food purchases, main place of food purchase, sources of information on food safety, self-assessment regarding general level of trust and attitude to risk, and type of customer (wasteful, frugal, independent, family-oriented, sensitive, impulsive, balanced, skeptical, uncertain, decisive, analytical).

Twelve sources of concern about food safety were assessed (Table 2). The scale ranged from 'not important' to 'very important'. The present study was conducted following the ethical standards set for all research involving human subjects by the Declaration of Helsinki (1964).

Cronbach's alpha statistic (Stadler, 2021) was calculated to assess the reliability of the scale. The KMO index (Kaiser-Meyer-Olkin) and Bartlett's sphericity test were applied to know the appropriateness of conducting a factor analysis. To simplify and identify factors related to consumer concerns about food safety, factor analysis was conducted using the principal components method and Varimax rotation with Kaiser normalization. Statistical analyses were conducted with a confidence level of $\alpha = 0.95$ as a criterion of significance. Statistical analyses were performed using IBM SPSS Statistics 29.

4. Results

The value of Cronbach's alpha statistic is high (0.868), confirming that the proposed set of food safety concerns correctly measured what it was intended to measure.

Respondents' answers show that concerns about food safety to a high and very high degree are related more often than in every second respondent to the control of official inspections (54.7% of indications), the quality assurance system used (52.2%) and the place where products

are purchased (51.5%), in addition to information on the label (50.6%), the food manufacturer (50.4%), and to the least extent to the COVID-19 pandemic (19.7%) - Tab. 1. This indicates the importance of trust in the results of official inspections, the quality systems in place, where products are purchased and the information provided on the label.

Table 1.

Respondents' views on factors affecting food safety concerns

Concerns*	doesn't matter	slightly	moderately	high	to a very high degree
4a	12.7	23.6	34.2	21.2	8.3
4b	2.6	11.9	34.8	36.1	14.5
4c	3.1	18.0	24.2	34.9	19.8
4d	4.4	11.7	32.4	38.3	13.2
4e	3.9	8.8	36.9	36.9	13.5
4f	6.8	18.4	34.8	27.5	12.5
4g	3.4	13.5	30.9	34.8	17.4
4h	4.7	17.1	30.6	31.2	16.4
4i	5.2	16.9	27.3	33.0	17.7
4j	8.6	20.8	36.4	28.6	5.7
4k	9.9	22.1	37.0	25.5	5.5
4l	30.9	23.1	26.2	14.0	5.7

4a – country/region of origin, 4b – information on the label, 4c – control of official inspections, 4d – the place to buy food, 4e – food producer, 4f - farmer, 4g – quality assurance systems used, 4h – independent certification bodies, 4i – applicable legal requirements, 4j – producers' organizations, 4k – activities of consumer organizations, 4l – COVID-19 pandemic.

Table 2.

Total explained variance - concerns

Component	Sums of squares of loads after rotation		
	Total	% of variance	% cumulative
1	3.367	28.062	28.062
2	2.323	19.354	47.416
3	1.859	15.491	62.908

Method of extracting factors - principal components.

The KMO index was 0.833, indicating an excellent relationship between the variables. Bartlett's test of sphericity was significant ($p < 0.001$), so the factor analysis model was adequate. The factors found were represented by almost 63% of the total variance (tab. 2). Factorial loads were between 0.496 and 0.816, so almost all factorial loads were above the critical value of 0.50 suggested by Hair et al. (2010). Based on this, three groups of concerns about food safety were identified (tab. 3).

The first component, explaining 28.1% of the variation, included primarily concerns about product oversight resulting from applicable legal requirements and related official inspections of food products, as well as issues related to the quality assurance systems in place and control of compliance with their requirements by independent certification bodies (3c, g, h, i).

Table 3.
Matrix of rotated components – concerns

	Component		
	1	2	3
4a	-0.116	0.645	0.361
4b	0.496	0.362	0.045
4c	0.709	0.286	0.094
4d	0.191	0.763	0.067
4e	0.405	0.735	0.062
4f	0.364	0.663	0.139
4g	0.786	0.192	0.118
4h	0.816	0.119	0.145
4i	0.777	0.081	0.264
4j	0.417	0.160	0.705
4k	0.458	0.191	0.681
4l	-0.017	0.104	0.791

Method of extracting factors - principal components. Rotation method - Varimax with Kaiser normalization.

* concerns signs as in Table 1.

A smaller value of factor loadings, but the highest among the other components, was also concerned about label information (3b), which is related to applicable legal requirements. The second component included factors related to the place of production and purchase of food and its producer (3a, d, e, f). In the third principal component, the highest value of factor loadings was recorded for concerns related to the food production environment (3j, k, l).

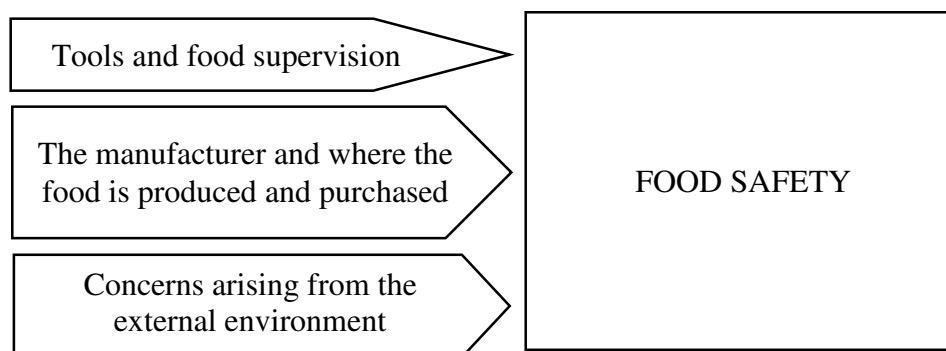


Figure 2. Sources of concern about food safety according to Gen Z students.

Source: Own elaboration.

Thus, the analysis made it possible to distinguish three groups of sources of consumer concern about food safety, these are concerns related to food safety tools and supervision, concerns related to the producer and the place where food is produced and purchased, and concerns arising from situations and factors related to the external environment (fig. 2). These analyses provided positive answers to the research questions posed.

5. Conclusions

Generation Z young adult consumers' concerns about food safety are mainly related to the control of official inspections, quality assurance systems used by food companies, and where products are purchased. For one in two respondents, concerns are related to product information visible on the label and the food manufacturer. The least concern about food safety was related to the COVID-19 pandemic. This indicates the importance of building trust in the results of official inspections, quality assurance systems used and food manufacturers and where products are purchased and that there is limited confidence among respondents in the aforementioned inspection services, food safety tools and manufacturers and distributors. The analysis identified three main groups of sources of concern for Generation Z students about food safety. These are primarily concerns about food safety tools and supervision, concerns about the manufacturer and where food is produced and purchased, and those stemming from situations and factors related to the external environment in which the food industry operates. This study fills a research gap by pointing out the importance of various sources of food safety concerns for young adult consumers representing Generation Z. These concerns are important political, social, and economic issues. The findings can help gain consumer confidence and be useful in developing food safety management policies to prevent foodborne illness. They can help food operators create more effective communications with Generation Z young adult consumers.

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ANALYSIS OF TRANSPORT EFFICIENCY IN POLAND ON THE EXAMPLE OF CARGO TRANSPORT

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Purpose: The aim of the analysis was to demonstrate the level of transport efficiency in Poland on the example of various modes of transport in selected years.

Methodology: Analysis of data from the library of the Central Statistical Office.

Findings: The evaluation results obtained from the analysis showed that changes in transport work were much more influenced by changes in transport distance than in cargo weight.

Originality/value: The publication discussed the topic transport efficiency in Poland on the example of cargo transport in the years 1995-2022. Combining interdisciplinary research in the areas of management and quality sciences with economics and finance.

Keywords: cargo transport, transport efficiency.

Category of the paper: Research paper.

1. Introduction

Transport is an important element of the economic activity of every company. It is a fundamental supply chain process that determines a company's level of profitability and customer satisfaction. Transport processes determine the flow of raw materials, semi-finished products and finished products, and thus determine the effectiveness of the entire supply chain management and, consequently, the level of customer satisfaction of the company. Transport is therefore an important element of the supply chain of every enterprise, responsible for the flow of goods and services between the producer and the consumer. It determines the business success or profit and loss balance of the company, and also affects its image in the eyes of contractors (Berg et al., 2017).

Transport has been the most important element of the flow of goods for hundreds of years. It allows goods to move from place to place, but also people who willingly use its possibilities. The phenomenon of transport is very common, but it still stimulates the desire to develop. New strategies and technologies implemented there make the flow of goods fast and convenient. However, this requires a lot of effort and the use of many modes of transport and extensive road, rail and air infrastructure. The time and quality of transport are influenced by many factors, which most often have their source in good organization of logistics and forwarding (Plawsky, 2020).

Nowadays, a person can transport almost anything. The transformation of the Polish economy, covering the last three decades, began in 1988 with the entry into force of the Economic Freedom Act. The mentioned time frames can be divided into periods such as (Divall, Hine, 2017):

- spontaneous political changes dating back to 1988-1991, when the command-distribution system was dismantled in Poland and close connections with the economies of the countries included in Comecon (Council for Mutual Economic Assistance) were eliminated, with particular emphasis on the Soviet Union;
- preparing the Polish economy to meet the accession conditions set by the European Union (deadline – December 16, 1991, i.e. signing the European Agreement – April 30, 2004);
- Poland's participation in the structures of the European Union (from May 1, 2004).

Transport data collected using various instruments, both traditional and IT, are a valuable source of knowledge about the state of the economy, which has a direct impact on conducting various analyzes and developing action strategies. The source of this data are usually institutions dealing with statistics (Dz.U. 2023, poz. 773).

2. Motivation and purpose

The important role of transport in the processes of socio-economic development and its special place in social life and economy is obvious. However, the second decade of the 21st century brings widespread globalization of the world economy and advanced integration processes in many regions of the globe, which makes transport a key factor in the development of modern societies. Developmental progressivity is the result of both expansive human activity in the social and economic sphere, as well as the modernization and expansion of transport infrastructure. In addition, there is constant progress in the technical development of means of transport (Motowidlak, Tokarski, 2022).

3. Methodology

To confirm changes taking place in various modes of transport, it is necessary to conduct an analysis based on statistical data. In the presented study, they cover the period from 1995 to 2022 (Główny Urząd Statystyczny, 2022). This is a period in which very significant changes took place in individual modes of transport (rail transport, road transport, air transport, pipeline transport, transport using inland navigation, transport using sea navigation). Due to the systematic increase in the volume of transported cargo, total transport, i.e. transport carried out by all the above-mentioned modes of transport, was also taken into account (Di Ciommo, Shiftan, 2017). For this purpose, transport data was used, mainly from the publications of the Central Statistical Office, regarding the volume of loads transported (exported) in the years 1995-2022.

4. Results

4.1. Cargo transport in tons

Thanks to statistical data on cargo transport in tons, it is possible to assess changes in transport services over the years. The above data arranged by type of transport in tonnes in the years 1995-2022 are presented in Table 1, which shows that during the period under study, the total volume of transported cargo (in tonnes) systematically increased until 2020. In 2021, it decreased by 360,439 thousand tons, while in 2022 a slight increase of 23,715 thousand tons can be observed. tone. tons compared to 2021. Referring to individual periods, it is worth noting that in the years 2005-2010, i.e. in the time horizon in which the global economic crisis began, the number of transport by rail, sea and inland navigation increased. An upward trend was observed in road transport of cargo. In the years 2010-2020, road transport of goods increased. However, in 2015 there was a noticeable decline in transport compared to 2010. Perhaps it was the result of a delayed reaction to the global recession. In 2021 and 2022, there will be a decline in road transport, which may be caused by the armed conflict in Ukraine. The decline in the number of sea transport continued, while the amount of cargo transported by rail increased. This is largely the result of improving the railway infrastructure.

Table 2 shows that road transport played the dominant role. Their share ranged from 75.8% (in 2005) to 87.2% (in 2020). Rail transport came in second place. The share of this transport ranged from 9.9% in 2020 to 18.9% in 2005. The next place was taken by pipeline transport, whose share ranged from 2.2% (in 2021) to 3.8% (in 2005), and maritime transport from 0.4% (in 2010-2022). to 1.8% (in 1995). Air transport occupied the last place in transport throughout the period. The share of this transport was the most stable and ranged from 0.0% to 0.1%.

Important information is provided by single-base indicators based on the volume of transport occurring in the first (1995) year of the period covered by the analysis. The calculated indicators are presented in Table 3. As Table 3 shows, since 2005 the total transport began to increase (the increase was 3.1%). The largest increase in total transport, amounting to 89.4%, occurred in 2020. In the following years, 2021 and 2022, a reduction in total transport can be observed to 63.3% and 65%, respectively. The relative changes in size in individual modes of transport were different. Table 3 also shows that in rail transport in the years 1995-2000 there was a decrease in the volume of transport, while the years 2000-2005 were a period of a significant increase in the level of transport. This was influenced by, among others, Poland's entry into the European Union. Special development concerned freight transport. The years 2005-2016 saw another decline in transport. Over the next six years, the level of transport stabilized, which was due to, among others, from: the growing level of transport using road transport (Więcek, Fajczak-Kowalska, 2011).

In road transport in the years 1995-2005 the volume of transport was almost the same. In the years 2005-2010 there was a dynamic increase in the level of transport. These included, among others: a consequence of the fact that in the period in question there was a significant increase in the number of vehicles and the number of transport companies using this type of transport. The increase in the number of vehicles was over 100%, and the increase in the number of enterprises was almost 100% (Kraśniewski, 2012). The years 2010-2015 were characterized by a slight decline in the level of transport, but still reaching a significant level. This was achieved, among others, by: creation of new expressways and highways, which were built, among others, with EURO 2012 taking place in Poland and Ukraine in mind. Since 2020, there has been an increase in transport using this mode of transport by 114.6%. Since 1995, air transport has seen a significant increase in transport. The upward trend was stopped only in 2010-2015, which was undoubtedly influenced by the effects of the global economic crisis that had its roots in 2008-2009. Since 2016, there has been a noticeable increase in transport (compared to 2015) by 86.4%, in 2017 by 141%, in 2018 by 186.3%, in 2019 by 250%, in 2020 by 186%, 4%, in 2021 by 313.6% and in 2022 by 440.9%. It should be added that air transport is one of the most expensive types of transport, so it is not surprising that the level of transport in this area has decreased. It is also worth mentioning an unusual event related to volcanic activity in April 2010, which also limited air traffic. This does not change the fact that it is still an extremely promising branch of transport, especially since numerous works are underway in Poland, resulting in the expansion of existing airports, which results in, among others, creation of modern cargo terminals. Such investments take place, among others: in Warsaw, Katowice and Rzeszów (Dz.U. 2001, nr 5, poz. 43). It is obvious that in the face of infrastructure improvement, new opportunities will appear related to air transport services, especially since their undeniable advantage is the speed of transport (Fajczak-Kowalska, 2012a).

Between 1995 and 2010, there was an increase in pipeline transport. There was some decline between 2010 and 2017. It is highly probable that, as in the case of air transport, the decline in transport dynamics in this area was the result of the far-reaching consequences of the global economic crisis, which translated into a reduction in the amount of purchased raw materials and materials transported by pipelines. This mainly applies to crude oil, liquid gases and heavy petroleum products. Taking a closer look at this branch of transport, it is worth emphasizing its low operating costs and high level of reliability, which makes the transport of the above-mentioned. transporting raw materials via pipelines is extremely profitable from an economic point of view. A separate issue is the strategic importance of gas supplies, a clear example of which is the controversy surrounding the construction of the Nord Stream 2 gas pipeline. Its construction would have a negative impact on Polish interests, including: due to the possibility of limiting gas transmission through the existing Yamal-Europe gas pipeline running through the countries: Belarusian and Polish. According to experts, this would be an argument in the negotiations between Russia and Poland regarding the prices of this raw material. The Russians, citing economic reasons, could declare the need to raise gas prices to make using the Yamal gas pipeline profitable (Wiśnicki, 2011). There is no doubt, therefore, that this type of transport is a key element of the strategic policy of many countries. Inland water transport is subject to large fluctuations. The years 1995-2000 and 2015-2022 were a period of some growth, in the years 2000-2005 there was a decline in transport dynamics, which deepened in the years 2005-2022. In turn, the years 2010-2015 brought a dynamic increase in transport dynamics. This proves the huge potential of this branch of transport, despite the lack of necessary investment activities. It should be emphasized that in Poland, apart from short sections of the lower Oder, the parameters of native routes do not correspond to the minimum international navigation conditions specified in the AGN Convention. This convention imposes on the Polish authorities the obligation to adapt the main waterways so that they have at least class IV navigability. Lower classes do not allow the use of EU funds related to trans-European transport corridors. The possibility of using these funds depends on achieving the parameters of navigability class IV, which involves achieving a transit depth of at least 2.5 m on the route. However, these conditions have not yet been met.

If the Oder were adapted, the industry would make huge profits, because thanks to the connection with the waterways systematized in Germany, it would be possible to send goods by barge to many European countries. However, decisions are needed at the government level, otherwise transport paradoxes may continue to arise, such as the transport of coal from domestic mines to Berlin's power plants. Currently, the situation is that it is transported by rail to Szczecin, then transferred to barges and transported to Berlin. The years 1995-2022 are a time of constant reduction in the dynamics of cargo transport by sea. This tendency can be explained by the decapitalization of the rolling stock previously used in this type of transport. Other reasons for this state of affairs include: growing competition from other branches of transport, a decline in the number of orders from foreign contractors and an insufficient level

of investment activity in this transport industry. This is due to the lack of a coherent strategy for the development of the maritime economy and conflicting ideas on how to improve the current state of affairs. For example, numerous road investments are being carried out to facilitate the transport of cargo to ports, but according to experts, local road routes are not able to handle such a flow of cargo. Rail transport would be more useful in this respect. However, no binding arrangements have been made for wider use of the railway sector (Porter, 2006).

In order to check whether the transport of goods in thousands of tons by modes of transport in the years 1995-2022 shows clear patterns, the parameters of the following linear development trend model were estimated (Model 1):

$$Y_{tr} = \alpha_{0r} + \alpha_{1r}T_t + \varepsilon_{tr} \quad (1)$$

where:

- Y_{tr} - transport volume in tonnes in year t by transport r ,
- T_t - time variable (trend) taking the following values: 1, 2, ..., 21,
- ε_{tr} - random variable,
- α_{0r}, α_{1r} - structural parameters of the model.

The calculation results are presented in Table 4, which shows that there are no clear regularities in the transport of cargo by mode of transport. Only for sea shipping and road transport, quite high coefficients of determination were obtained: $R^2 = 0.86$ for sea transport and $R^2 = 0.72$ for road transport. Although the α_0 estimates of the α parameter are statistically significant for all types of transport, a statistically insignificant α_1 estimate was obtained for rail transport. The critical value of the Student's t -test for the significance coefficient of 0.05 is 2.19 in this case. For other types of transport, the α_1 estimates are statistically significant, but the low values of the R^2 determination coefficients do not allow the use of a linear model of development trends to prepare forecasts (Fajczak-Kowalska, 2016).

There are also no clear regularities in the structure of cargo transport in thousands of tons. Based on the calculation results presented in Table 5, it can be concluded that the estimates of the α_0 parameter for all types of transport are statistically significant, as the Student's t -test values significantly exceed the critical value of 2.19. However, statistically significant estimates of the α_1 parameter were obtained for road transport (2.86), inland navigation (4.24) and sea navigation (9.30). The lack of regularity in the structure of transport according to individual modes of transport is evidenced by the low values of the determination coefficients R^2 . Only for maritime shipping, the value of the determination coefficient of 0.82 can be considered satisfactory.

4.2. Average cargo transportation distance

The basic measure of transport activity is the transport of loads of a specific size (weight) expressed in tons. Adopting this criterion may prove insufficient in some situations. Therefore, the distances over which loads are transported by particular types of transport are taken into account.

Information on the average distance of transporting 1 ton of cargo by type of transport in the years 1995-2022 is presented in Table 6, which shows that the average distance of transporting 1 ton of cargo was subject to quite significant fluctuations. A steady increase in the average distance was only recorded for road transport. In the years 2010-2022, the average distance of transporting one ton of cargo by rail increased. It is worth noting here that it is desirable for this distance to be as large as possible, because the competitiveness of this form of transport increases with the increase in the distance over which given loads are transported. During the same period, the average transport distance in air transport increased significantly, while the average transport distance in sea transport decreased significantly.

The changes taking place in the average transport distance of 1 ton of cargo in the period under study are presented in the calculation results in Table 7, which show that in air transport in the years 2005-2010 there was a decrease in the average transport volume, which in 2010 reached the level of 83.6%. In 2015 we saw an increase to 123.2%. In pipeline transport, distances increased compared to 2016, but in 2017 they stopped. In land transport, in 2010 there was a more than two-fold (212.7%) increase in the average transport distance of one tonne of cargo; since 2019, there has been a decrease in the average transport distance. However, in maritime shipping there was a very significant decrease in the average transport distance and amounted to only 19.1% compared to 1995. It can be said that in maritime transport, the relationship between ocean transport and short sea transport has completely changed (Nowak et al., 2018).

In order to determine whether there are clear patterns in individual modes of transport, the parameters of the trend model were estimated. The calculation results obtained for this model are presented in Table 8, which shows that the continuing trend of changes in the average transport distance is indicated primarily by: road transport (growing trend with an average increase in distance of 7.79 km per year) and sea transport, characterized by an average annual decrease in transport distances of almost 330 km. For the remaining industries, due to irregular changes in the category in question, it was not possible to map them using a linear trend model.

4.3. Cargo transportation according to transport work

A more universal measure of the volume of cargo transport is transport performance expressed in tonne-kilometers, taking into account both the transported weight of the cargo and the transport distance. Information on the volume of transport in tonne-kilometers is presented in Table 9, which shows that since 1995 there have been noticeable fluctuations in transport performance when transporting the entire load. The constant growth concerns only road and air transport, in other industries there were declines and increases in the period in question. Pipeline transport has achieved some stability, the condition of which is the existence of long-term contracts for the supply of raw materials. In the years 2015-2022, there is a noticeable increase in freight transport (Fajczak-Kowalska, Misztal, 2019).

The structure of transport in tonne-kilometers is presented in the calculation results in Table 10, which shows that the share of freight transport in tonne-kilometers has changed over time. In 1995, the largest share was taken by sea transport, which amounted to 55.1%, second place was taken by rail transport, with a share of 23.0%, and only third was road transport, with a share of 17.0%. The lowest share had air transport - 0.1% and land transport - 0.3%. The primacy of sea transport remained until 2005, when road transport took the leading position, gradually increasing its share in the following years. Since 2010, there has been a decline in the share of rail, pipeline and sea transport in transport (Fajczak-Kowalska, 2012b).

During the period under study (1995-2022), there were very significant changes in the share of individual modes of transport. A downward trend can be observed in rail transport. In 2010, the share of this type of transport decreased by 7.6% compared to 1995. In the remaining years of the analyzed period, the share of rail transport ranged from 9.5% in 2020 to 23% in 1995. In road transport there was a systematic increase in transport from 17.0% in 1995 to 85.4% in 2020. In the years 2005-2018, the increase in the share of transport was probably due to Poland's accession to the European Union on May 1, 2004. The share of air transport in transport expressed in tonne-kilometers was very small and amounted to 0.1 throughout the period under study. Quite large fluctuations occurred in pipeline transport, ranging from 3.7% in 2021 to 11.1% in 2005. The share of inland navigation was small and ranged from 0.1% in 2020-2022 to 0.6 % in 2015. Such a low share of transport is influenced by the short length of waterways in Poland. Moreover, the condition of these roads and the means of transport used to transport goods by inland navigation leave much to be desired. The largest decline in the share of transport, reaching almost 50%, occurred in maritime transport. The main reason for this decline was the systematic liquidation of transport fleet and the liquidation or restructuring of enterprises dealing with this type of transport.

Changes in transport (transport performance) in tonne-kilometers compared to 1995 are presented in the calculation results in Table 11, which show that the largest increase in total transport, amounting to 79.8%, occurred in 2020. Increase in transport compared to 1995 occurred in the case of road and air transport. It is worth noting a clear increase in the dynamics

of transport work in the inland navigation sector in 2015 - compared to 2010, the increase was 132.1%. According to data from the Central Statistical Office, road transport has the largest share in freight transport. In 2015, the volume of cargo transported by this form of transport, measured by transport performance, reached 1,767.8 billion tonne-kilometers and was 2.4% higher than that recorded in the previous year. The leading position in terms of transport performance was taken by Germany (314.7 million tonne-kilometers), Poland was second and Spain was third. Analysts point out that transport companies from the East are becoming more and more competitive, which affects the situation on the domestic and international markets. Obtaining a satisfactory transport order is becoming more and more difficult. They emphasize that the main problem when it comes to Western markets are not competitors, but administrative and legal barriers that are intended to protect domestic markets, thus harming the competitiveness of the Community market (Fajczak-Kowalska, 2021).

It is significant that Polish dominance in the road transport market is based on companies operating in Poland, and not on Polish companies. It should be noted that the largest enterprises of this type belong to foreign capital. These include the Dutch concern Raben, the German DB Schenker, and the French FM Polska and DPD Polska. Even Pekaes is now owned by Strada Holding from Luxembourg. When it comes to the leading road transport companies in Poland, only one of them has a Polish owner. This is ROHLIG SUUS Logistics. Interestingly, Polish entrepreneurs took it over over a decade ago from its German owner (Pawłowska, 2015).

As Table 12 shows, when looking at the trend model for freight transport by mode of transport, it can be seen that the trend for road and sea transport continues. As in the case of trend models for cargo transport distances, transport performance shows a constant trend only in two branches: road and sea transport. Comparing the trend model for the weight of transported loads, it should be concluded that changes in the volume of transport work were influenced to a much greater extent by changes in the transport distance than changes in the weight of the load. When analyzing the models of trends in the transport work structure, the only acceptable result is the result obtained for road transport, where the share of transport work in this branch was explained in 96%, and the statistically significant assessment of the α_1 parameter indicates an increase in this share by an average of 3.5% year to year, as shown in Table 13.

5. Conclusions

The greatest changes affecting the structure and volume of demand for transport occur in the innovative and technological sphere of transport, in production technologies of other sectors of the economy, in the basis of location decisions and in the functioning models of societies. In the transport of goods, improving accessibility is a key location factor influencing the

distribution of facilities constituting the potential to generate traffic in truck transport. Assuming a macro scale, increasing the level of accessibility may result in a higher level of GDP and an increase in traffic (in the short term this is the result of demand effects, and in the long term it is the effect of supply effects). In turn, an increase in competitive advantage in the truck transport sector resulting from improved accessibility may result in a modal shift and an increase in traffic on road networks. As in passenger transport, limited accessibility due to limited journeys results in modification of the traffic schedule. Therefore, there is no doubt that infrastructure investments are advisable, which will enable greater market accessibility (Tokarski, 2022).

The development of forwarding and transport companies results from many factors, which include: spatial, economic, technological, production, cooperative and social motives (Demińska, 2011). These are the needs resulting from human nature, the desire to move and live in society. Another element is the scope of people's activities - they produce goods based on resources available in different parts of the world, so they must transfer these products as quickly as possible. Many of these products are necessary for our lives, so someone has to provide them. To meet the numerous requirements for transport, there are many forwarding companies on the market. Their activity consists in organizing the transport of cargo and performing all or some of the activities related to it.

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Appendix

Table 1.

Freight transport in thousands of tons by types of transport in 1995-2022

Year	Type of transport						Total
	Rail transport	Road transport	Air transport	Pipeline transport	Inland shipping	Sea shipping	
1995	225348	1086762	22	33353	9306	24968	1379759
2000	187247	1083071	28	44342	10433	22774	1347895
2005	269553	1079761	34	54249	9607	9362	1422576
2010	216899	1551841	41	56208	5141	8362	1838492
2015	224320	1505719	38	54850	11928	6963	1803818
2016	222523	1546572	41	54058	6210	7248	1836652
2017	239501	1747266	53	52393	5778	8254	2053245
2018	249260	1873022	63	55287	5107	9149	2191888
2019	233744	1921073	77	52376	4681	8727	2220678
2020	218381	2331758	63	51489	3991	8135	2613817
2021	237915	1952465	91	49855	3465	9587	2253378
2022	237587	1976278	119	52591	2076	8442	2277093

Source: own study based on Central Statistical Office data.

Table 2.

Freight transport structure (by weight) in percentage in the years 1995-2022

Year	Type of transport					
	Rail transport	Road transport	Air transport	Pipeline transport	Inland shipping	Sea shipping
1995	16.3	78.7	0.1	2.4	0.7	1.8
2000	13.8	80.3	0.1	3.3	0.8	1.7
2005	18.9	75.8	0.1	3.8	0.7	0.7
2010	13.1	83.1	0.0	3.1	0.3	0.4
2015	12.4	83.5	0.0	3.0	0.7	0.4
2016	12.1	84.2	0.0	2.5	0.3	0.4
2017	11.7	85.1	0.0	2.5	0.3	0.4
2018	11.4	85.5	0.0	2.5	0.2	0.4
2019	10.5	86.5	0.0	2.4	0.2	0.4
2020	9.9	87.2	0.0	2.3	0.2	0.4
2021	10.6	86.6	0.0	2.2	0.2	0.4
2022	10.4	86.8	0.0	2.3	0.1	0.4

Source: own study based on Central Statistical Office data.

Table 3.

Dynamics of cargo transport by weight for types of transport (year 1995 = 100)

Year	Type of transport						Total
	Rail transport	Road transport	Air transport	Pipeline transport	Inland shipping	Sea shipping	
2000	83.1	99.7	127.3	133.0	112.1	91.2	97.7
2005	119.6	99.4	154.6	162.7	103.2	37.5	103.1
2010	96.3	142.8	186.4	168.5	55.3	33.5	133.3
2015	99.5	138.6	172.7	164.5	128.2	27.9	130.7
2016	98.8	142.3	186.4	162.1	66.7	29.0	133.1
2017	106.3	160.8	241.0	157.1	62.1	33.1	148.8
2018	110.6	172.3	286.3	165.8	54.9	36.6	158.9
2019	103.7	176.8	350.0	157.0	50.3	34.9	160.9
2020	96.9	214.6	286.4	154.4	42.9	32.6	189.4
2021	105.6	179.7	413.6	149.5	38.4	38.4	163.3
2022	105.4	181.9	540.9	157.7	22.3	33.8	165.0

Source: own study based on Central Statistical Office data.

Table 4.*Parameter estimates and statistical characteristics for Model 1*

Type of transport	Model parameters					
	Rating a_0	$t(a_0)$	Rating a_1	$t(a_1)$	Se	R^2
Rail transport	223754	16.73	1288	1.18	30202	0.08
Road transport	901083	14.86	30842	6.73	128666	0.72
Air transport	27.12	12.79	0.82	4.47	4.90	0.53
Pipeline transport	38640	19.37	943	6.07	4300	0.70
Inland shipping	9837	12.04	- 147.25	2.19	1866	0.25
Sea shipping	28889	19.07	- 1199.3	9.83	3388	0.86
Total	1202293	24.23	32541	7.76	113308	0.77

Source: own study based on calculations.

Table 5.*Parameter estimates and statistical characteristics for model 1 for the structure of freight transport in thousands of tons*

Type of transport	Model parameters					
	Rating a_0	$t(a_0)$	Rating a_1	$t(a_1)$	Se	R^2
Rail transport	17.30	14.84	- 0.20	2.20	2.58	0.19
Road transport	76.59	55.46	0.31	2.86	3.05	0.30
Air transport	0.002	15.80	0.000007	2.66	0.0003	0.02
Pipeline transport	3.13	13.98	0.001	2.19	0.50	0.00
Inland shipping	0.77	13.20	- 0.02	4.24	0.13	0.49
Sea shipping	2.20	16.70	- 0.10	9.30	0.29	0.83

Source: own study based on calculations.

Table 6.*Average distance of transporting 1 tonne of cargo by type of transport in 1995-2018 in kilometers*

Year	Type of transport					
	Rail transport	Road transport	Air transport	Pipeline transport	Inland shipping	Sea shipping
1995	307	47	3359	405	94	6643
2000	291	67	3120	459	112	5869
2005	185	111	3142	468	133	3389
2010	225	144	2807	430	200	2364
2015	226	181	4139	398	183	1830
2016	228	196	4598	411	134	1137
2017	229	199	4868	402	152	1134
2018	238	202	4934	386	153	833
2019	234	206	4852	370	140	783
2020	234	198	3587	397	129	818
2021	229	210	3757	370	142	788
2022	250	206	3739	364	214	1374

Source: own study based on Central Statistical Office data.

Table 7.

Dynamics of the average distance of transporting 1 ton of cargo by mode of transport in the years 1995-2022 (1995=100)

Year	Type of transport					
	Rail transport	Road transport	Air transport	Pipeline transport	Inland shipping	Sea shipping
2000	94.8	142.6	92.9	113.3	119.1	88.3
2005	60.3	236.2	93.5	115.6	141.5	51.0
2010	73.3	306.4	83.6	106.2	212.7	35.6
2015	73.6	385.1	123.2	98.3	194.7	27.5
2016	74.3	417.0	136.9	101.5	142.6	17.1
2017	74.6	423.4	144.9	99.3	161.7	17.1
2018	77.5	429.8	146.9	95.3	162.8	12.5
2019	76.2	438.3	144.4	91.4	148.9	11.8
2020	76.2	421.3	106.8	98.0	137.2	12.3
2021	74.6	446.8	111.8	91.4	151.1	11.9
2022	81.4	438.3	111.3	89.9	227.7	20.7

Source: own study based on Central Statistical Office data.

Table 8.

Estimation of a trend model for average transport distance

Type of transport	Model parameters					
	Rating a_0	$t(a_0)$	Rating a_1	$t(a_1)$	Se	R^2
Rail transport	295.62	20.32	- 5.12	4.42	32.16	0.52
Road transport	33.50	9.19	7.79	23.39	8.06	0.97
Air transport	3006.01	13.86	4.19	0.24	479.8	0.05
Pipeline transport	455.80	47.54	- 1.35	1.76	21.20	0.16
Inland shipping	95.53	9.33	3.76	4.59	22.70	0.54
Sea shipping	7170.5	24.36	- 329.79	11.94	650.1	0.89

Source: own study based on calculations.

Table 9.

Transport performance in millions of tonne-kilometers by type of transport in 1995-2022

Year	Type of transport						
	Rail transport	Road transport	Air transport	Pipeline transport	Inland shipping	Sea shipping	Total
1995	69116	51200	74	13493	876	165863	300622
2000	54448	72843	88	20354	1173	133654	282559
2005	49972	119740	107	25388	1277	31733	228217
2010	48707	223170	114	24157	1030	19773	316951
2015	50603	273107	156	21843	2187	12739	360635
2016	50650	303560	190	22204	832	8242	385678
2017	54797	348559	257	21080	877	9362	430784
2018	59388	377778	313	21314	782	7619	467253
2019	54584	395311	374	19394	656	6830	477149
2020	51096	461582	227	20437	516	6658	540516
2021	54387	410224	341	18429	493	7554	491428
2022	59306	406902	445	19132	445	11602	497832

Source: own study based on Central Statistical Office data.

Table 10.*Structure of cargo transport work by mode of transport in 1995-2022 (%)*

Year	Type of transport					
	Rail transport	Road transport	Air transport	Pipeline transport	Inland shipping	Sea shipping
1995	23.0	17.0	0.1	4.5	0.3	55.1
2000	19.3	25.7	0.1	7.2	0.4	47.3
2005	21.9	52.4	0.1	11.1	0.6	13.9
2010	15.8	69.5	0.1	7.9	0.3	6.4
2015	14.0	75.7	0.0	6.1	0.6	3.5
2016	13.1	78.7	0.1	5.8	0.2	2.1
2017	12.6	80.1	0.1	4.8	0.2	2.2
2018	12.7	80.9	0.1	4.6	0.2	1.6
2019	11.4	82.8	0.1	4.1	0.2	1.4
2020	9.5	85.4	0.0	3.8	0.1	1.2
2021	11.1	83.5	0.1	3.7	0.1	1.5
2022	11.9	81.7	0.1	3.9	0.1	2.3

Source: own study based on Central Statistical Office data.

Table 11.*Transport performance dynamics in percent (1995 = 100)*

Year	Type of transport						
	Rail transport	Road transport	Air transport	Pipeline transport	Inland shipping	Sea shipping	Total
2000	78.8	142.3	118.9	150.9	133.9	80.6	94.0
2005	72.3	233.9	144.6	188.2	145.8	19.1	75.9
2010	70.4	435.9	154.1	179.0	117.6	11.9	105.4
2015	73.2	533.4	210.8	161.9	249.7	7.7	120.0
2016	73.3	592.9	256.8	164.6	95.0	5.0	128.3
2017	79.3	680.8	347.3	156.2	100.1	5.6	143.3
2018	85.9	737.8	423.0	158.0	89.3	4.6	155.4
2019	78.9	772.1	505.4	143.7	74.9	4.1	158.7
2020	73.9	901.5	306.7	151.5	58.9	4.0	179.8
2021	78.7	801.2	460.8	136.6	56.3	4.5	163.5
2022	85.8	794.7	601.4	141.8	50.8	6.9	165.6

Source: own study based on Central Statistical Office data.

Table 12.*Parameter estimates and statistical characteristics of freight transport by mode of transport in tonne-kilometers for the trend model*

Type of transport	Model parameters					
	Rating a_0	$t(a_0)$	Rating a_1	$t(a_1)$	Se	R^2
Rail transport	62666	26.0	-798.8	4.16	5332	0.48
Road transport	7529	0.9	12193.1	17.22	19651	0.96
Air transport	76.98	11.1	2.5	4.56	15.39	0.52
Pipeline transport	17455	14.4	338.3	3.50	2678	0.39
Inland shipping	9735	7.0	10.8	0.97	307.9	0.05
Sea shipping	184789	18.5	-9694.1	12.20	22043	0.89
Total	273553	16.8	2052	1.59	35912	0.12

Source: own study based on calculations.

Table 13.

Parameter estimates and statistical characteristics of the transport structure trend model in tonne-kilometers

Type of transport	Model parameters					
	Rating a_0	$t(a_0)$	Rating a_1	$t(a_1)$	Se	R^2
Rail transport	22.34	29.32	- 0.36	5.92	1.68	0.65
Road transport	8.21	3.68	3.53	19.83	4.96	0.96
Air transport	0.03	14.42	0.0006	3.57	0.005	0.42
Pipeline transport	6.60	8.24	0.06	1.01	1.79	0.06
Inland shipping	0.37	7.07	0.0009	0.22	0.11	0.04
Sea shipping	0.007	18.48	- 0.00004	1.31	0.0009	0.09

Source: own study based on calculations.

LEVEL OF SUSTAINABLE CONSUMPTION IN HOUSEHOLDS IN POLAND ACCORDING TO NON-INCOME FACTORS

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Purpose: The aim of the analysis was to demonstrate the relationship between the impact of selected (non-income) factors and the level of sustainable consumption of households in Poland in selected years.

Methodology: Analysis of data from the library of the Central Statistical Office.

Findings: The most important economic factors determining household expenses include income, which determines primarily the size and structure of expenses and the prices of goods.

Originality/value: The publication discusses the impact of selected (non-income) factors on the level of sustainable consumption in households. Combining interdisciplinary research in the areas of management and quality sciences with economics and finance.

Keywords: household budgets, households in Poland, sustainable consumption.

Category of the paper: General review.

1. Introduction

Consumption currently has a very large impact on changes taking place both in the environment and in society, where it emphasizes its stratification. Therefore, an important issue is sustainable development, the main goal of which is to manage in such a way as to meet the needs of both current and future generations, taking into account environmental protection. In the economic literature, most attention has been paid to the theory of the consumption function. In the second half of the 1930s, some economic theorists began to link consumption with income and, on this basis, predict changes in global consumption, relating their considerations to various types of income. This led to the creation of many concepts, called income hypotheses in the economic literature, the most important of which are the concept of permanent income and the life cycle theory (Bywalec, 2012; Zalega, 2012).

The literature states that the usefulness of treatments performed by representatives of this trend was measurable, the so-called cardinal utility, in the sense that it could be measured by every consumer and every household. The following objections can be raised against such theories (Jevons, 1871; Marshall, 1890).

- each consumer realizes the value of the purchased product only after using it for some time,
- when assessing the suitability of the purchased goods, natural and technical parameters characterizing the goods, economic parameters and parameters visible to the buyer's senses should be taken into account.

The authors built individual theories based primarily on the analysis of their own mental experiences, which they then tried to transfer to other people in order to explain the regularities observed in economic life.

In the works of the outstanding English economist Marshall (1890), who studied, among other things, the behaviour of households in making consumption decisions, the basis of the theory of demand is the theory of marginal utility in an approach similar to Jevons (1871) and Austrian economics. He formulated the "law of diminishing marginal utility". He referred to a generalization in the sphere of physiology: namely, the strength of the reaction to a given stimulus weakens - at a specific time - with each subsequent repetition of this stimulus. Marshall (1890) begins his theory of marginal utility by stating that "a well-known and fundamental feature of human nature" is reflected in "the law of satiation of wants or diminishing utility". Marshall (1890) provides no evidence for the existence of this law, but defends it against misinterpretation. As a result, we must settle for a tautological definition of the law of diminishing marginal utility relating to the tastes of a given moment, formulated in such a way as to cover all eventualities without exception.

Consumption is the process of using goods and services to meet human needs (Kramer, 1997). The theories of consumption presented by many authors were based mainly on the behaviour of a single household and did not take into account the issue of aggregation, which aims to establish certain regularities in the behaviour of specific communities, in accordance with the adopted laws governing behaviour. units. By the 1930s, these theories had become of little use. Economics' attention has focused mainly on issues related to long-term growth and the economic cycle. The basic aim of the analysis was to identify economic policy measures that would enable controlling these processes. This resulted in the main issue of consumption theory becoming the determination of factors influencing all consumption expenditures or expenditures on goods of fundamental importance for the development of the economic situation (residential houses, clothing, household appliances). The analysis of the structure of population expenditure and real consumption as well as changes in consumption patterns is based on taking into account demographic factors. Kudrycka (1996) divides factors into three groups: economic, demographic and social, and subjective. Mynarski (1967) distinguishes factors characterizing the family and directly related to it (family income, number of people in

the family, age, gender, degree of kinship, stage of family development, professional structure, role of husband and wife in decision-making, belonging to a socio-economic group, housing resources, level of savings, place of residence) and factors shaping the general market situation (national income and its division, prices of goods and their mutual relations, state of market supply, seasonal phenomena, fashion, quality of work of the commercial apparatus, state policy in the field of consumption management).

2. Literature review

2.1. Demographic factors

In the literature on factors influencing consumer demand, various criteria for their division are adopted. Brown (1954) divides demand factors into economic and social. Hodoly (1961) introduces a division into endogenous and exogenous factors. Schafer (1953) presents four divisions of factors: economic and non-economic, individual and social, biological and psychological, and primary and secondary. Among the demographic factors, the most basic are age and gender. Gender determines needs in terms of clothing, footwear and partly food. Age determines many needs, their intensity and the level and structure of consumption. The age factor is used for analyses in the form of age groups and the family life cycle. They constitute a collective criterion for relatively homogeneous groups that will behave similarly in the consumption process. An equally important demographic factor is the size of households. This coefficient is used to divide households into groups with very different characteristics (e.g. one-person, two-person households).

Demographic factors, classified by some authors as a large group of non-economic factors, are treated as the most important determinants of consumer demand after economic factors (farm income and commodity prices) (Zarzycka, 1992). Research on the impact of demographic factors on household consumption was conducted, among others, by: Zając (1962, 1966), Welfe (1962, 2003, 2005), Mynarski (1964, 1967), Banasiak (1967, 1969), Zarzycka (1980, 1992), Fajczak-Kowalska (2001), Więcek (1983, 2013, 2014).

Taking into account demographic factors in consumer demand functions is very important, because in modern societies there are tendencies to reduce the size of households. This phenomenon occurs both as a result of the decrease in the average number of children in a family and as a result of the reduction of multi-generational households to single- or two-generation families. The number of people in a household directly affects the amount of its expenses and the amount of income per household member. Increasing the number of people in a family usually results in a decrease in income. Changing the size of farms causes changes in the way they are managed. A larger number of people on the farm results in savings resulting

from the so-called increase in the scale of management. These savings result from more economical shopping and food preparation. Even greater savings results from the use of indivisible goods by a larger number of people (e.g. apartment, furniture, household appliances, car, etc.). The savings generated in this way can be used partly to increase the amount of basic goods and partly to purchase new higher-level items.

2.2. Sociological, psychological and social factors

Sociological factors determining consumption are closely related to demographic factors. Sociological factors include education, profession, place of residence, as well as nationality, marital status and professional activity (Kraśiński et al., 1984).

Psychological factors include habits, traditions, habits and motives (internal mechanisms of creating needs and actions in the area of consumption), human attitudes (lasting forms of responding to given stimuli in specific situations), opinions (which are the articulation of attitudes), predictions of the future (according to the individual's time horizon, both in terms of experience and future expectations) (Tymowski, 1966, 1968; Zarzycka, 1980, 1992).

Social factors, in accordance with the specification adopted for the econometric model, are: education of the head of the family, membership in a socio-economic group, size of the family's place of residence and region. Due to the increasingly stronger impact of the above variables on the level and structure of consumption, they are introduced into consumer demand models. The research conducted so far shows that education has a significant impact on the amount of expenditure per age of aggregates of goods. Education determines the nature of professional work and influences the intellectual level of a given individual, among others. increased education raises needs in terms of reading, transmitting and receiving cultural goods (Tymowski, 1966, 1968; Zarzycka, 1980, 1992).

It can be assumed that, for example, expenditure on books, magazines and daily press will be higher among people with higher education than among people with primary education. It can be assumed that in the case of many other goods satisfying cultural, food and housing needs, the hypotheses will be similar. This leads to the conclusion that the consumption pattern (model) is different and more diverse in the case of families that include people with higher education than in the case of other families. It should be noted that the general level of education of society is increasing, and therefore the differences in consumption are blurring. Despite the existence of such trends, it is known that certain environmental factors and related habits may have a significant impact on the development of the consumption model (Sikorska, 1979; Zarzycka, 1980, 1992).

Based on the analysis of the impact of income and the income-independent impact of the variable - education - on changes in expenses, four groups of expenses were distinguished, subject to differentiation. The first group of expenses is characterized by a decreasing tendency with increasing education, while the effect of income weakens. This variable causes changes in the consumption structure, expressed in a decrease in the relative level of expenditure satisfying

basic needs along with an increase in the level of education. An example would be consumers' reaction to food spending. An increase in the level of education generally causes its decline (Sikorska, 1979).

The second group concerns expenses that are characterized by an increase in income elasticity coefficients with a simultaneous decrease in expenses, regardless of the level of income, as the level of education increases. This phenomenon can be observed in the case of tobacco and alcohol. The income effect is related to qualitative changes occurring in the consumption of these products. In the case of incomplete primary, primary and basic vocational education, expenditure on tobacco products and alcohol is mainly influenced by income, while in the case of secondary and higher education, the impact of education is stronger than the impact of the income variable and causes a decrease in expenditure.

The third group includes expenses for housing and fuel, clothing and footwear. For these aggregates, no significant differences were observed due only to changes in the level of education. It can be suspected that in the area of clothing and footwear, differences resulting from education are qualitative rather than quantitative. In terms of housing and fuel expenses, the lack of differentiation is due to the fact that consumers have limited opportunities to influence their amount.

The fourth group includes expenses that increase with the increase in the level of education, regardless of changes in income. These are expenses on hygiene and health care, culture, sports and recreation, as well as transport and communication. Households whose "head" has higher education are, on average, characterized by a higher share of expenditure on transport and communication, hygiene and culture than households whose "head" has basic vocational education; however, the share of expenditure on alcohol, tobacco and food is smaller. The only aggregate for which there is quite significant variation also between the lowest levels of education (incomplete primary, primary, basic vocational) is hygiene and health care.

Another factor influencing the level and diversity of consumption is belonging to a socio-economic group. This factor was dealt with by many authors, including: Welfe (1962, 2003, 2005), Kudrycka (1977), Wąsik, Wydymus, Zeliś (1978), Podolec (1995), Fajczak-Kowalska (2001), Więcek (1983, 2013, 2014). Taking this feature into account is related to the hypothesis that the social and professional environment has a significant impact on household habits and preferences. Studying differences in expenditure and consumption (of food) between socio-economic groups is possible thanks to the fact that since 1993, the Central Statistical Office has published information on income, expenditure and consumption of households belonging to seven socio-economic groups. These are employees, unemployed people, agricultural workers, farmers, self-employed people, pensioners and people living on unearned sources.

3. Analysis results

The above statement that in modern societies there is a tendency to reduce the size of households is confirmed by the results of budget research for the years 1994-2022. Due to the fact that in consumer demand functions, the average number of people in a household and the average number of consumption units are most often taken as explanatory variables illustrating the effects of the impact of demographic variables. Changes in the average size of farms in the years 1994-2022 (or separately for retirees and pensioners in the years 1997-2022) are presented in the calculation results presented in tables 1 and 2.

Table 1 shows that the number of households of retirees and disability pensioners decreased the most - by 0.74 people. A high value of the range was also obtained in the case of self-employed households (0.70 person). The next places are occupied by farmers' households (range = 0.62), workers' households (0.52), total employees' households (0.50), total retirees' and pensioners' households (0.43), and non-working households (0.40), households, the smallest changes occurred in the households of retirees and pensioners (separately) and amounted to 0.32.

In the entire surveyed group of farms, the reduction in the average number of people per farm was 0.58. On average, in terms of the average number of people in the years 1994-2022, the largest households were agricultural (4.16), workers (3.64), self-employed (3.49), total workers (3.38), and the non-working class (3.06), households of pensioners (2.17), households of pensioners in total (2.17), households of pensioners (separate) (2.07). The average total farm size in the years 1994-2022 was 2.99.

The regularity of changes over time (1994-2022) is shown by the calculation results in table 2, according to the model:

$$Y_{ts} = \alpha_{0s} + \alpha_{1s}T_t + \varepsilon_{ts} \quad (1)$$

Y_{ts} - number of units of consumption in year „t”, t, in socio-economic group „s”.

α_{0s} , α_{1s} - structural parameter of the model.

T_t - time variable.

ε_{ts} - random variable.

The regularity and systematicity of changes in the examined period are indicated by the a_1 scores obtained for the linear model of development trends. For all groups of farms, these assessments are negative and, what should be emphasized, statistically significant. The most regular changes over time occurred in households of the self-employed ($R^2 = 0.98$), households of employees in general ($R^2 = 0.895$) and households of pensioners ($R^2 = 0.851$). The largest fluctuations in terms of farm size occurred in agricultural farms ($R^2 = 0.466$). The average number of people in a household for the entire study population was very regular, as $R^2 = 0.966$.

Another demographic variable may be the average number of units of consumption. This variable takes into account the average number of people in the household, the gender and age of its members. The number of consumption units is calculated using the following scales, determining the individual caloric demand of consumed food depending on gender and age:

- | | |
|---|--|
| a) children under the age of: | b) men aged: |
| <ul style="list-style-type: none"> • up to 1 year: 0.25, • 1 year: 0.30, • 2 years: 0.40, • 3-7 years: 0.50, • 8-11 years: 0.60, • 12-13 years: 0.70; | <ul style="list-style-type: none"> • 14-17 years: 0.85, • 18 years and over: 1.0; |
| | c) women aged: |
| | <ul style="list-style-type: none"> • 14-17 years: 0.75, • 18 years and over: 0.85. |

Information on changes in the number of units of consumption in the analysed period 1994-2022 is presented in tables 3 and 4.

Table 3 shows that the largest changes in the number of units of consumption occurred in the years 1994-2022 in the households of retirees (range = 0.43), blue-collar workers (range = 0.39), and blue-collar households in total (range = 0.32), non-working - working class households (range = 0.31), pensioner households (range = 0.27). The total number of consumption units decreased by 0.42. Changes in the number of consumption units in the examined period are illustrated by the calculation results presented in Table 4, in accordance with model (1).

Table 4 shows that the number of consumption units systematically decreased, as evidenced by the negative a_1 evaluation values obtained for the linear development trend model. The a_1 ratings, except for farms, are statistically significant for all other groups of farms surveyed.

The greatest changes occurred in the households of retirees ($a_1 = - 0.030$), followed by the households of the self-employed ($a_1 = - 0.024$), the unemployed ($a_1 = - 0.014$), all employees ($a_1 = - 0.013$), retirees and pensioners in total ($a_1 = - 0.013$), retirees (separately), ($a_1 = - 0.012$), employee households ($a_1 = - 0.003$).

The smallest changes occurred on agricultural farms ($a_1 = - 0.004$). Over the entire period under study (1994-2022), the number of consumption units decreased by - 0.019 each year. The downward trend was quite regular, as the values of the determination coefficient R^2 are relatively high and range from 0.650 for households of retirees and disability pensioners in total to 0.986 for households of the self-employed.

The lowest value of the determination coefficient $R^2 = 0.088$ was obtained on agricultural farms. For workers' farms, a low value of the determination coefficient $R^2 = 0.401$ was also obtained.

Among the features expressing spatial differentiation of consumer demand, there are those that allow the characterization of regional differences in consumer preferences. This issue is very complex and many works have been devoted to it. The following works should be mentioned: Welfe (1962, 2003, 2005), Zajac (1962, 1966), Kramer (1977, 1980, 1997), Podolec (1995).

All the factors mentioned above, as well as many other, less frequently studied, create a system of interconnected elements. The behaviour of consumers and households accepting a specific consumption pattern, expenditure structure and consumption structure, both on a macroeconomic and microeconomic scale, depends on the system of psychological factors affecting demographic and sociological groups of people.

4. Conclusions

Currently, the development of sustainable consumption is of great importance, which assumes meeting the needs of society and raising its standard of living while maintaining an optimal and responsible level of consumption of natural resources. The topic of sustainable consumption is often discussed nowadays due to decreasing natural resources. The main goal of producers and consumers has become to get more with the least possible consumption. Sustainable consumption aims to reduce waste, especially food, reduce pollution levels and meet needs in such a way that future generations can also benefit from natural resources.

The decisions that households make regarding the selection of goods to meet their needs depend, as noted in the article, on many factors. Their number is very large and their impact is complex and changes over time. These include economic, demographic and social factors. The most important economic factors determining household expenses include income, which determines primarily the size and structure of expenses. Another factor influencing household spending decisions is commodity prices. Demographic factors, classified by some authors as non-economic factors, are: age, gender, family size and structure, and its developmental stage. Social factors include the education of the head of the family, the socio-economic group, the size of the city in which the family lives and the region.

Nowadays, sustainable consumption is a very important element of sustainable development, the aim of which is to improve the education of societies in the field of sustainable consumption and production. More and more actions are being taken to limit the spread of consumerism and start thinking in line with the idea of sustainable consumption. The problem is on a global scale, there are many places in the world where there is a problem with providing food, but there are also many places where there is too much food and it is wasted. Excessive consumption leads to a number of effects, the most important of which is excessive consumption of natural resources and thus the degradation of the natural environment.

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Appendix

Table 1.

Selected statistical characteristics of demographic variables of the average number of people in a household in the years 1994-2022

Type of household	Value					
	Min	Max	Range	Mean	Standard deviation	Coefficient of variation [%]
Total	2.66	3.24	0.58	2.99	0.189	6.32
Working together	3.09	3.59	0.50	3.38	0.146	4.32
Working class	3.30	3.82	0.52	3.64	0.139	3.82
Non-working class	2.87	3.27	0.40	3.06	0.119	3.89
Farmers	3.77	4.39	0.62	4.16	0.164	3.94
Self-employment	3.19	3.89	0.70	3.49	0.235	6.81
Pensioners and annuitants	1.85	2.28	0.43	2.11	0.141	6.68
Pensioners*	1.88	2.20	0.32	2.07	0.104	5.02
Annuitants*	1.78	2.47	0.74	2.17	0.245	11.29

* Data separately for retirees and disability pensioners covered the years 1997-2022.

Source: own study based on Central Statistical Office data.

Table 2.

Parameter estimates and statistical characteristics of the average number of people in a household

Type of household	Model parameters					
	a ₀	t(a ₀)	a ₁	t(a ₁)	Se	R ²
Total	3.32	222.80	-0.026	25.15	0.035	0.966
Working together	3.62	153.43	-0.019	11.56	0.056	0.859
Working class	3.84	115.58	-0.016	7.06	0.079	0.694
Non-working class	3.26	265.57	-0.016	18.95	0.029	0.942
Farmers	4.36	84.20	-0.016	4.38	0.123	0.466
Self-employment	3.90	271.08	-0.032	32.69	0.034	0.980
Pensioners and annuitants	2.32	70.68	-0.017	7.26	0.078	0.706
Pensioners*	2.22	86.09	-0.014	6.91	0.057	0.715
Annuitants*	2.57	58.45	-0.036	10.40	0.097	0.851

* Data separately for retirees and disability pensioners covered the years 1997-2022.

Source: own study based on Central Statistical Office data.

Table 3.

Selected statistical characteristics of demographic variables of the average number of consumption units in a household in the years 1994-2022

Type of household	Value					
	Min	Max	Range	Mean	Standard deviation	Coefficient of variation [%]
Total	2.26	2.68	0.42	2.52	0.139	5.52
Working together	2.57	2.52	0.35	2.80	0.104	3.71
Working class	2.76	3.15	0.39	3.00	0.091	3.03
Non-working class	2.38	2.69	0.31	2.55	0.100	3.92
Farmers	2.23	3.66	0.43	3.47	0.107	3.08
Self-employment	2.63	3.13	0.50	2.87	0.173	6.02
Pensioners and annuitants	1.70	2.02	0.32	1.88	0.109	5.79
Pensioners*	1.70	1.97	0.27	1.86	0.087	4.67
Annuitants*	1.53	2.14	0.61	1.89	0.201	10.63

* Data separately for retirees and disability pensioners covered the years 1997-2022.

Source: own study based on Central Statistical Office data.

Table 4.

Parameter estimates and statistical characteristics of the average number of consumption units in a household

Type of household	Model parameters					
	a_0	$t_{(a_0)}$	a_1	$t_{(a_1)}$	Se	R^2
Total	2.76	173.84	- 0.019	17.06	0.038	0.930
Working together	2.96	129.74	- 0.013	7.91	0.054	0.740
Working class	3.10	102.12	- 0.008	3.84	0.072	0.401
Non-working class	2.72	197.42	- 0.014	14.01	0.033	0.899
Farmers	3.52	80.16	- 0.004	1.46	0.104	0.088
Self-employment	3.17	356.94	- 0.024	39.13	0.021	0.986
Pensioners and annuitants	2.04	71.84	- 0.013	6.39	0.067	0.650
Pensioners*	1.99	89.69	- 0.012	6.59	0.049	0.696
Annuitants*	2.22	58.76	- 0.030	9.87	0.083	0.837

* Data separately for retirees and disability pensioners covered the years 1997-2022.

Source: own study based on Central Statistical Office data.

THE INFLUENCE OF E-LEADERSHIP ON PRODUCTS AND SERVICES QUALITY AND ORGANIZATIONAL PERFORMANCE DURING BLACK SWAN EVENT

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Purpose: The COVID-19 pandemic has dramatically transformed global organizational operations, necessitating a reevaluation of leadership paradigms due to the challenges to business continuity posed by this Black Swan event. With the shift to remote work, the focus on e-leadership has become crucial. The aim of this study is to examine the impact of e-leadership on organizational performance, specifically through product and service quality, and to explore how the severity of such crises might affect this relationship.

Design/methodology/approach: During the active phase of the COVID-19 pandemic in Q1 2021, a survey encompassed 1160 organizations across Poland, Italy, and the USA. Higher-level managers from each organization provided responses using the CAWI method. Variables explored included e-leadership, product and service quality (PSQ), organizational performance, and COVID-19 crisis severity. The moderated mediation model was constructed using the Macro Process for IBM SPSS. The study deployed r-Pearson correlation analysis, mediation, and moderation analyses, contextualized by COVID-19 severity.

Findings: The study revealed a statistically significant correlation among e-leadership, product and service quality and organizational performance. Specifically, a robust link was identified between PSQ and organizational performance. Mediation analysis confirmed that PSQ serves as a significant mediator in the relationship between e-leadership and organizational performance. Furthermore, COVID-19 crisis severity emerged as a significant moderator, intensifying the positive impact of e-leadership on organizational performance via PSQ.

Research limitations/implications: While the study's focus on COVID-19 presents certain limitations, it sets the stage for future research, urging exploration of e-leadership's significance across varied crisis scenarios to determine its consistent relevance in modern organizational frameworks.

Originality/value: This study underlines e-leadership's crucial role in navigating organizational challenges during Black Swan events, with a spotlight on the COVID-19 pandemic. Contributing uniquely to crisis management literature, it emphasizes the increasing importance of e-leadership in the era of digital transformation.

Keywords: e-leadership, product and service quality, organizational performance, Black Swan event, COVID-19.

Category of the paper: Research paper.

1. Introduction

The COVID-19 pandemic suddenly and significantly changed the way organizations operate in the modern global economy. Ensuring business continuity in the turbulent environment, caused by the Black Swan event necessitated the reevaluation of all aspects related to management (Han et al., 2022; Tworek et al., 2023). Previous scientific reports clearly indicate the importance of leadership in the operation and achievement of results in an organization, but the intensity of changes that occurred during this significant crisis require reconsideration of the phenomena that have raised hitherto (Garretsen et al., 2022). Moreover, in order to stop the spread of contamination, the geographical distribution of employees previously working together has fundamentally changed - a significant part of the activities carried out has been moved to remote mode (Bieńkowska et al., 2022).

The current research results show that scientists consider the issue of e-leadership to be particularly important during the COVID-19 pandemic, and also emphasize that there is a key need for effective leadership in any crisis caused by Black Swan event (Chamakiotis et al., 2021). According to Gilson and colleagues (2014), the role of e-leadership is crucial in times of disruptive events, not only because of the unique impact it has on how employees cope with immediate obstacles, but also because it will ultimately prepare them in the long term to respond to the turbulent changes occurring in the worldwide. Moreover, the impact of e-leadership is not only visible as the impression on employees, but also as the reaction in the environment.

Simultaneously, the emphasis on maintaining high service and product quality becomes especially crucial in today's highly competitive business landscape, where customer expectations are continuously evolving, and market dynamics are subject to rapid changes (Dahlgaard et al., 2019). While the significance of service and product quality has long been recognized as fundamental to organizational success (e.g. Khan, 2011; Sabella et al., 2014; Silva et al., 2021), the direct relationship between e-leadership and these quality aspects remains notably under-explored in empirical research. Despite its acknowledged importance in quality management, the scarcity of studies specifically investigating this relationship highlights a significant gap in the literature. This gap is particularly relevant given the rapid evolution of digitalization in leadership and its potential to significantly influence service and product quality (Sharma et al., 2023).

Therefore, the main aim of the article is to verify the mechanism of e-leadership influence on organizational performance through products and services quality and establish whether the severity of crisis caused by Black Swan event boosts such influence. Such aim will be fulfilled using critical literature analysis, which will be a basis for hypotheses development and using empirical study in order to verify the proposed hypotheses.

2. Theoretical discussion and hypothesis development

2.1. E-leadership

The traditional role of leadership has been the subject of many studies and seems to be well established in the literature (Karakitapoğlu-Aygün et al., 2023; Lin et al., 2023; Northouse, 2019; Oc et al., 2023; Wang et al., 2023). However, the changes in the environment, both the dynamic development of information and communication technologies and unexpected interruptions, such as the crisis caused by the black swan event, i.e. the COVID-19 pandemic, resulted in the emergence of the issue of managing virtual teams in addition to the classic approach to leadership. The consequence of this phenomenon was the increased interest in the issue of e-leadership both among practitioners and researchers (Avolio, Kahai, 2003; Cortellazzo et al., 2019). There is no doubt that the issues of leadership differ in relation to employees located physically and dispersed, connected only online (Chamakiotis et al., 2021). First of all, working based on technology requires a leader to ensure a completely different level of its delivery and security than in the case of teams operating traditionally. Second of all, it is necessary to properly select team members, taking into account not only substantive skills and knowledge, but also efficient use of IT tools. Finally, virtual teams require a different approach to management - for example, get better results when the leader acts as a mentor and the tasks and responsibilities associated with them are delegated (Ale Ebrahim et al., 2009; Avolio, Kahai, 2003; Kayworth, Leidner, 2015). Therefore, it seems necessary to develop new leadership practices that will allow for the sustainable development of teams working remotely, as well as ensuring the continuity of the organization's operation (Contreras et al., 2020). This is particularly important because remote work is expected to be implemented in the regular functioning of the organization (Benitez et al., 2022; Carnevale, Hatak, 2020) and, consequently, the need for managerial training in the field of leadership of virtual teams appears (Larson, DeChurch, 2020). In addition, it is believed that remote employees are more difficult to lead than face-to-face ones (Nunamaker et al., 2009). This is by cause of the problems that the studies have highlighted as characteristic of employees connected online - their interpersonal relationships disorders, lack of social contacts, lack of trust in superiors and colleagues, insufficient skills in using IT tools and data overload (Van Wart et al., 2017).

Considering the above, there are many challenges faced by e-leaders. Due to the almost unlimited possibilities of recruiting from human resources around the world, working in a remote environment is characterized by the fact that employees can work regardless of organizational boundaries, geographic location or time zones (Lilian, 2014). Employees may also belong to different cultures, speak different languages, have special needs, have different communication practices, share different values, and interpret symbols in different ways (Asatiani et al., 2021).

The role of e-leadership in the above context seems to be very important. The e-leader's task is to prepare a psychologically safe space in which employees can feel good, and consequently will be willing to overcome the difficulties that arise in online work (Gibson et al., 2014). It is within the leader's scope of decision making process to select work tools, including IT tools, which may cause negative consequences. One of threatening results that can be observed among employees is technostress. The growing body of literature in this area has led to conclusions that technostress negatively affects people in organization, their well-being, engagement, and consequently job performance (Tuan, 2022; Wu et al., 2022). Also due to the fact that the nature of work nowadays has changed – possibility of performing duties outside the organization, flexible working hours, blurring of the boundaries between work and private time - makes it necessary to provide employees with work-life balance and well-being while working remotely (Chamakiotis et al., 2021). In addition, numerous researchers have investigated the important role of trust in managing virtual teams, which is mentioned among the features of an effective e-leader (Zander et al., 2013). All the indicated activities aimed at leading to success by organizations could not occur without the communication skills possessed by the e-leader, of course with the use of information and communication technologies (Lilian, 2014). However, it cannot be forgotten that despite the online connection of the leader and employees, certain issues traditionally related to leadership remain unchanged. Setting goals, inspiring, feedback or motivating are issues that still need to be considered when managing remote employees (Lilian, 2014).

Bearing in mind the complexity of issues related to leadership, Roman and colleagues decided that it was necessary to develop The Six E-Competency (SEC) Model. According to the authors, it is extremely important for the success of virtual team management that the leader has e-communication skills, e-social skills, e-change management skills, e-tech savvy, e-team skills, and e-trustworthiness. E-communication skills are related to the ability to communicate using information and communication technologies in such a way as to avoid errors and mistakes in the transmission of content, as well as to manage information in an orderly and clear manner. E-social skills are related to the ability to create a friendly and creative online environment that supports cooperation between employees. E-change management, in turn, is the ability to effectively manage change when implementing processes remotely. E-tech savvy is related to the leader's possessed and updated knowledge in the use of information and communication technologies. E-team skills is the ability to manage a virtual

team. They are related to the competence in creating, building and maintaining a team. Finally, e-trustworthiness is the ability to ensure employees, through information and communication technologies, that leader is trustworthy, honest and can be relied on (Roman et al., 2019).

2.2. E-leadership influence on organizational performance through service and product quality

2.2.1. E-leadership and organizational performance

It is common knowledge that management is responsible for ensuring appropriate working conditions for employees who, in a joint effort, will ensure the survival, competitiveness and performance of the organization (Kulshreshtha, Sharma, 2021). The reports of previous research clearly indicate that e-leadership is an important factor influencing the performance of virtual teams, and even a prerequisite for their success (Chamakiotis et al., 2021; Contreras et al., 2020). Larson and DeChurch (2020) assume that the change of work to one that uses information and communication technologies will increase the role of leadership in achieving results by virtual teams in various terms (Larson, DeChurch, 2020).

In research conducted by Gallenkamp et colleagues (2011), it was noted that trust in leaders of virtual groups, which is an important part of the e-leadership construct, has a positive effect on group performance. On the other hand, reports provided by Cascio & Shurygailo (2008) prove that low levels of trust result in low team productivity. Communication as part of e-leadership is also considered in many studies in the context of performance. Duarte and Snyder (2001) in their research discuss the impact of feedback from the team leader on virtual team performance, which in turn translates into organizational performance. On the other hand, Geister et al. (2006) argues that it is necessary to secure team communication on a regular basis, especially task oriented one to ensure performance. Also Fernandez and Jawadi (2015) point to an important problem in this regard. In the conducted research, it turned out that teams working remotely have a lower performance compared to traditionally working teams, especially for knowledge-intensive tasks. Therefore, the role of an e-leader in proper knowledge management cannot be overestimated.

Other studies have also found a positive relationship between leadership in the context of virtual teams and performance. These reports specifically focused on transactional leadership (Purvanova, Bono, 2009). Therefore, considering the variety of reports in this area, both taking into account various aspects of e-leadership, as well as a comprehensive approach to the phenomenon, it can be concluded that there are dependencies between e-leadership and organizational performance.

2.2.2. E-leadership and service and product quality

In the context of quality management, leadership plays a crucial role in ensuring that quality standards for products and services are met, maintained, and continuously improved (Silva et al., 2021; Teoman, Ulengin, 2018). Leadership holds a central position among the seven

quality management principles, underscoring its pivotal role in driving the organization's commitment to quality and continuous improvement (ISO 9001:2015). Leaders are the first to apply the quality focus and their role is crucial in motivating employees in assimilating its principles (Kaminski et al., 2012). Their firm commitment to these principles serves as a guide for the entire organization, fostering a culture of excellence (Javed, 2015). By leading by example and instilling a shared vision of quality, leaders not only motivate employees but also ensure the alignment of organizational goals with quality objectives, leading to enhanced customer satisfaction, loyalty and overall organizational performance (Hoe, Mansori, 2018; Kaynak, 2003; Khan, 2011; Sabella et al., 2014).

The significance of service and product quality has been widely recognized and acknowledged for years, making it a fundamental aspect of organizational success (Agus, 2005; Gorla et al., 2010; Ramayah et al., 2011). Service quality encompasses factors such as responsiveness, reliability, and assurance in the delivery of services (Parasuraman et al., 1985), while product quality pertains to the attributes, features, and performance of goods (Garvin, 1984). In both cases, quality signifies the ability to consistently meet defined standards and meet or exceed customer needs and expectations. The goals of quality management encompass multiple dimensions, with one of them being the optimization of organizational processes and resources to ensure the production of high-quality products and services (Tari et al., 2007).

Although the importance of leadership in quality management is well recognized, there remains a notable scarcity of empirical or quantitative research investigating the direct relationship between e-leadership and service and product quality. Among the few existing studies, we emphasize several contributions. Desmaryani et al. (2022) conducted a study on e-leadership and service quality in higher education. They found that digital leadership significantly impacts the quality of the e-learning system. Universities with effective digital leadership demonstrate higher-quality e-learning systems. In another study, Nasution and Muhammad (2023) emphasized the vital significance of digital leadership within the National Police context, highlighting that digital leadership plays a critical role in driving transformation and enhancing the quality of services delivered to the community.

A considerable number of studies adopt an indirect approach to investigate the relationship between e-leadership and quality outcomes. These studies mainly focus on the aspects of the integration of information and communication technologies in decision-making processes within the domain of leadership. In their respective recent studies, Basu et al. (2023) highlights that the integration of AI technologies in human resource management enables organizations to achieve heightened efficiency, subsequently exerting a positive influence on the overall quality of products and services. Mariani et al. (2023) support this notion by emphasizing that the implementation of AI systems supporting decision-making processes enhance product quality. Furthermore, Pérez-Aróstegui et al. (2015) shed light on a crucial aspect of leadership by highlighting the role of IT competences in facilitating effective communication of quality values between top management and employees. Li et al. (2016) emphasized that the utilization

of IT in leadership confers advantages in enhancing service quality through improved responsiveness.

2.2.3. E-leadership, service and product quality and organizational performance

The literature extensively supports the well-established interplay between organizational performance and service and product quality. Numerous studies have explored and demonstrated the impact that the quality of services and products can have on an organization's overall performance (e.g. Kaynak, 2003; Khan, 2011; Silva et al., 2021; Teoman, Ulengin, 2018). Organizations that consistently offer high-quality products and services not only encourage customer satisfaction and loyalty (Chen et al., 2019; Fernandes, 2018; Hoe, Mansori, 2018; Naini et al., 2022; Ngo, Nguyen, 2016; Tan et al., 2016) but also solidify their market reputation and competitive stance (Fernandes, 2018; Hapsari et al., 2017; Ruckert, Rao, 1994; Sabella et al., 2014). As a result, these organizations are more likely to achieve higher levels of productivity (Choi et al., 2015; Rew et al., 2018) and profitability (Ali et al., 2021; Myrodia et al., 2017) in their respective industries.

The high quality of products and services can often be traced back to effective and diligent quality management initiatives (Rönnbäck, Witell, 2008). Within these practices, leaders emerge as pivotal figures, championing initiatives centered on quality and fostering a commitment to ongoing improvement (Hoe, Mansori, 2018; Kaynak, 2003; Khan, 2011; Sabella et al., 2014; Nguyen, 2023). E-leaders, with their digital-centric approach, not only steer digital endeavors but also shape an organization's broader innovative spirit (Li et al., 2016). Weill and Ross (2009) underscore the significance of digital platforms in this scenario, characterizing them as 'an integrated set of electronic business processes and the technologies applications, and data supporting those processes' (p. 4). Such platforms give e-leaders the means to enhance innovation, manage cost, and reinforce stakeholder relationships, ultimately improving the quality of products and services (p. 16). This viewpoint finds backing from Zutshi and Grilo (2019), who contend that the adoption of digital platforms in management paves the way for innovative business paradigms and refined quality assurance strategies. Zhang and Cao (2023) also expand on these views, positing that digital platforms serve as potent tools, empowering leaders and other stakeholders to engage effectively with customers and, in turn, motivating them to enhance product quality.

Given the above, it can be concluded that e-leadership, in the era of digital transformation, holds the dual responsibility of navigating the technological landscape and ensuring service and product excellence. By influencing the quality of services and products, e-leadership indirectly charts the trajectory of an organization's performance. Building on this foundation, the study introduces the following hypothesis:

H1: E-leadership is positively influencing organizational performance through the quality of services and products.

2.3. COVID-19 severity as a booster of the relation between e-leadership and service and product quality

The outbreak of the COVID-19 pandemic brought a compelling need for organizations to adapt and pivot towards digital frameworks. This shift demanded more than just transferring operations online; it necessitated a cohesive, strategic, and robust digital leadership approach to ensure that service and product quality remained uncompromised.

In the literature, several studies from different industries indicate that introducing digital leadership in times of pandemic serves as a booster for achieving high service and product quality. Hamzah et al. (2021), focusing on the education industry, highlight that the availability of digital learning opportunities and the establishment of vibrant digital learning communities stand as crucial markers of teaching excellence. For school leaders, it becomes crucial to facilitate professional development programs, empowering teachers with hands-on skills while enhancing their digital teaching practices. Such initiatives not only foster teachers' confidence but also amplify the quality and effectiveness of the educational system. Drawing parallels in the education sector, Sujaya (2022) suggests that when organizational leaders adeptly implement digital leadership tactics within their teams, educational bodies are better positioned to adapt, innovate, and remain true to their core visions and objectives. E-leadership influence improvements in school performance and student achievements, resulting in enhanced service quality.

In the healthcare industry effective leadership has one of the most important impact on the quality results i.e. patient satisfaction and reduction of adverse effects (Sfantou et al., 2017). The positive relationship between leadership and service quality is even stronger in time of crisis such as the COVID-19 pandemic (Joniaková et al., 2021). It necessities the utility of digital technologies, which are often expected to improve the quality of care and operational efficiency by facilitating clinical and administrative tasks linked to the assessment, transmission, evaluation, and precision of medical treatment (Kraus et al., 2021). Oleksa-Marewska and Tokar (2022) have identified a correlation between proficient digital leadership and improved employee well-being. Digital technology-driven healthcare organizations have reported enhanced employee satisfaction through increased flexibility and balance between work and life, which translates into higher quality of healthcare delivery and increased patient satisfaction (Wiener et al., 2021). Digital leadership's adoption, coupled with remote work paradigms, has catalyzed healthcare service quality enhancement through various means, including consistent service provision, enhanced flexibility, and streamlined administrative processes (Garavand et al., 2022; Kraus et al., 2021). Narayanamurthy and Tortorella (2021) delve deeper into this area, concluding that remote work in service organizations contributes to increasing productivity, job satisfaction and output quality.

In a broader perspective, Susilawati et al. (2021) emphasize the role of e-leadership in public services during the pandemic era. Their research illustrates how leadership has become connected with the use of information technology, especially in contexts where health protocols

and restrictions limit physical contact. The study underscores the essential role of digital tools in preserving, and even enhancing, public service performance in the absence of direct physical interactions. When organizations adeptly transition to a virtual communication framework, they are positioned to significantly enhance service quality.

A literature review revealed that the severity of the COVID-19 pandemic underscored the pivotal role of e-leadership in upholding and enhancing the commitment to quality. As the world gradually moves into the post-pandemic phase, the imprints and lessons of this era promise to influence the evolution and significance of e-leadership in the future. In light of the foregoing discussion, the following hypotheses were formulated:

H2: COVID-19 crisis severity boosts the positive influence of e-leadership on organizational performance through the quality of services and products.

The hypotheses are presented in the Figure 1.

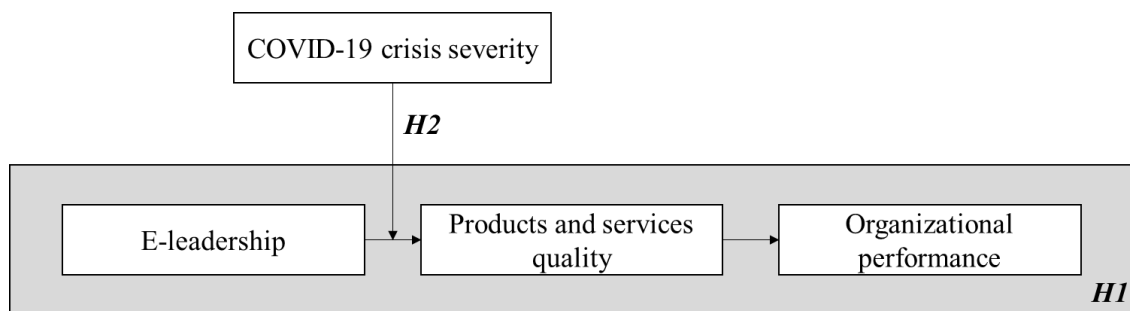


Figure 1. Hypotheses development.

Source: own elaboration.

3. Research methodology

The proposed theoretical model (Figure 1) was verified based on empirical research, which was funded by National Science Center in Poland by grant No. 2020/37/B/HS4/00130 titled “Development of the Job Performance model based on Employees' Dynamic Capabilities for various phases of crisis in organization”. A pilot study was initially conducted to assess the quality of the research tool proposed, followed by empirical research to test the proposed hypotheses. The pilot study involved 25 managers who acted as competent judges, and their feedback was used to refine the research tool for the main stage of the study. The questions that were not well understood were rewritten, and steps were taken to prevent any common method bias. The main survey was carried out in the first quarter of 2021 amid the COVID-19 pandemic's active wave, among 1160 organizations operating in Poland, Italy, and the USA. A single survey was completed by a higher-level manager in each organization using a purchased panel of respondents, and data were collected using the CAWI method. Table 1 provides information on the sample used for the empirical research.

Table 1.
Sample description

Country	Not in crisis	In crisis	Total
Poland	83	343	426
USA	95	406	501
Italy	45	188	233
Total	223	937	1160

Source: own elaboration.

3.1. Variables

To allow verification of hypotheses the following variables were used: e-leadership, products and services quality, organizational performance and COVID-19 crisis severity.

E-leadership: variable assessed on a 5 points' Likert scale (1: I strongly disagree to 5: I strongly agree) using 6 items concerning e-communication skills, e-social skills, e-change management skills, e-tech savvy, e-team skills, and e-trustworthiness (Roman et al., 2019).

Products and services quality (PSQ): variable assessed on a 5 points' Likert scale (1: I strongly disagree to 5: I strongly agree) using 1 item (Kaplan, Norton, 1996).

Organizational performance: variable assessed on a 5 points' Likert scale (1: I strongly disagree to 5: I strongly agree) using 10 items based on Balances Scorecard concept (Kaplan, Norton, 1996).

COVID-19 crisis severity: one item questions concerning the level of severity of COVID-19 crisis.

Table 2.
Variables overview

Variable	No of items	Alpha Cronbach	AVE (CFA)
Organizational performance	10	0.886	0.494
PSQ	1	-	-
E-leadership	9	0.843	0.568

Source: own elaboration.

To determine the suitability of the scales for the study, Cronbach's α and Factor Analysis were conducted and are presented in Table 2. Given that the scales used were previously validated by their creators, this approach appeared adequate. To avoid any potential common method bias, a systematic method variance control was employed. Based on the results obtained, it can be concluded that nearly all of the measurement scales were well-suited, reliable, and internally consistent.

3.2. Mediation analysis

In order to verify the hypotheses, the moderated mediation model was developed using Macro Process for IBM SPSS (model 7). Based on that, first the mediation analysis and then – moderation analysis – were performed.

First of all, the mediation analysis was performed. Saks (2006) identifies three conditions, which must be confirmed in order to establish mediation model. To determine whether a mediator affects the relationship between two variables, there are three criteria that must be met. Firstly, there should be a correlation between the mediator and the independent variables. Secondly, there should also be a correlation between the mediator and the dependent variables. Finally, when the mediator is controlled for, any significant relationship between the independent and dependent variables should either be reduced (partial mediation) or completely disappear (full mediation).

Therefore, first of all, the r-Pearson correlation analysis was performed in order to verify the first two conditions stipulated by Saks (2006).

Table 3.
Correlation analysis between analyzed variables

		E-Leadership	PSQ	OrgPerf
E-Leadership	r-Pearson	1	,079**	,160**
	p		,007	<,001
	N	1197	1181	1148
PSQ	r-Pearson	,079**	1	,710**
	p	,007		<,001
	N	1181	1205	1171
OrgPerf	r-Pearson	,160**	,710**	1
	p	<,001	<,001	
	N	1148	1171	1171

Source: own elaboration.

The obtained results, which are presented in Table 3, clearly show that there is a statistically significant correlation between the analyzed variables. The highest correlation occurs in case of the relation between PSQ and organizational performance. It allows for the implementation of further steps on the road of verification of mediation model. To achieve this, a moderated mediation model was created using Process Macro for IBM SPSS to examine the relation between the e-leadership (independent variable) and organizational performance (dependent variable). In this model, PSQ was tested as the mediator to verify hypothesis H1. The aim was to obtain a statistically significant regression model where the moderated mediation effect occurs and is statistically significant. It was not enough to analyze the mediation separately from the moderation, as the proposed set of hypotheses concerns the moderated mediation. That is why the mediation occurring in the model should be analyzed in the context of assumed moderation (using model 7 from Process Macro in IBM SPSS). The results of the analysis of mediation can be found in Table 4.

Table 4.*PSQ as the mediator of the relation between e-leadership and organizational performance*

Mediator	Direct effect value	Moderated mediation effect value	Boot LLCI	Boot ULCI	R2
Products and service quality	0,1328	0,1027	0,0526	0,1522	0,510

Source: own elaboration.

The results show that the moderated mediation model is statistically significant and well-fitted ($F(2,1143) = 595,0643$ and corrected $R^2 = 0,510$). Moreover, from the point of view of verification of the mediation occurring within the model, it should be stated that PSQ is a statistically significant mediator of the model ($p < 0,001$, coeff. = 0,478, se = 0,014). It is important to underline that the mediating effect is statistically significant. Therefore, the obtained model shows that PSQ is indeed a mediator of the relation between e-leadership and organizational performance, which allows to accept H1 hypothesis stating that **e-leadership is positively influencing organizational performance through the quality of services and products.**

3.3. Moderation analysis

Second of all, the moderation analysis was performed. The mediation model was analyzed in the context of covid-19 severity to verify the statistical significance of it as moderator of the relation between e-leadership and organizational performance, mediated by PSQ. The hypotheses H2 was tested using the moderated mediation model, testing the following relation: covid-19 severity as the moderators of the relation between e-leadership and PSQ. In order to do so, a new variable - covid-19 severity - a moderator, was added to the relation. Three regression models were then created using the Process Macro for IBM SPSS. The first model was created as a base for comparison, with only independent variable used as predictor. The second model used both the independent variable and the moderator as predictors. The objective was to examine whether the moderating influence was present in the entire sample, considering that the analyzed relation is a part of the mediation model, using model 7. To confirm it, the third model was introduced using moderator as the only predictor. The results of the analysis are presented in Table 5.

Table 5.*Regression models' statistics*

Model description	R ²	Delta R ²	Moderator coeff.	Standard error	t-stat	p
E-leadership, Covid-19 severity, Moderator <i>dependent v.: PSQ</i>	0,510	0,016	0,214	0,049	4,354	>0,001

Source: own elaboration.

Therefore, the moderated mediation model was the basis for two conclusions. First, already established, that the assumed mediation is statistically significant and occurring in the model. Second, the obtained results also show that *covid-19 severity* is a statistically significant moderator in case of the relation between e-leadership and PSQ within in the model (coeff. = 0,214; $p < 0,001$). Therefore, as Table 5 shows, the result allow to accept the H2 hypothesis, stating that **COVID-19 crisis severity boosts the positive influence of e-leadership on organizational performance through the quality of services and products.**

4. Discussion

The cognitive scope of the article was to determine the relationship between variables potentially influencing the aspect determining business continuity, i.e. organizational performance. The considerations took into account e-leadership, which is extremely important in managing contemporary organizations, as well as product and service quality - construct crucial not only for the organization, but also for the customer's. In addition, the impact of the factor that is one of the most important characteristics of the crisis caused by Black Swan event - COVID-19 severity - was taken into account. As a result, based on the conducted research, the theoretical model was built and empirically verified. It was confirmed that the products and service quality mediates the relation between e-leadership and organizational performance, as well as the COVID-19 severity moderates in the relation between e-leadership and products and service quality within those frames. The obtained model is well-fitted and the dependencies between the variables are statistically significant.

The previous considerations seem to be consistent with the existing research results, at the same time enriching the current state of knowledge. The crisis caused by the COVID pandemic required a change to the remote working mode, and this modification resulted in the need to use leadership solutions different than before (Bieńkowska et al., 2022; Zarghami, 2021). Therefore, even though the relationship between e-leadership and performance (from different perspectives, including organizational one) seems to be undoubted (Chatterjee et al., 2023), the whole issue is much more complex and it seemed advisable to include other aspects when examining this relationship. Benitez and colleagues (2022) discovered that digital leadership capability influences innovation performance, but this is not a direct connection, but through other variables. Chamakiotis and colleagues (2021) seem to agree with this statement. The researchers have noticed that there is a connection between e-leadership and creative performance, and there may be mediators in this relationship. The authors also emphasize how important it is to take into account the context of the COVID-19 crisis in performed analysis.

The above-mentioned scientific analyzes saw a mediating potential between constructs related mainly to the characteristics of employees, but it seemed worth including in the considerations a more broad issue related to the organization, employees, but also to the market, i.e. product and service quality. This is particularly important from the point of view of the financial and non-financial success of the organization, because consumer behavior, especially in the context of purchasing decisions, implies the further operation of the entity in the economic space. Thus, product and service quality was included as a mediator between e-leadership and organizational performance. AlAjmi (2022) seems to agree with this statement, by noting the relationship between digital leadership and the quality of services among teachers. On the other hand, especially in customer focus oriented organizations, the impact of quality assurance activities on performance is visible (Mar Fuentes-Fuentes et al., 2004).

Taking all of the above into account, it should be emphasized that it must not be forgotten how severe the crisis affecting the organization is. Actions taken by individuals, including decision-making processes, but also preventive and corrective activities, depend on how the crisis is perceived (Trkman et al., 2021).

5. Conclusions

The main aim of the article was to verify the mechanism of e-leadership influence on organizational performance through products and services quality and establish whether the severity of crisis caused by Black Swan event boosts such influence. Such aim was fulfilled using critical literature analysis, which will be a basis for hypotheses development and using empirical study in order to verify the proposed hypotheses.

The literature analysis allowed to establish that e-leadership has the potential to influence organizational performance through products and services quality. However, what's more important, Black Swan events have been established as the source of positive influence on organization in this manner, boosting the positive influence of e-leadership on products and services quality and underlining the role of information technology support for organizations. The empirical research conducted among 1160 organizations operating in Poland, Italy and USA in 2021 confirmed the proposed hypotheses and allowed to verify that COVID-19 (used as the example of Black Swan event) indeed boosted the positive effect of e-leadership on organizational performance through products and services quality. Therefore, the article offers the contribution to management sciences, especially in the field of crisis management, showing the importance of e-leadership in maintaining and obtaining sufficient organizational performance during crisis caused by Black Swan event.

There are some limitations of the study. One of the biggest ones is connected to the fact of using COVID-19 as the example of Black Swan event. Due to its specific characteristic and the need for rising dependence on information technologies, it is clear that e-leadership has a rising role in organizations operating under such conditions. The verification based on such an example does not necessarily mean that the established influences will take place under condition of crisis caused by different Black Swan event. However, the obtained results allow to formulate a crucial conclusion for organizations operating under the COVID-19 crisis and after it. They also allow to indicate the future direction of research – verification of the established relations under condition of crises caused by different Black Swan events, in order to establish whether e-leadership will keep its importance for contemporary organizations regardless of the type of crisis.

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TALENT MANAGEMENT IN THE ERA OF THE FOURTH INDUSTRIAL REVOLUTION

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Purpose: The purpose of this article is to identify the trends and interests of researchers in the area of talent management in the era of the fourth industrial revolution.

Design/methodology/approach: The achievements and results presented in the article were obtained from bibliometric studies conducted in the Web of Science and Scopus databases. The study used dynamic literature analysis and knowledge visualization. semantic maps of keywords were created to identify the topics and context in which the research deals with skills, competencies and talent management. VoSviewer software (version 1.6.16) was used to create the semantic maps.

Findings: The results obtained in the bibliometric survey confirm that the interest of researchers, from all over the world, concerning the fourth industrial revolution is constantly growing. In the Web of science and Scopus databases, publications on this topic continue to increase, but the vast majority of them are devoted to technology, digitization and digitalization, thus topics relevant to building the technical architecture of the business model. A clear research gap was identified in the area of the social architecture of the business model, of which talent management is a component. Semantic keyword maps were created to identify the topics and context in which the research deals with talent management in the era of the fourth industrial revolution.

Research limitations/implications: The literature analysis was narrowed to peer-reviewed articles published in English, indexed in the Web of Science and Scopus databases, which is a limitation of the study.

Originality/value: Original achievements obtained during the research include obtaining valuable research results on key areas linking talent management and the fourth industrial revolution.

Keywords: talent management, Fourth Industry Revolution, business model.

Category of the paper: research paper.

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1. Introduction

The fourth industrial revolution raises numerous opportunities and possibilities for today's businesses, but also daunting challenges. It is most often seen as a technological change, which is wrong, as it is also a social and economic change brought about by digital transformation. It can be defined as an age in which modern technological solutions shape the industrial environment and affect the economy and society, intensifying the sustainable development of the world (Grabowska, 2021). The Fourth Industrial Revolution refers to the social, industrial and technological changes brought about by the digital transformation of industry, which are identified with the concept of Industry 4.0 (Adamik et al., 2023).

Industry 4.0 is essentially a trend toward automation and data exchange in manufacturing technologies and processes that include Cyber Physical Systems (CPS), Internet of Things (IoT), Cloud Computing, Cognitive Computing and Artificial Intelligence (Alvarez-Aros et al., 2021; Cezarino et al., 2021). Industry 4.0 is a combination of ICT technologies and MES (Manufacturing Execution Systems), which allow for reduced planning and lead times and ongoing resolution of quality problems (Wang et al., 2023). Industry 4.0 is a change in the way production is controlled, including dynamic retooling of production resources initiated by information carried in workpieces. A smart factory requires broadband communication, both at the level of individual sensors, devices and actuators, as well as in wide-area network environments that integrate geographically distributed intelligent resources in real time (Saniuk et al., 2019). The application of modern technologies involves understanding their usability and the impact they can have on enterprise processes. Each Industry 4.0 technology is characterized by specific benefits. As pointed out by authors G. Tortorella, T. Saurin, P. Hines et al. (2023) Industry 4.0 with flexible production systems is expected to change the operating conditions of societies that are increasingly comfortable with cyber technology and are very aware of their needs and expectations.

The currently observed increase in the implementation of Industry 4.0 pillars and the focus of companies on dehumanizing production systems have caused numerous concerns among workers, the public and even governments. In Industry 4.0, the work environment is determined by integrated and advanced manufacturing technologies equipped with sensors that track machine operation and communication systems that report data and perform advanced simulations. The role of today's workers is very rarely mentioned, which has caused public concern and resulted in discussions on expanding the boundaries of Industry 4.0 to Industry 5.0 with due consideration for the role of humans in a company implementing Industry 4.0 technologies. The concept of Industry 5.0 involves the return of the human factor to industry, i.e. increased cooperation between humans and intelligent production systems. Combining the best of both worlds - the speed and accuracy guaranteed by automation with the cognitive skills and critical thinking of humans - ensures the success of Industry 5.0 (Yordanova, 2021, Doyle-

Kent, Kopacek, 2019). Industry 4.0 puts technology at the center, while Industry 5.0 focuses on production workers who see progressive automation as a threat to job loss. Industry 5.0 recognizes the power of technology for industrial (business) development, but combines the achievement of business goals with social goals in the workplace and beyond (social and environmental responsibility) (Ghobakhloo et al., 2023). Cyber-physical systems intertwined with social and environmental frameworks underpin the manufacturing process. Today, CPS operating in smart factories lead to economic growth and put people at the center of collaboration with smart resources and a more robust perception of sustainability (Sachsenmeier, 2016; Demir, Cicibas, 2017; Raja et al., 2023).

The Fourth Industrial Revolution, underpinned by the technologies of Industry 4.0 and the assumptions of Industry 5.0, is, like the previous three revolutions, a challenge for the economy and society as a whole. Academics are engaging in discussions as to the essence of the transformation, and specialized research centers and consulting firms are carrying out studies on various aspects of the implementation of Industry 4.0 technologies and their effects not only on consumers and society as a whole but also on the future labor market. French and British economists P. Aghion, C. Antonin, S. Bunel and X. Jaravel, have provided a new perspective on automation, arguing that its direct effect can be an increase in employment, not a reduction. In their view, automation can help a company become more profitable and thus grow, leading to an increase in employment. Technology can also allow companies to enter new business areas or focus on products and services that require more labor (Aghion et al., 2022).

The concept of Industry 4.0 and Industry 5.0 are a huge challenge for enterprises not only because of the application of modern technologies (such as the Internet of Things, Big Data Analytics, Cloud Computing, etc.) associated with the creation of Cyber-Physical Systems, but also for the development of human resources. As a result of this concept, changes in production organization and employment structure are observed, which may even lead to the use of new forms of knowledge and skills (Hecklau et al., 2017). New theoretical knowledge and practical skills of industrial workers and managers are expected. In a world determined by the pillars of Industry 4.0, talent management will be an important aspect of human resource management. Under the conditions of Industry 4.0, there is increasing talk of the need for talent management. It is understood as a strategic process involving the identification of employees distinguished by above-average abilities and the creation of an appropriate organizational culture conducive to the development of this group. The competitive advantage of enterprises' business models depends to a large extent on an appropriately selected workforce (Huang et al., 2022). However, the biggest limitation of enterprise transformation in line with the Industry 5.0 concept may be the lack of appropriately qualified personnel, the inability to adequately train employees, and the difficulty in attracting knowledgeable people to enterprises. At the same time, digital transformation will also force employers to create entirely new positions, including in areas such as innovation, security and management of sensitive data, or cooperation with customers and suppliers (Ivanov, 2022; Leng et al., 2022). There are a great many challenges

awaiting employers in the area of finding employees for Industry 5.0. Identifying these challenges became the imperative for conducting a bibliometric analysis aimed at identifying trends and interests of researchers in the area of talent management in the era of the fourth industrial revolution (this is also the purpose of the article).

2. Materials and methods

The study adopted the Dynamic Literature Linkage Analysis method introduced by C. Colicchia and F. Strozzi (2012), as it combines Systematic Literature Review (SLR) and analysis with visualization of the bibliographic network. The search for scientific publications was conducted using the Web of Science (WoS) core collection, a database provided by Clarivate Analytics, and Scopus, a database provided by Elsevier. According to the methodology adopted in the study, the following research stages were carried out: planning, implementation and reporting.

The subject of the analysis was to identify trends and research interests in the area of talent management in the era of the fourth industrial revolution. Identification of topic/research areas is a critical step in the analysis. Its results may change if different search phrases and criteria are used. The search was conducted on January 15, 2023 in the Web of Science and Scopus databases. All results obtained were exported to .ods, .bib, .txt files for further use using VOSviewer software. The defined research area was converted into phrases:

- (TS=("industry 4.0")) AND TS=(talent management)),
- (TS=("industry 5.0")) AND TS=(talent management)).

The above phrases, in the Web of Science database, were searched in the "Topic" category, including title, abstract, keywords defined by the author(s) and keywords plus (so-called "KeyWords Plus" - words and phrases extracted from the titles of cited articles, as defined in the Web of Science database). The Scopus database was searched for title, abstract and keywords defined by the author(s). The time range of the search from January 1, 2011 to December 31, 2022 was adopted. 2011 was set as the beginning of the search, this was dictated by the fact that it was in 2011 that a group of German experts introduced a strategy for industrial development based on smart technology called Industry 4.0, while the term Industry 5.0 officially began to be used in 2021. Thus, the search timeframe 2011-2022 includes works in the field of the fourth industrial revolution, which is formed by Industry 4.0 and Industry 5.0. The results obtained were further narrowed down to scientific, peer-reviewed articles published in English.

Research using bibliometric analysis applied knowledge visualization, which includes such issues as visualization of research results. Semantic maps of keywords were created to identify the topics and context in which the research deals with skills, competencies and talent management. VoSviewer software (version 1.6.16) was used to create the semantic maps.

3. Results and discussion

The topic area of talent management in connection with Industry 4.0 would be addressed by 125 researchers in the WoS database and 90 in the Scopus database. Researchers from 32 countries, representing 97 research centers, published 35 papers, which were published in 25 source titles and indexed in the WoS database. In contrast, in the Scopus database, 90 researchers from 18 countries, representing 51 research centers, published 26 papers that were published in 22 source titles.

Among the most active researchers in the WoS database are F. Aguayo-Gonzalez (2), M.J. A. Gutiérrez (2), M. Anshari (2); among the most popular titles are Mobile Information Systems (1), Sa Journal of Human Resource Management (1), Sensors (1); the countries from which the largest number of researchers come are England (5), China (5), Australia (4), India (4), South Africa (4); research centers to which the most papers are affiliated are Nottingham Trent University (2), Brunei Darussalam University (2), University of Johannesburg (2), University of Nottingham (2), University of Seville (2).

Among the most active researchers in the Scopus database are F. Aguayo-Gonzalez (2), M. Anshari (2), F. Aguayo-González (2); among the most popular titles are International Journal of Systematic Innovation (1), Journal of Legal Ethical And Regulatory Issues (1), Mobile Information Systems (1), SA Journal Of Human Resource Management (1), Sensors (1); the countries from which the largest number of researchers come are Malaysia (4), China (3), India (3), Indonesia (3), Spain (3); the research centers to which the largest number of papers are affiliated are National Taiwan University of Science and Technology (2), University of Seville (2), Brunei Darussalam University (2).

The topic of talent management in connection with Industry 5.0 was covered by 7 researchers in the WoS database and 14 in the Scopus database. Researchers from 3 countries, representing 4 research centers, published 3 papers, which were published in 3 source titles (Mobile Information Systems (1), Sa Journal of Human Resource Management (1), Sensors (1)) and indexed in the WoS database. On the other hand, in the Scopus database, researchers from 6 countries, representing 8 research centers, published 5 papers, which were published in 5 source titles (International Journal of Systematic Innovation (1), Journal of Legal Ethical And Regulatory Issues (1), Mobile Information Systems (1), SA Journal Of Human

Resource Management (1), Sensors (1)). Due to the small number of papers of this research area, at this point it is not yet possible to say which authors are leading.

Summarizing the analyses carried out, the basic statistics relating to the bibliometric database created for the research area "Talent Management" are presented in Table 1.

Table 1.

Basic bibliometric indicators of scientific articles from the research area "Talent Management"

Scientific articles from 2011 to 2022 from the field of research - talent management	Base Wos	Base Scopus
(TS=("industry 4.0")) AND TS=(talent management)		
Number of records	35	26
Number of researchers	125	90
Most active researchers	F. Aguayo-Gonzalez (2), M.J.A. Gutiérrez (2), M. Anshari (2)	F. Aguayo-Gonzalez (2), M. Anshari (2), F. Aguayo-González (2)
Number of source titles	25	22
Most popular source titles	Sa Journal of Human Resource Management (3), Applied Sciences (2), Energy Reports (2), Sustainability (2)	Sa Journal of Human Resource Management (3), Sustainability (2), Applied Sciences (2)
Number of countries	32	18
Countries from which the largest number of researchers come	England (5), China (5), Australia (4), India (4), South Africa (4)	Malaysia (4), China (3), India (3), Indonesia (3), Spain (3)
Number of research centers	97	51
Research centers to which most papers are affiliated	Nottingham Trent University (2), Brunei Darussalam University (2), Johannesburg University (2), Nottingham University (2), Sevilla University (2)	National Taiwan University of Science and Technology (2), Sevilla University (2), Brunei Darussalam University (2)
(TS=("industry 5.0")) AND TS=(talent management)		
Number of records	3	5
Number of researchers	7	14
Number of source titles	3	5
Most popular source titles	Mobile Information Systems (1), Sa Journal of Human Resource Management (1), Sensors (1)	International Journal of Systematic Innovation (1), Journal of Legal Ethical And Regulatory Issues (1), Mobile Information Systems (1), SA Journal Of Human Resource Management (1), Sensors (1)
Number of countries	3	6
Number of research centers	4	8

Source: own study.

Based on the results obtained by searching the WoS and Scopus databases, Figure 1 shows the growth dynamics of researchers' interest in the skills area in conjunction with Industry 4.0, while Figure 2 shows the growth dynamics of researchers' interest in the skills area in conjunction with Industry 5.0.

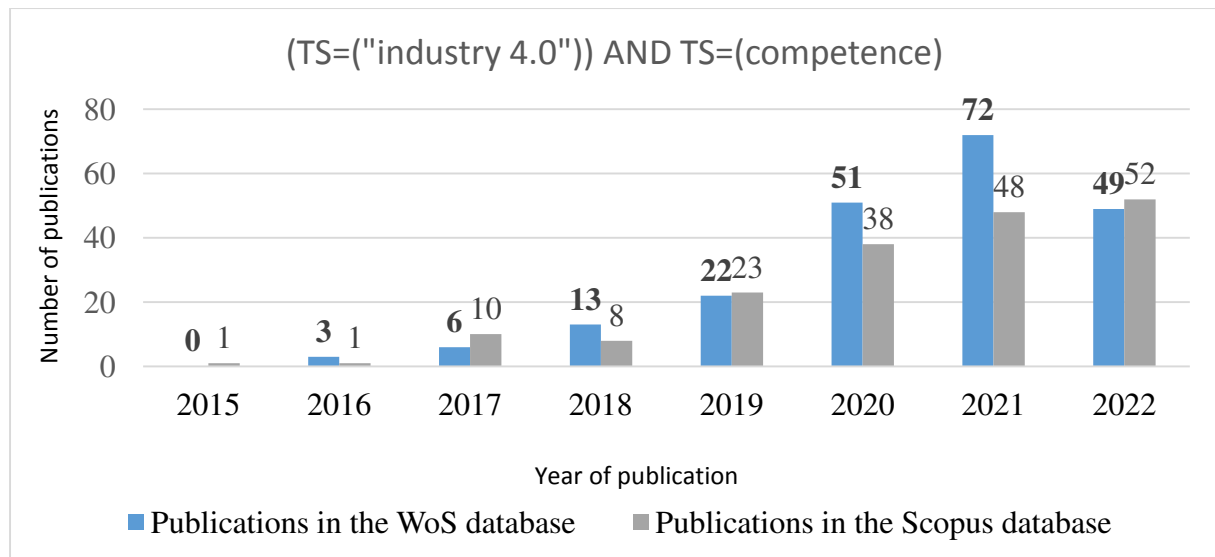


Figure 1. Growth rate of published articles in WoS and Scopus database from 2011 to 2022 for the phrase (TS=('industry 4.0')) AND TS=(talent management).

Source: own study.

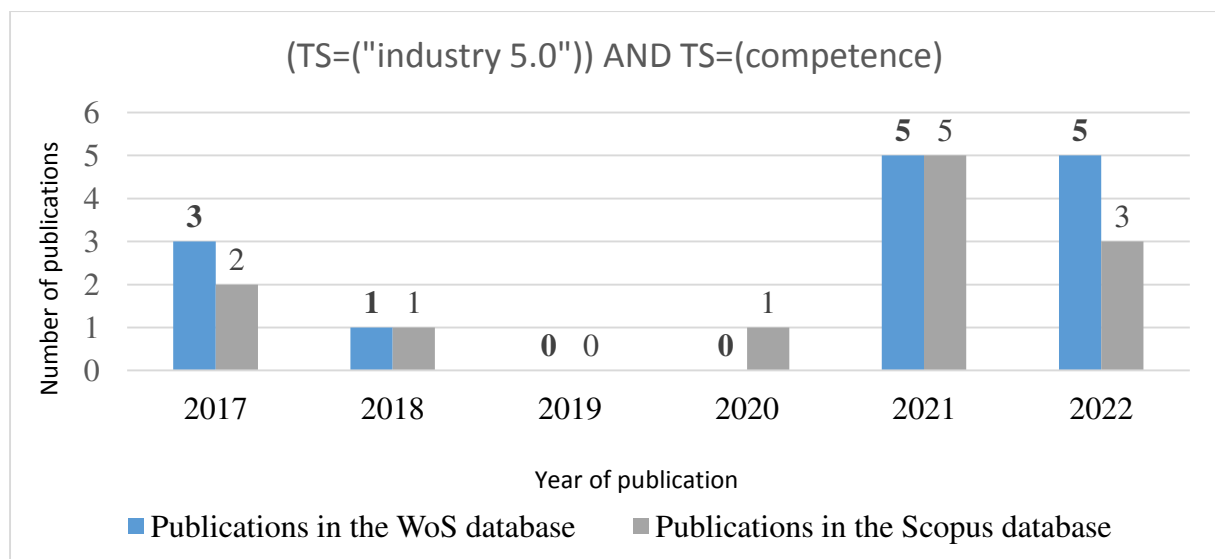


Figure 2. Growth rate of published articles in WoS and Scopus database from 2011 to 2022 for the phrase (TS=('industry 5.0')) AND TS=(talent management).

Source: own study.

A review of the dynamics of the number of published scientific papers in the area under study clearly indicates that these topics are still new and little researched. Researchers' interest in talent management is shaped as follows:

- Talent management + Industry 4.0 (TS=('industry 4.0')) AND TS=(talent management) - the first papers from this research area were indexed in 2015, at which time 3 articles appeared in the WoS and Scopus baize. In subsequent years, researchers successively published more papers in this area, but still not many. In 2022, 16 papers were indexed in the WoS baize and 11 in the Scopus baize.

- Talent management + Industry 5.0 (TS=("industry 5.0")) AND TS=(talent management) - this research area is in the very early stages of publication, with 2 articles appearing in WoS in 2021 and three in Scopus. In the following year, one article was indexed in WoS database and two in Scopus.

Table 2 shows to which fields of science articles in the WoS database are most often assigned. And Table 3 shows to which areas of knowledge articles are most often assigned in the Scopus database.

Table 2.

WoS fields of study to which retrieved works were assigned for the phrases Talent Management + Industry 4.0

Place in the ranking	Fields of science defined in the Web of Science database	Search results (number of documents)
(TS=("industry 4.0")) AND TS=(talent management)		
I	Management	19
II	Business	6
III	Environmental Sciences	5
IV	Engineering Industrial	4
	Environmental Studies	
	Green Sustainable Science Technology	

Source: own study.

Analyzing the data in Table 2, it can be seen that publications with the phrase (TS=("industry 4.0")) AND TS=(talent management) were assigned to the following WoS science fields: management (19), business (6), environmental science (5), industrial engineering, environmental research, sustainable science technology (4). With regard to publications in the phrase (TS=("industry 5.0")) AND TS=(talent management) it is not yet possible to determine to which fields of science they are most often assigned, due to their small number.

Table 3.

Scopus knowledge areas to which the retrieved works were assigned for the phrases competency + Industry 4.0/ 5.0

Place in the ranking	Fields of science defined in the Web of Science database	Search results (number of documents)
(TS=("industry 4.0")) AND TS=(talent management)		
I	Business, Management and Accounting	16
II	Computer Science	11
III	Social Science	9
	Engineering	
IV	Environmental Science	5
(TS=("industry 5.0")) AND TS=(talent management)		
I	Computer Science	3
II	Social Science	2
III	Business, Management and Accounting	

Source: own study.

As can be seen from the data in Table 3, publications with the phrase (TS=("industry 4.0")) AND TS=(talent management) were assigned to the following Scopus knowledge areas: business, management and accounting (16), computer science (11), social science, engineering (9), environmental science (5). On the other hand, publications in the phrase (TS=("industry 5.0")) AND TS=(talent management) were assigned to: computer science (3), social sciences, management business and accounting (2).

Analyzing the keywords from all searched publications in the WoS and Scopus database in the field of talent management and Industry 4.0 (Figure 3) and in the field of talent management and Industry 5.0 (Figure 4), two dominant research streams can be observed. The first trend is directly related to complex technology enabling cyber-physical networks and the use of robots in smart enterprises, while the second is related to managing employee development based on trust, exploring employee talent and nurturing a sense of job satisfaction.

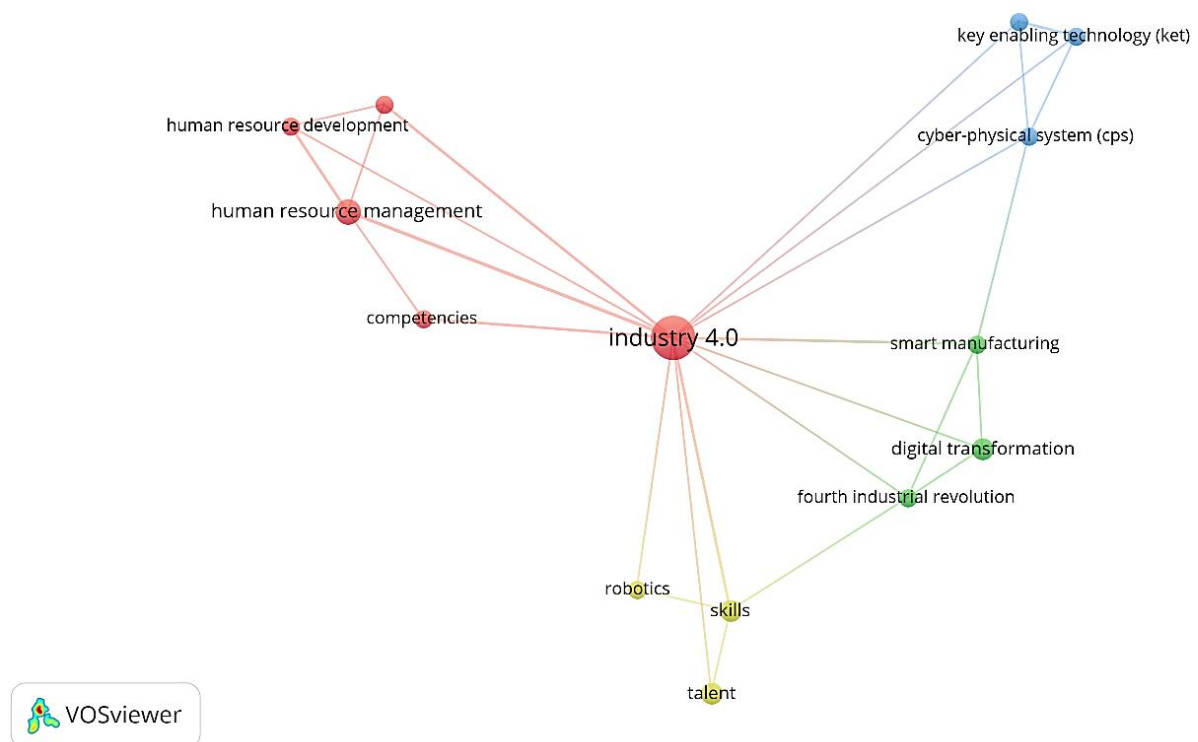


Figure 3. Keyword map for the phrase (TS=("industry 4.0")) AND TS=(talent management).

Source: own study.

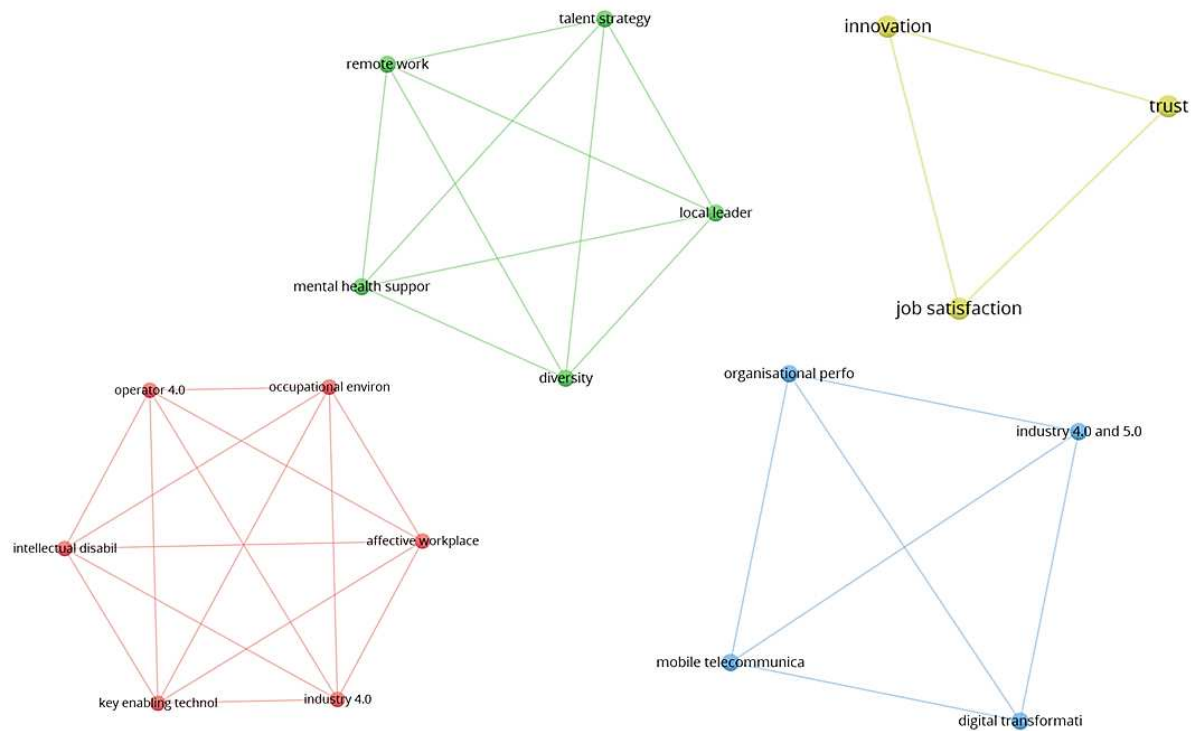


Figure 4. Keyword map for the phrase (TS=("industry 5.0")) AND TS=(talent management).

Source: own study.

For the subject area of talent management and Industry 4.0/ 5.0, from the set of publications indexed in the WoS database, articles marked as the most cited (Highly Cited Papers) were selected, while from the Scopus database, ten articles with the highest number of citations were selected and their content analyzed (for the research area of talent management and Industry 5.0 - all publications were analyzed) to identify what research issues are addressed in them. Many articles were duplicated in both databases, so the final five articles were selected for analysis:

1. Chang, Y.H., Yeh, Y.J.Y. (2018). Industry 4.0 and the need for talent: a multiple case study of Taiwan's companies. *International Journal of Product Development*, 22(4), 314-332. Talent is a key resource in the development of Industry 4.0. The purpose of this article is to analyze companies' need for and acquisition of talent.
2. Dhanpat, N., Buthelezi, Z.P., Joe, M.R., Maphela, T.V., Shongwe, N. (2020). Industry 4.0: The role of human resource professionals. *SA Journal of Human Resource Management*, 18(1), 1-11. The purpose of the article was to explore the role of human resource (HR) professionals in navigating Industry 4.0.
3. Galvan-Vela, E., Ravina-Ripoll, R., Tobar-Pesantez, L.B. (2021). A structural equations model of job disengagement from the constructs of organizational justice, job satisfaction, innovation and trust in the era of industry 5.0. *J. Legal Ethical & Regul. Issues*, 24, Employees play an important role in the performance of companies, so studying the elements of company behavior and climate is essential to retaining human

talent. This study aims to determine the impact of perceived fairness, job satisfaction, support for innovation and trust on employee turnover and the relationship between these variables. Digitalization in advanced industries such as mobile telecommunications emphasizes the agility required to attract talent in a dynamic environment in terms of marketing, competition, etc. This study aimed to investigate the mediating effect of digital process management on the relationship between talent management (TM) and organizational performance.

4. Mian, S.H., Salah, B., Ameen, W., Moiduddin, K., Alkhalefah, H. (2020). Adapting universities for sustainability education in industry 4.0: A channel of challenges and opportunities. *Sustainability*, 12(15), 6100. Despite the global recognition and realization of Industry 4.0, its holistic adoption is limited by specific skill requirements among the workforce. Personnel are expected to acquire adaptive thinking, cognitive and computational skills, mainly in the areas of information technology, data analysis, etc. As a result, universities that have laid the groundwork for future talent or trends in society must adapt and modernize existing programs, facilities and infrastructure. This transformation of higher education in line with the vision of Industry 4.0 has its opportunities and challenges. There are, of course, many factors involved, and these need to be judiciously evaluated in order to strategically plan for this metamorphosis. The purpose of this article was to explore and analyze the various factors that influence the progress and implementation of Industry 4.0 in universities in terms of sustainable education.
5. Whysall, Z., Owtram, M., Brittain, S. (2019). The new talent management challenges of Industry 4.0. *Journal of management development*, 38(2), 118-129. The transformational changes in business environments brought about by the fourth industrial revolution create a perfect storm for strategic human resource management, prompting an examination of the implications of this context for talent management theory and practice. This article aims to discuss these issues.

4. Conclusion

The bibliometric analysis of global scientific works in the area of talent management in conjunction with Industry 4.0 and Industry 5.0 represents an effort to rationalize and systematize existing knowledge in the field of selected aspects of the social architecture of business models of companies operating under the conditions of the fourth industrial revolution. The analysis made it possible to show, in terms of time, the reconstruction of scientific productivity effects in the studied areas.

The results obtained in the bibliometric study confirm that the interest of researchers, from all over the world, concerning the fourth industrial revolution is constantly growing. In the Web of science and Scopus databases, publications on this topic continue to increase, but the vast majority of them are devoted to technology, digitization and digitalization, so topics relevant to building the technical architecture of the business model. Authors pay a great deal of attention to the technological aspects and digitization in the context of challenges for businesses. A clear research gap has been identified in the area of how to manage the development of employees' career paths through talent management.

A search of academic publications in the Web of Science and Scopus database in the field of talent management, represents only a fraction of the total body of publications on the fourth industrial revolution. Although it is still an under-researched topic, this does not mean that it is unimportant for building the business models of the enterprise of the future, particularly for human resource management. For many years, scholars and business practitioners have stressed that a company's most valuable resource is its motivated and well-qualified employees. So it is surprising to see so little attention paid to the social architecture management aspects of the business model. This may be due to the fact that the foundation of the Industry 4.0 concept, which has its origins in 2011, is technology, only the Industry 5.0 concept (from 2021) restores the rightful place of humans in businesses.

The countries from which the researchers working on this topic come are: England, China, Australia, India, South Africa, Malaysia, Indonesia and Spain. A review of the dynamics of the number of published scientific papers from the area under study clearly indicates that these topics are still new and little researched, the area is at a very early stage. By 2022, 38 articles have been indexed in the Wos database, and 31 in the Scopus database (noting that some articles are indexed in both databases simultaneously). These publications were assigned to management, business, environmental sciences, industrial engineering, environmental research and sustainable development technologies. None of the publications were assigned to computer science and related sciences as in the case of publications containing the keywords skills and/or competencies. Two dominant trends can be seen in these publications - a trend directly related to complex technology enabling cyber-physical networks and the use of robots in smart enterprises, and a trend related to managing employee development based on trust, exploring employee talent and nurturing a sense of job satisfaction. The topics covered in these articles in relation to talent management are:

- Demand for talent and talent acquisition by companies implementing Industry 4.0 technologies;
- The role of human resources (HR) professionals in navigating Industry 4.0;
- The impact of perceived fairness, job satisfaction, support for innovation and trust on employee turnover and the relationship between these variables;

- The mediating effect of digital process management on the relationship between talent management (TM) and organizational performance;
- An analysis of the factors that influence the progress and implementation of Industry 4.0 in universities for sustainable education;
- Implications of strategic human resource management for talent management practice.

In theoretical terms, the conducted study contributes to the identification of the current state of knowledge on talent management in relation to Industry 4.0 and Industry 5.0, by analyzing the evolution of the state of knowledge and trends. An interesting direction for future research may be the further exploration of this topic with its extension in relation to the formation of skills and competencies of employees of enterprises of the future.

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THE LINK BETWEEN PERCEIVED ORGANIZATIONAL SUPPORT, JOB SATISFACTION AND ORGANIZATIONAL CITIZENSHIP BEHAVIOR – DOES EMPLOYEE AGE MAKE A DIFFERENCE?

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Purpose: The purpose of this study is to explain the relationship between perceived organizational support (POS) and organizational citizenship behavior (OCB) in the public sector. We test to see if there is a mediating effect of job satisfaction (JS) on the relationship, and a moderating influence of employees' age on the relationship.

Design/methodology/approach: Data were collected from 1310 employees of public organizations in Poland. The current study used SPSS Amos for data analysis purposes.

Findings: The key statistical results in this study reveal that POS has a positive influence on employees' OCB. Furthermore, job satisfaction mediates this relationship. The research also shows that age moderates the relationship between perceived organizational support and organizational citizenship behavior. These relationships are stronger in older workers.

Research limitations/implications: The data were collected from a single source by conducting surveys among employees of public organizations. The cross-sectional nature of the research may therefore constitute a limitation, so it is worth considering a longitudinal research project that might capture changes in such constructs as job satisfaction over time. The results may also be difficult to generalize because the research was conducted within a single culture. This highlights potential future directions of research in this area that would take other contexts into account.

Practical implications: The research results can contribute to a better understanding by managers and HR professionals of the importance of organizational support for the development of employees' citizenship behavior and encourage them to use activities and HR practices that would bring about such support.

Originality/value: This research enriches the literature on public organizations with an analysis of the relationships between perceived organizational support and organizational citizenship behavior taking into account job satisfaction as a mediator of this relationship. The work is a response to the researchers' call to include the age of employees as a moderator in the relationship between POS and OCB.

Keywords: organizational citizenship behavior, perceived organizational support, job satisfaction, age group.

Category of the paper: Research paper.

1. Introduction

Although we rely in the 21st century on advanced technologies and modern innovative solutions, human resources still determine the effectiveness of many organizations. Employees can increase the efficiency of an organization and should therefore feel that organization's ongoing support. Perceived organizational support (POS) theory was introduced by Eisenberger and colleagues in the 1980s and is defined as "an employee's perception of being valued and cared about by the organization" (Eisenberger et al., 1990, p. 52). Perceived Organizational Support is also valued as the assurance that aid will be available from the organization when it is needed to carry out one's job effectively and to deal with stressful situations (Shanock, Eisenberger, 2002). As Firmansyah et al. (2022, p. 2) claimed, POS is "a member's perception of the extent to which the organization values their contribution and cares about their well-being". Liu (2004) indicated that, if employees perceive greater support from an organization, they are likely to make additional efforts leading to better organizational performance. These considerations were also confirmed by Blancero (2009).

The consequences of POS can be found in organizational support theory. In line with the reciprocity norm, POS contributes to employees' sense of caring for the organization and to their striving to achieve its goals. Furthermore, as Demir (2015, p. 134) writes, "the care, approval, and respect connoted by Perceived Organizational Support should fulfill socio-emotional needs, leading workers to incorporate organizational membership and role status into their social identity". Third, POS should lead employees to believe that their organization appreciates their improved performance. Therefore, it can be assumed that POS and its consequences are related to the theory of social exchange, according to which employees, in return for the support received, will reciprocate with other positive behaviors or attitudes (Shanock, Eisenberger, 2002). Mentioned prominently among these is citizenship behavior, which is understood as individual workplace behavior not directly recognized by an organization's formal reward system but that serves to promote the general well-being of the organization (Kandeepan, 2016). The influence of POS on OCB has been demonstrated by, among others, Singh et al. (2015), Osman et al. (2015) and Andrade and Neves (2022). So too, Kapela and Pohl (2020), Kurtessis et al. (2015) and Muhammad (2014) found that, when employees perceive their organization as supporting them, they show more OCB.

However, as Meiske (2018) argues, for employees to feel the urge to exhibit out-of-role behavior, including OCB, the focus should also be on their work-related attitudes. Among these attitudes, Greenberg and Baron (2003) mention job satisfaction. "Job satisfaction" is a term that defines an optimistic feeling and affective reaction towards a job, occasioned from an assessment of its characteristics (Yuen et al., 2018). Mushtaq et al. (2014) opine that contented employees have a greater tendency to display positive behaviors that can effectively contribute to the overall performance of the organization. Thus, personal job satisfaction (JS), just like POS, encourages an employee to undertake work that exceeds the formal role, and thus to display citizenship behaviors (Meiske, 2018).

On the other hand, when members of the organization feel well-treated and receive adequate support from their organization, they will feel satisfaction (Witt, 1991). The impact of poorly perceived organizational support results in low satisfaction (Meiske, 2018). Thus, POS results in both OCB and JS.

The positive impact of POS on both OCB and job satisfaction has been confirmed in the meta-analysis of Rhodes and Eisenberger (2002). There are many studies that have analyzed the relationship between these variables (Biswas, Mazumder, 2017; Fatimah et al., 2011; Islam et al., 2014; Linda et al., 2019). However, the relationship between POS and OCB, taking into account job satisfaction, has been subjected to very little analysis, and the results of these analyses are not clear. For example, Linda et al. (2019) surveyed 80 employees of the Regional Revenue and Asset Agency of West Pasaman Regency. Their results indicated that POS had a negative effect on OCB, while the effect of job satisfaction was positive. In turn, Wei and Hongli's research (2017) conducted among employees of Chinese companies proved that POS and JS have significant correlations with OCB, and JS plays a mediating role between POS and OCB. Other results were achieved by Meiske (2018), who conducted research among lecturers employed at University of Lambung Mangkurat. The findings of that study suggest that POS indirectly affects OCB lecturers through job satisfaction, but that there is no significant negative direct relationship between POS and OCB. The differences in research results provide an impetus to conduct further analyses in this area. Additionally, our research focuses on a specific group of entities – public institutions, specifically local government units.

Sridhar & Thiruvankadam (2014) posit that every organization must foster unlimited support, without which the structure would be disrupted. It is therefore worth looking at the relationship between POS and its outcomes also in institutions that operate differently from companies. This is particularly true of public organizations. Indeed, as the results of the analysis by de Geus et al. (2020) indicate, the picture of organizational behavior and attitudes among employees of public institutions is fragmented and unclear, hence the need for research within this group of actors. Our research attempts to address this need. We focus on public institutions that have particular characteristics, e.g. usually a formal structure – and what follows is bureaucracy, whose formal structures, as Amah (2017) writes, are not an embodiment of excellence. They often experience weak leadership and administrative authorities, which can

have a negative impact on employee attitudes and behavior, e.g. innovativeness. Very often, they are faced with multiple and sometimes contradictory goals (Rainey, 2009). Moreover, a public organization cannot always use such diverse sources of support as can a private organization. Unlike private companies that offer goods and services, public organizations interact with customers as citizens, an interaction governed by different laws and constraints (Pandey, Moynihan, 2008; Rosenbloom, 2013). These constraints can affect both role-based and non-role-based behavior (de Geus et al., 2020). However, OCB findings have encouraged public organizations to use citizenship behavior to increase organizational performance (Vigoda-Gadot, Golembiewski, 2001) and the welfare of citizens, as well as to improve the image of public organizations (Mahfudz et al., 2021). Indeed, public institutions are increasingly subjected to public scrutiny and performance demands from citizens, while also struggling to sustain service levels in the face of decreased funding (Hassan, 2015; Vigoda-Gadot, Golembiewski, 2001). Therefore, OCB is one way that an organization can respond to such challenges, as it encourages employees to go beyond formally determined role requirements (de Geus et al., 2020).

It should also be noted that, while conducting research among employees of public institutions, we paid special attention to their age. This was because, already in the last century, Carstensen et al. (1999) proved that the relationship between POS and its results can be moderated by the demographic variable of age. Later also, Kurtessis et al. (2015) focused on age as a moderator of the relationship between POS and job satisfaction and organizational commitment. In our research, we considered age as a moderating variable in the relationship between POS and OCB, which has not yet been studied. We believe that it is age that may disturb this relationship in public institutions. As Torsello (2019) stated, young workers have different demands on the organization than do older people. They want to quickly acquire new skills, they expect a participatory style of management, and they treat hierarchies very negatively and want to avoid them, which, unfortunately, is often not possible in public organizations. Moreover, according to the analysis of resource conservation theory, when the physical strength of employees begins to decline with age, they begin to appreciate and optimize other resources that provide them with peace of mind and rationality (Charoensukmongkol, Puyod, 2022). In addition, as Bal et al. (2010) claimed, older workers have a more objective view of what support they expect from their organization and have learned to better cope with negative experiences. Therefore, it can be assumed that employees will perceive the support of the organization differently depending on their age. There is evidence that older workers tend to have a more positive perception of their employer (Carstensen et al., 1999). On the other hand, research indicates that age-related differences in motivation and goals may also have an impact on employees' attitudes and behavior (Cavanagh et al., 2020), including citizenship behavior (Ajlouni et al., 2021). Singh and Singh (2010) argue that older people will show more civic behavior towards their co-workers compared to younger workers, who are focused on their own development. It is therefore worth taking a closer look at these relations and checking whether age can play a regulating role in them.

Our research thus aims to answer the following questions:

1. What is the impact of perceived organizational support on the organizational citizenship behavior of public organization employees?
2. Does employee age influence this relationship and, if so, how?
3. To what extent does job satisfaction mediate the impact of perceived organizational support on organizational citizenship behavior in public organizations?

The purpose of this study was to obtain empirical evidence to explain the relationship between perceived organizational support and organizational citizenship behavior through the creation of job satisfaction. Our objective is also to extend current knowledge by exploring the extent to which the POS–OCB relationship varies across employee ages.

Through this article, we provide additional empirical evidence regarding the direct effects of POS on OCB, but also its indirect effects through job satisfaction. In addition, no similar research has been conducted in public institutions on this relationship. Moreover, this is the first study to take into account the possibility of employee age moderating the relationship between POS and OCB. The work is a response to the researchers' call to include the age of employees as a moderator in the relationship between POS and OCB. The work is therefore a response to the call of researchers to take into account the age of employees as a moderator in this relationship.

2. Theoretical Framework and Hypothesis Development

2.1. Organizational Citizenship Behavior

Organ (1988, p. 4) defines OCB as “an individual behavior that is discretionary, not directly or explicitly recognized by the formal reward system, and that in the aggregate promotes the effective functioning of the organization”. In the 1980s, Organ and his colleagues were the first to adopt the term “OCB”. As Firmansyah et al. (2022, p. 2) write, Organization Citizenship Behavior “is a voluntary behavior to help others exceed the demands of the role in the workplace or being organized and is not rewarded by the achievement of task performance”.

According to Podsakoff et al. (2000), OCB is a profound individual contribution that exceeds the demands of the person’s role in the workplace, and has an impact on performance assessment. Appelbaum et al. (2004) add that the OCB concept relates to employee behavior that is not part of an individual job description, is not included in the employment contract and is beneficial to the organization’s performance. Organizational Citizenship Behavior is similarly defined by Purwanto (2022), who writes that OCB is a desired behavior that contributes to the organization’s efficient operation but is not required of employees as a part of their regular work duties. Organizational Citizenship Behavior (OCB), according to Desky

et al. (2020), is individual behavior that is not explicitly acknowledged by the formal reward system and will have an effect on more successful organizational activities.

OCB is any positive activity that employees voluntarily engage in that benefits the organization and has a positive influence on coworkers. Therefore, citizenship behavior is a voluntary and altruistic activity by members of the organization (Shanker, 2018). As Adil et al. (2021) claim, OCB refers to anything that employees opt to undertake spontaneously and willingly that is outside of the confines of their specified, legally binding obligations.

Despite the definition of OCB having been revised multiple times, the constructions have kept their core (Hoffman et al., 2007). All OCB definitions emphasize that they are behaviors that go beyond the scope of standard contractual obligations and for which the employee neither expects nor receives remuneration. Furthermore, they increase the performance of the organization.

Organizational citizenship behavior is a multidimensional concept and has a variety of constructs (Sadiq and Ahmad, 2020). Podsakoff et al. (2000) listed seven dimensions of these behaviors: helping behavior, sportsmanship, organizational loyalty, organizational compliance, individual initiative, citizenship virtue, and self-development. Thus, OCBs include, for example, helping others, helping a new employee to catch up, being punctual, staying at work after hours, taking on additional responsibilities, making creative suggestions, tolerating temporary impositions without complaint, defending an organization, encouraging teamwork, volunteering, accommodating colleagues' work schedules, etc. (Choong, Ng, 2022; Kark, Waismel-Manor, 2005; Organ et al., 2006; Podsakoff et al., 2000).

Despite OCBs being by definition voluntary and uncontrolled behavior, their consequences are visible in the results of the organization's operation. They can influence the effectiveness of an organization by: reducing disparities in the level of tasks performed and results achieved (Podsakoff, MacKenzie, 1997); increasing the productivity of colleagues and superiors (MacKenzie et al., 1993); freeing up resources for more productive purposes (Smith et al., 1983); and enhancing the organization's ability to attract and retain the best employees (Organ, 1988). As Meiske (2018, p. 27) states, "From an organizational point of view, OCB is necessary because the type of behavior included in OCB improves the resources' utilization and reduces the need for more formal control mechanisms, and does not require a lot of expense".

Organizational citizenship behaviors generate many benefits for the company. Their impact on the performance of individuals, teams and entire organizations has been confirmed by many researchers. This voluntary citizenship of members of an organization is focused on, among other things, helping others, loyalty, accepting principles and rules, willingness to cooperate, and creative self-development, and is therefore oriented towards the good of the organization.

Citizenship behavior increases the loyalty and commitment of members of an organization (Tepper et al., 2004). Bateman and Organ (1983) found, in their project, that job satisfaction is not only a predictor of OCB, but also a consequence of it. OCB is positively correlated with employee well-being and positive mood (Glomb et al., 2011), personal development (Hansen et al., 2003), and physical and mental health (Brown et al., 2003). It is negatively correlated with the intention to change employer (Barzoki, Rezaei, 2017; Ladebo, 2005) and actual staff turnover and absenteeism among members of the organization (Podsakoff et al., 2009). In public organizations, too, OCBs can influence lower turnover rates, lower absenteeism rates and greater trust in the workplace (de Geus et al., 2020). OCBs are related to productivity, efficiency and cost reduction (Podsakoff et al., 2000), higher job satisfaction (Chin, 2015), higher client satisfaction (Felfe, Heinitz, 2010), and low levels of counterproductive behaviors (Reynolds et al., 2015). OCB results in firm survival (Ojebola et al., 2020) and quality performance (Wickramasinghe, Perera, 2014). Koys (2001) further argued that citizenship behavior influences the effectiveness of an organization by increasing financial indices as well as the quantity and quality of work performed. OCB improves the performance and competitiveness of organizations (Smith et al., 1983).

As mentioned above, citizenship behavior brings many benefits not only to employees, but also to the entire organization. Because these behaviors are discretionary and not rewarded, it is very important to identify the precursors that motivate employees to take these actions. According to Organ (Organ, 2018), organizations must encourage and retain those employees who perform tasks that go beyond formally defined roles.

Four mechanisms lie at the basis of the manifestation of organizational citizenship behaviors: *reciprocity and exchange processes* described within the social exchange theory, *identification mechanism*, *impression management*, and thus activities related to image management and *positive relationships* (Blatt, 2008).

Meanwhile, the antecedents of OCB fall into four main categories, namely: individual characteristics, task characteristics, organizational characteristics, and leadership behaviors (Podsakoff et al., 2000).

Individual characteristics include job attitudes (e.g. job satisfaction, perceived fairness, and organizational commitment), worker role perception, demographic variables, employee abilities and individual differences (Ojebola et al., 2020). Task characteristics entail task feedback and inherent task satisfaction. Organizational characteristics include organizational level of flexibility, advisory and coworker staff support, and perceived organizational support. The predictors of OCB among leadership characteristics include contingent reward behavior and supportive leader behaviors (Kasa and Hassan, 2016). Due to the subject of the article, POS will be described later as one of the predictors of OCB.

2.2. Perceived Organizational Support and Organizational Citizenship Behavior

Perceived organizational support (POS) is defined as the belief among employees that their employer is concerned for their well-being and also provides resources to assist them in coping with the demands of their job (Eisenberger et al., 1986). So, more generally, POS can be defined as how much an organization values its employees (Allen, 2003).

As Osman et al. (2015) write, what matters to employees today is not merely remuneration. Rather, they prefer to work in organizations that appreciate their employees and their contribution. Organizational support both attracts employees and reduces turnover, creating an ideal workplace.

Perceived Organizational Support includes fair treatment, supervisory support, rewards and favorable job conditions (Osman et al., 2015). POS also includes support for those employees who need to find a balance between work and family life. Therefore, organizational support also manifests as flexibility in how work is organized to reduce the strains related to work-to-family conflicts (Andrade, Neves, 2022). Perceived organizational support is “also valued as assurance that aid will be available from the organization when it is needed to carry out one’s job effectively and to deal with stressful situations” (Shanock, Eisenberger, 2002, p. 698).

According to Meiske (2018), when workers feel a high level of organizational support, they are likely to absorb their membership of the organization into their identities. This leads to the employee identifying with the organization and, consequently, personally contributing to the development and results of the organization. POS is founded on the social exchange principle, which states that each side must contribute something of value to the other side and that the exchange must be fair to both sides (Wang, Cheng, 2010).

Therefore, organizational support should provide employees with what they need in order to identify with the organization and should promote their perceived obligation to care for the welfare of the organization. This allows a relationship to emerge between POS and OCB.

Over the years, many researchers have indicated a positive relationship between POS and employee OCBs (Eisenberger et al., 1986; Kapela, Pohl, 2020; Kurtessis et al., 2015; Miao, Kim, 2010). POS is a predictor of OCB because, when employees perceive their organization as being supportive and caring for their welfare and needs, they want to reciprocate this feeling by engaging in citizenship behaviors. According to social psychology, employees act as citizens in reciprocity to the perception that organizations support their individual interests (Homans, 1958). This “self-interests” viewpoint is founded on the assumption that meeting individuals’ psychological needs promotes positive social behavior (Chiaburu et al., 2015).

However, empirical analyses of the relationship between POS and OCB have not produced consistent results. For example, Chiaburu, Chakrabarty, Wang, and Li (2015) found a significant positive relationship between POS and OCB, but that the level of relationship between these two variables depends on the specific cultural environment. In addition, some studies have shown the relationship between POS and OCB to be stronger at the organizational

than individual level (Eisenberger et al., 1986; Wayne et al., 2002). Kapela and Pohl (2020), meanwhile, conducted research on social sector employees. Their results indicated that POS is related to OCB in this sector, but more strongly at the personal level. Research conducted by Meiske (2018) among lecturers at University of Lambung Mangkurat, meanwhile, indicated that the lecturers' perceived organizational support did not positively affect their organizational citizenship behavior. The results of her study explain that the relationship between POS and OCB must be formed through the creation mechanism of job satisfaction and organizational commitment. It is therefore worth pursuing this subject further to better understand the possible relationship between POS and OCB, especially in the less-studied public sector. Given the above, we hypothesize that:

H1: POS is positively related to employees' OCB in the public sector

Additionally, our research focuses on age as a moderator in the relationship between POS and OCB. First, we base our assumptions on the theory of person–organization fit, especially supplementary fit (Muchinsky and Monahan, 1987). On the employee side, it is demographic characteristics (such as age) that constitute the general characteristics taken into account when assessing fit (Riordan, Wayne, 2008). We can therefore expect that a differentiating individual characteristic, namely age, may influence the individual's perception of organizational support, which may increase or decrease the frequency of citizenship behaviors.

Furthermore, as mentioned in the introduction, according to the analysis of resource conservation theory, the decreasing physical strength of employees with age means that, over time, they more appreciate other resources provided by the organization. Mental comfort and rationality are important to them (Charoensukmongkol, Puyod, 2022). Therefore, older workers will perceive organizational support differently than younger workers.

In addition, numerous studies have shown a significant relationship between demographic data and citizenship behaviors. Significant links between age and OCB have been noted by, *inter alia*, (Altuntas, Baykal, 2014; Chattopadhyay, 1999; Wanxian, Weiwu, 2007). Saleem (2017) showed in their research at universities that dependencies were greatest in workers of over 40 years of age. Moreover, Rhoades and Eisenberger (2002) indicated that demographic characteristics, including age, are also related to POS. Research by Cobanoglu and Derinbay (2016) on a sample of 494 primary school teachers showed that perceived organizational support among teachers is not differentiated by gender, branch, educational status or formal recognition of professional achievements. The POS of teachers is differentiated only by age.

Age as a control variable is close to both OCB and POS. Therefore, it is important to clarify the precise effects of age on the relationship between POS and OCB. Hence, we propose the following hypothesis:

H2: The positive relationship between POS and OCB is moderated by age. In particular, the positive effect of POS on OCB will be stronger among older employees.

2.3. The Mediating Role of Job Satisfaction

Job satisfaction is a key employee attitude. It denotes the employee's primary affective reactions to various aspects of work and professional experience (Igbaria, Guimaraes, 1992; Pitaloka, Sofia, 2014). It defines how an employee feels in their work and what they think about it (Colquitt et al., 2019). Most researchers agree that it is a positive emotional response to work (Oshagbemi, 2003; Scarpello, Vandenberg, 1992). Already Locke (1976) emphasized in his definition that satisfaction means a pleasant or positive emotional state resulting from an evaluation of work and professional experiences. It is the complex of feelings and beliefs that people have about their work (Jones, George, 2015). It is associated with employee satisfaction not only with the job itself, but also with the broader organizational context of the job (Jernigan et al., 2002; de Juana-Espinosa, Rakowska, 2018; Pluta, 2015)

Various aspects of job satisfaction can be considered (Indarti et al., 2017). Already, Herzberg, Mausner and Snyderman (1959) defined and measured job satisfaction as a global concept and as a concept with two separate aspects – internal satisfaction (related to the work itself) and external satisfaction (related to the environment in which the work is done). A similar classification was made by Schnake and Dumler (2003), who indicated internal job satisfaction to be employee satisfaction with the nature of work, achievements, recognition, or development, and external job satisfaction as being related to the employee's feelings about external aspects of work (such as remuneration, leadership style, workplace atmosphere, or relationships with colleagues), while distinguishing social satisfaction as satisfaction with aspects of relationships with people in the work environment, such as friendship or respect. This confirms that job satisfaction is a complex and relatively difficult-to-measure category, especially as it is influenced by many variables related to both individual and social, cultural, organizational, and environmental factors. On the other hand, it is closely connected to the organization's results, such as high performance level or high organizational commitment (Indarti et al., 2017). It directly affects employees' organization-related physical and mental well-being, and thus productivity, absenteeism, turnover rate, and employee relations (Meyer et al., 2004). According to Organ et al. (2006), job satisfaction most strongly influences citizenship behavior, organizational commitment and employee engagement. Employees who are happy with their job make additional efforts and are more likely to demonstrate OCB and contribute positively to the organization's activities (Sawalha et al., 2019). Employees who are satisfied with their job are more likely to speak positively about the organization and help colleagues, and are more compliant in carrying out their duties (Robbins, Judge, 2013), as well as being more loyal to the organization and co-workers (Lewicka et al., 2018). In turn, a lack of job satisfaction leads to employees tending to behave sub-optimally, to not try their best, and to rarely make sacrifices of time or extra effort in their job (Indarti et al., 2017).

Due to the scope of its impact, job satisfaction is one of the most frequently studied of employee attitudes (Judge, Kammeyer-Mueller, 2012) and appears to be a key determinant of citizenship behavior in an organization (Heriyadi et al., 2020; Nurjanah et al., 2020). Such positive relationships were confirmed in the research of Organ and Konovsky (1989), Williams and Anderson (1991), Pitaloka and Sofia (Pitaloka, Sofia, 2014), and Ramadhan and Saudi (2018).

The relationship between job satisfaction and organizational citizenship behavior may derive from the principle of reciprocity or the postulates of social exchange theory, which show that employees with high job satisfaction will try to reciprocate with the organization by exhibiting citizenship behaviors (Organ, 1977). The self-determination theory (SDT) of Deci and Ryan (2008), which explains the formation of a person's internal motives in response to external factors such as satisfaction, can also explain these behaviors (Fachrudin, Sholihin, 2021).

The literature indicates that job satisfaction also acts as a mediator between various organizational behavior variables (Crede et al., 2007). Among others, research by Bayarçelik and Findikli (2016) confirms that satisfaction mediates the perception of organizational justice and desire to leave a job; meanwhile, research by Güteryüz, Güney, Aydın and Aşan (2008) indicates that it mediates the relationship between emotional intelligence and organizational commitment; and research by Khalaf et al. (2019) indicates that it mediates employee engagement and organizational performance. Therefore, the question arises as to whether it also mediates the relationship between employees' perceived organizational support and their citizenship behavior. The extent to which employees perceive that the organization provides them with support and is ready to provide assistance when they need it may affect their sense of responsibility for contributing to the organization by displaying attitudes and behaviors conducive to the achievement of the organization's goals. Considering job satisfaction as a form of emotional response to a situation that reflects work, performance assessment or professional experiences, Locke (1976) indicates that the employees' perception of the organizational support they receive influences their job satisfaction. Therefore, in light of the claim by Biswas and Mazumder (2017) that job satisfaction is a direct consequence of employees' perception of work and the work environment, and employees with high job satisfaction display citizenship behaviors, we hypothesize that:

H3: Job satisfaction mediates the relationship between perceived organizational support and citizenship behavior in public organizations.

To summarize, the purpose of this study is to explain the relationship between perceived organizational support and organizational citizenship behavior. We test to see if there is a mediating effect of job satisfaction on the relationship, and a moderating influence of employees' age on the relationship. The research model is shown in Fig. 1.

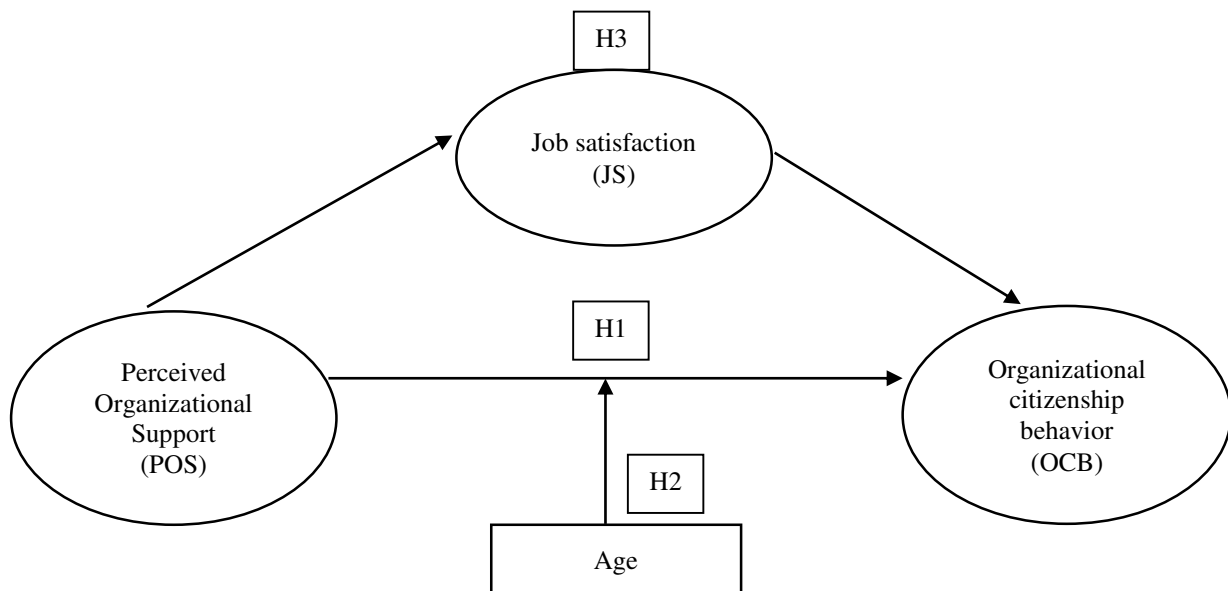


Figure 1. Hypothesized model of relationships.

3. Methods

3.1. Research procedure

The main objective of the quantitative research was to identify the relationship between perceived organizational support and citizenship behaviors, in which job satisfaction is considered to be an important mediator of the process. The analyses of these relationships also took into account employee age.

The research was implemented in the following stages:

First was an analysis of the domestic and foreign literature on citizenship behaviors in organizations and their antecedents, perceived organizational support, and the mediating role of job satisfaction. The literature analysis (desk research, web research) constituted the substantive foundation for the primary research and enabled the key research questions to be formulated.

The second stage involved deriving the research hypotheses from the literature analysis and constructing a hypothetical research model. This stage allowed the variables of importance to the analyzed process to be identified, the understanding of these variables to be expanded and the postulated relations between them to be determined.

The third stage was to design a measurement tool to collect data on the main constructs as part of the proposed hypotheses.

In the next stage, potential respondents were identified, and data collection methods were selected. The research was realized from July to October 2021. It employed an online survey covering employees of public organizations in Poland. We focused on local government units

located all over Poland. We used the public Polish database at <https://www.gov.pl/web/mswia/baza-jst>.

The research was approved by the Scientific Research Ethics Committee of the Nicolaus Copernicus University (Permit No. 19/2021/FT). It should be noted that the study does not fall within the field of clinical psychology.

The study was carried out with the collaboration of the local government units' HR departments.

Before the research, we obtained written consent from the management of each public unit. Finally, the questionnaire was sent by email to 2 101 public offices. The HR department invited potential participants and provided them with the link to the survey. Participants were informed that their participation in the study was entirely voluntary. An invitation appeared over the study in which participants were informed about the purpose of the study. Respondents were previously informed that the survey was only about their beliefs about themselves. Before starting the study, each respondent consciously verbally consented to participate. There was no remuneration for participating in this study. The responses of the respondents were anonymous. They could withdraw at any time. Respondents entered their answers directly online.

In total, the authors received 1 130 correctly completed questionnaires (the data were found to have no missing values). Missing values, outliers, and multicollinearity were examined since they might have an impact on the validity of the findings.

In the fifth stage, the data collected during the research were subjected to statistical analyses using structural equation modeling (SEM).

In the final stage, the research hypotheses were verified, the research results were discussed, the contribution of the conducted research to management theory and practice was indicated, and the research limitations were specified.

3.2. Measures

The research process was based on designing measuring instruments to collect data on the main constructs under the proposed hypotheses. The studied variables were measured using a set of items derived by adapting existing research tools that were selected based on the literature review.

The questionnaire consisted of 19 items from the literature that measure basic constructs such as perceived organizational support, organizational citizenship behavior, job satisfaction and the demographic characteristics of respondents (indicated in Table 1), which acted as control variables.

To measure job satisfaction, following Judge, Bono and Locke (2000), a shortened five-item version of the Brayfield and Rothe (1951) scale was used. An example item is "I find real enjoyment at work". The six-item scale from Shanock and Eisenberger (2006) (the short scale version developed by Eisenberger et al. (1986)) was used to measure POS. An example item is

“My organization strongly considers my goals and values”. The eight-item scale by Lee and Allen (2002) was used to measure OCB. A sample item from the scale is “Attend functions that are not required but that help the organizational image”.

All items were rated using a seven-point Likert scale from 1 (strongly disagree) to 7 (strongly agree). The survey was translated from English into Polish by two independent experts. The agreed Polish version was back-translated into English by another expert with a satisfactory degree of convergence with the original.

3.3. Description of the research sample

The quantitative study was the main stage of the procedure carried out in order to empirically verify the hypothetical model. The survey covered 1310 respondents. Table 1 shows the demographics of the study participants. Overall, 79.1% of the participants were female and only 20.9% were male. Half of the total group of respondents were over 40 years old (62.2%) and over 66.2% had organizational tenure of more than 15 years. In addition, only 65 (4,9%) of the participants had secondary education, 105 (8%) held bachelor’s degree, 1140 (87%) held a master’s degree level of education or above. The majority of respondents (60%) worked in local government units located in cities with up to 50,000 inhabitants.

Table 1.
Respondent profiles

Characteristics		Full Sample (n = 1310)	
		Frequency	Percentage
Gender	Female	1 036	79.1
	Male	274	20.9
Age	under 30	104	7.9
	31–40	391	29.8
	41–50	489	37.3
	51–60	253	19.3
	over 60	73	5.6
Organizational Tenure	Less than 5 years	92	7.0
	5–15	351	26.8
	15–25	461	35.2
	25–35	256	19.5
	Over 35	150	11.5

Source: Own research.

3.4. Data analysis methods

The current study used SPSS Amos for data analysis purposes. The correlations and reliability were tested using SPSS, whereas confirmatory factor analysis and hypothesis testing were conducted with AMOS. To test for homogeneity and internal consistency, Cronbach’s alpha statistic and convergent validity were calculated. Discriminant validity was checked by confirmatory factor analysis. The hypotheses were tested by structural equation modelling (SEM), which allows the researcher to describe unobservable latent variables. The model was

estimated in the SPSS Amos 16 package using the maximum likelihood method. The adopted level of significance was 0.05. Additionally, results were confirmed by bootstrap analysis with 5000 samples.

3.5. Measurement model

The reliability and validity of the scales were tested by Cronbach's alpha statistic, composite reliability (CR) and average variance extracted (AVE). Table 2 contains values of the statistics.

All values of Cronbach's alpha statistics were above 0.7, which means the results are reliable (Nunnally, 1978). Furthermore, the composite reliability (CR) was between 0.83 and 0.92 for all factors, which exceeded the recommended value: 0.7. Every construct also has an average variance extracted (AVE) higher than 0.5 and fulfills the Fornell-Lacker criterion. All measures confirm good reliability, and composite and convergent validity of the scales used (Fornell, Larcker, 1981; Tavakol, Dennick, 2011). Factor loadings were higher than 0.5 and statistically significant for all analyzed variables (Hair et al., 2006).

Table 2.

Assessment of the measurement model (construct reliability and validity)

Factor	Cronbach's alpha	CR	AVE
Perceived Organizational support	0.917	0.919	0.695
Job satisfaction	0.892	0.897	0.687
Organizational citizenship behavior	0.786	0.829	0.501

Source: Own research.

This article used AMOS 16. (Chicago: IBM SPSS) to carry out the CFA, comparing the benchmark model (four-factor model) with the competition models (one-, two-, and three-factor model). The degree of each model's index superiority and inferiority is listed in Table 3.

Table 3.

Confirmatory factor analysis

Factor	Question	Loadings	P value
Perceived Organizational Support	My organization values my contribution to its well-being.	0.818	
	My organization really cares about my well-being.	0.871	0.000
	My organization strongly considers my goals and values.	0.914	0.000
	My organization shows very little concern for me. (R)	0.792	0.000
	My organization takes pride in my accomplishments at work.	0.765	0.000
Job satisfaction	I find real enjoyment at work.	0.882	
	I feel fairly satisfied with my present job.	0.878	0.000
	Most days I am enthusiastic about my work.	0.860	0.000
	I consider my job to be rather unpleasant. (R)	0.679	0.000
Organizational citizenship behavior	Willingly give my time to help others who have work-related problems.	0.508	
	Assist others with their duties.	0.563	0.000
	Attend functions that are not required but that help the organizational image.	0.801	0.000
	Offer ideas to improve the functioning of the organization.	0.806	0.000
	Take action to protect the organization from potential problems.	0.797	0.000

Source: Own research.

We can see that the fit indices for the benchmark model are obviously superior to those of the other three models, indicating that the three variables used in this article (Perceived Organizational Support, Job Satisfaction, Organizational Citizenship Behavior) are independent of each other and have high discriminative validity. Model D has the best model fit indicators.

4. Results

4.1. Descriptive statistics and correlations

Table 4 summarizes the means, standard deviation and correlations for all variables. Correlations between all analyzed variables are statistically significant. Organizational citizenship behavior in particular is positively related to organizational support (0.388), job satisfaction (0.454) and age (0.211). Furthermore, between job satisfaction and organizational support, a positive correlation also exists (0.670). In table 4, the HTMT ratio was also calculated to check discriminant validity. The Heterotrait–Monotrait Ratios (HTMT) between all three constructs were below 0.9, which means that the discriminant validity was ensured (Henseler et al., 2015).

Table 4.

Means, standard deviation, and correlations

Variables	Mean	s.d.	1	2	3
1. Organizational support	4.410	1.292	(0.834)		
2. Job satisfaction	5.141	1.179	0.670**	(0.829)	
3. Organizational citizenship behavior	5.235	0.867	0.388**	0.454**	(0.707)
4. Age	41–50 years ⁽¹⁾	-	0.128**	0.140**	0.211**

Notes: (1) – Median, *p < 0.05, ** p < 0.01, Values in parentheses are square roots of AVE.

Source: Own research.

4.2. Hypothesis testing

To test the hypothesis that job satisfaction is a mediator between organizational support and organizational citizenship behavior, three structural equation models were estimated. First, the relations between organizational support and job satisfaction (model 1) or organizational citizenship behavior (model 2) were checked. In the last model, job satisfaction was incorporated into the regression equation as a mediator between organizational support and organizational citizenship behavior. To our approach we adopted the procedure described in Song et al. (2020). The results obtained in all three models are presented in Table 5.

Table 5.*Results of estimated models (basic and with the mediating effects of job satisfaction)*

Variable	Job satisfaction	Organizational citizenship behavior (OCB)	
	Model 1	Model 2	Model 3
Perceived Organizational support	0.670***	0.387***	0.151***
Job satisfaction			0.355***
RMSEA	0.069	0.081	0.073
IFI	0.989	0.961	0.955

Notes: *p < 0.05, ** p < 0.01, *** p < 0.001.

Source: Own research.

Organizational support was significantly related to both: job satisfaction (Model 1, $\beta = 0.670$, $p < 0.001$) and organizational citizenship behavior (Model 2, $\beta = 0.387$, $p < 0.001$). After including job satisfaction in the main model, the organizational support still has a statistically significant (though smaller) effect on organizational citizenship behavior (Model 3, $\beta = 0.151$, $p < 0.001$). Furthermore, job satisfaction influences OCB (Model 3, $\beta = 0.355$, $p < 0.001$). This means that job satisfaction partly mediates relationships between these two variables (organizational support and organizational citizenship behavior).

Although goodness-of-fit indicators for Model 3 are satisfied (RMSEA < 0.08, IFI > 0.95), the indirect effect of organizational support on OCB via job satisfaction was additionally checked using a bias-corrected bootstrapping procedure. Based on 5000 samples, the low and high limit of bias-corrected 95% confidence intervals were estimated for indirect effect (Byrne, 2010). As shown in Table 6, the indirect effect of organizational support on organizational citizenship behavior via job satisfaction is 0.237 and is statistically significant (the confidence interval does not contain 0 (Byrne, 2010)).

Table 6.*Indirect effects of organizational support (via job satisfaction) on OCB*

Path	Indirect Effect	Standard error	Low limit	High limit
Perceived Organizational support→Job satisfaction→OCB	0.237	0.032	0.175	0.302

Source: Own research.

The hypothesis that age is a moderator of relationships between organizational support and organizational citizenship behavior was tested by the four calculated models. The first model contains no predictive variables. In the second model, organizational support was added, while age was added in the third, and cross-level interactions between age and organizational support in the last. This is in line with the approach proposed by, *inter alia*, Kanwal et al. (2019). The results for all calculated models are presented in Table 7.

Table 7.*Results for cross-level analysis*

Variable	Coefficient	s.e.	P value	X ²	RMSEA	IFI
1. Null model				32.902	0.156	0.932
2. Organizational support	0.387	0.016	0.000	9.660	0.081	0.960
3. Age	0.165	0.015	0.000	8.274	0.075	0.958
4. Organizational support x Age	0.596	0.027	0.000	7.193	0.069	0.970

Abbreviations: χ^2 , Chi square; IFI, Incremental Fit Measures; RMSEA, Root Mean Square Error of Approximation.

Source: Own research.

The results for the last model show that age significantly and positively moderated the relationship between organizational support and organizational citizenship behavior ($\beta = 0.596$, $p < 0.05$). Model four also has the best value of goodness-of-fit measures, which confirms that age should be included in the model as a moderator.

Furthermore, Table 5 shows that age on its own has an impact on organizational citizenship behavior (Model 3). Greater age was associated with greater intensity of this type of behavior. But to analyze age as a moderator of the relation between organizational support and organizational citizenship behavior, additional models were calculated. First, all respondents were split into three groups according to age. Then the impact of organizational support on OCB was tested in each group separately. The results are presented in Table 8.

Table 8.*Impact of organizational support on OCB in respondents grouped by age*

Variable	Coefficient	s.e.	P value	X ²	RMSEA	IFI
1. All respondents	0.387	0.016	0.000	9.660	0.081	0.960
2. AGE: up to 40	0.255	0.022	0.000	5.590	0.096	0.942
3. AGE: 41 to 50	0.392	0.028	0.000	4.124	0.080	0.959
4. Age: over 50	0.560	0.032	0.000	3.199	0.082	0.963

Abbreviations: χ^2 , Chi square; IFI, Incremental Fit Measures; RMSEA, Root Mean Square Error of Approximation.

Source: Own research.

It is shown that the impact of organizational support on OCB was weakest in the youngest group of respondents ($\beta = 0.255$, $p < 0.05$). Model 2 also has the worst goodness-of-fit measure values. In the last group (Model 4), the influence of organizational support on OCB was the strongest.

5. Discussion and implications

The aim of this study was to obtain empirical evidence to explain the relationship between perceived organizational support and organizational citizenship behavior in public sector organizations through the creation of job satisfaction. Our objective was also to extend the

current knowledge by exploring the extent to which the POS–OCB relationship varies by employee age. The structural equation modeling results allowed interesting conclusions to be drawn. The results confirm the first hypothesis – that POS positively influences the OCB of employees of public institutions. Employees who feel supported by their organization want to reciprocate that support by engaging in citizenship behavior. The higher the level of POS, the greater the level of OCB manifested. This confirms that POS is an important activating factor for OCB in public organizations – unlike in private organizations, where Podsakoff et al. (2000) found that it is individual factors, such as employee characteristics, that are more important than organizational factors such as organizational support. It is in public institutions that high power distance dominates, and formal structures are more important than informal arrangements (Jehanzeb, 2020). Therefore, employee support needs to be more visible and tangible so that this power distance does not lead to experience disconnect. Then employees will not engage in OCB (Danish et al., 2015).

Our results are consistent with empirical evidence from public organizations, including by Singh and Gupta (2015), who conducted research on a group of 200 public sector employees. De Geus et al. (2020) pointed out in their meta-analysis that, in the public sector, POS is recognized as one of the reasons for the higher level of OCB, as our research also confirmed. Jehanzeb (2020) writes that employees' trust in organizational policies and decision-makers is strengthened by organizational support systems and employee development programs, which, in turn, improves OCB. Also, the results of Sumarsi (2019) or Sumarsi and Rizal (2021) indicate that, if employees feel supported by the organization and this support is in line with their norms and expectations, then they feel a stronger commitment to stay in the organization, to voluntarily make additional efforts for the organization and to engage in other organizational citizenship behaviors. We also found a significant relationship between POS and OCB. Organ noted that employees' positive attitudes towards the organization (such as perceived organizational support) may be even more closely related to their extra-role behaviors than to their in-role behaviors (Organ, 1988). Wayne et al. (1997) argue that employees strive for a balance in the exchange relationship with the organization by displaying behavior appropriate to the level of commitment and support they receive from the organization.

Additionally, our research confirmed the second hypothesis – that the positive relationship between POS and OCB is moderated by age. The positive effect of POS on OCB is stronger among older employees. This relationship became stronger as the age of the respondents increased. This is the first such discovery in the public sector. This is in line with Sing and Singh's (2010) findings that older employees are more likely to exhibit citizenship behaviors than younger employees, while requiring more organizational support (Rakowska et al., 2020), with Bal et al. (2010) arguing that they are more aware of what this support should constitute.

Furthermore, the results provide empirical evidence to support the third hypothesis – that job satisfaction mediates the relationship between perceived organizational support and organizational citizenship behavior in such a way that the relationship is strengthened if we add

job satisfaction to it. This means that employees with higher job satisfaction are likely to display more citizenship behavior. This is in line with the findings of van Dick et al. (2008) and Zenker and Rütter (2014) confirming that job satisfaction positively influences organizational citizenship behavior. De Geus' (2020) analyses of public organizations also confirmed that job satisfaction is an important factor in OCB growth. The results of Yeo et al. (2013) clearly indicate that job satisfaction led to higher levels of OCB in the public organizations studied. Previous studies have also indicated the relationship between perceived organizational support and OCB, but there was a research gap on the relationship between these variables, including on job satisfaction as a mediator. Although OCB is behavior that is not expected to be rewarded, our research shows that POS improves employee satisfaction and encourages engagement in citizenship behavior. Therefore, the high awareness of the organization's support, which the employee really feels, builds job satisfaction, which in turn will encourage the employee to display extra-role behaviors. This, therefore, indicates the indirect existence of a social exchange mechanism between the leader of a public organization and his subordinates. Our results also indicated the use of reciprocal norms in organizational support theory, which explains how employees who feel cared for, supported, and enabled by the organization would return the good by displaying positive behavior in the form of OCB.

The results of our research confirm results obtained in contexts other than that of public organizations, as well as in other configurations of dependencies, e.g. the role of job satisfaction in mediating organizational justice and organizational citizenship behavior (Fachrudin and Sholihin, 2021). Relevant studies on these issues from the perspective of public organizations are still few. Therefore, our research enriches the literature on public organizations with an analysis of the relationships between perceived organizational support and organizational citizenship behavior taking into account job satisfaction as a mediator of this relationship. In addition, our results are a response to the calls of other authors regarding the need to include moderators in the POS-OCB relationship in the form of, for example, the age of the respondents (Meiske, 2018).

5.1. Practical implications

The research results also have some practical implications. They can contribute to a better understanding by managers and HR professionals of the importance of organizational support for the development of employees' citizenship behavior and encourage them to use activities and HR practices that would bring about such support. As Hammer et al. (2011) suggest, it is worthwhile for organizations to adopt policies and actions that will positively influence employees' perceptions of organizational support, because, if they feel supported by their organization, they are more likely to engage in citizenship behavior (Lambert, Lambert, 2000). In order to improve POS, we propose that public organizations take care of a fair system of reward and equal treatment of employees, especially in terms of supporting them in the performance of their duties. The research results proved that the positive relationship between

POS and OCB is moderated by age. This relationship is stronger for older workers. Our discovery is disturbing. Therefore, our recommendation is that public organizations in which key positions have been occupied by the same elderly people for many years should open up to young people. These organizations should be focused on positive relations with these employees as well. For people under 40, personal career and development are very important (Ok, Vandenberghe, 2016). The organization should therefore invest in these employees and offer them career advancement. If career-minded employees receive support to develop themselves, they are likely to be more likely to engage in OCB.

As job satisfaction has been proven to mediate the relationship between perceived organizational support and citizenship behavior, organizations should focus on how to increase job satisfaction. This applies especially to identifying factors that might support employees, because the perception of this support influences citizenship behaviors that bring multiple benefits to the organization. It is worth paying attention to the employment policy, development opportunities or communication in the organization. It is also important to take into account the age structure of employees and to identify the needs of different generations so that solutions intended to increase job satisfaction can be adapted to the expectations of different generations.

Managers should pay attention to the extent to which employees feel supported by the organization and take steps to ensure that employees perceive the organization as supportive. An important role may be played by shaping the right organizational culture, positive working environment, and leadership style, as research suggests that attributes such as job satisfaction are important factors influencing OCB in the public sector (de Geus et al., 2020). Consequently, the sense of support from the organization may, according to the rule of reciprocity, improve commitment to achieving the organization's goals (this is indicated, for example, by the findings of Sumarsi (2019) or Firmansyah et al. (2022), who confirm that organizational commitment mediates the relationship between perceptions of organizational support and citizenship behavior) but may also engender other positive employee attitudes and behaviors, including citizenship ones. The research results may therefore be useful for both practitioners and other researchers engaged in this issue.

5.2. Conclusions

The issues raised, both in the literature analyses and in the empirical research, have captured how perceived organizational support is related to organizational citizenship behavior and job satisfaction of employees in public institutions. This helped to build a picture of these relationships and their strength. The research confirmed that perceived organizational support influences employees' citizenship behavior, and job satisfaction was found to be an important mediator of these relationships. Furthermore, the age of the employee was found to be relevant to these relationships. It follows that the study of individual relationships is useful for the development of organizational behavior theory and management practice in shaping desirable employee attitudes and behaviors. In addition, conducting research in public organizations has

helped to extend the findings on the attitudes and behaviors of employees in this sector. It indicated that, in such organizations, although it appears that the sense of service and commitment to a mission is a sufficient premise for OCB, job satisfaction is important for the development of organizational citizenship behavior.

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GENERATION Z'S ATTITUDES TOWARDS TOURISM STUDIES AND CAREERS VS. ITS TOURISM ACTIVITY

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Purpose: This study provides a closer look at Generation Z as tourists, students, and tomorrow's tourism and hospitality (T&H) practitioners. Specifically, this study proposes new insights into theoretical concepts and empirical evidence by examining T&H students' tourism activity (as representatives of Generation Z) and the way it may affect their attitudes towards their studies as well as their intentions towards working in the T&H industry upon graduation.

Design/methodology/approach: A desk-research method and an online questionnaire were used. Data were collected from students of Higher Educational Institutions in Northern Poland that offered T&H programs.

Findings: This study has identified the main characteristics of Generation Z's tourism activity and has also proven that tourism activity of this study's participants may be a critical factor in determining their positive perception of T&H as their field of study and as a place of their future employment.

Research limitations/implications: The study found that both the recovery and spillover theories may constitute a useful theoretical framework to explain the proposed relationships in a non-occupational setting, such as T&H students. In doing so, the existing knowledge has been developed, and a new insight has been provided. However the results of this research cannot be generalized, thus, future studies with a larger sample of students from other HEIs are recommended.

Practical implications: Findings of this study have several implications for T&H educators and practitioners, particularly those responsible for social media promotion and human resources management. Specifically, it is vital to create short and understandable content that will satisfy Gen Z's need to obtain information quickly through mobile devices to design attractive social media websites of tourist attractions and other tourist entities to create a favorable image and attract Gen Z's attention. Tourism management can take also through an educational system to support students in developing their interests in travel via different university activities. Finally, T&H industry must also redefine its HR policy keeping in mind

characteristics of new entrants from Generation Z to attract and retain young and talented employees within T&H organizations.

Originality/value: This study context fills a cognitive gap and contributes to a better understanding of Generation Z's tourism activity and how it may relate to students' attitudes and behavioral intentions as future professional workforce. Moreover, the current study extends empirical results to the context of T&H students in East-Central Europe, where to the best of Authors' knowledge, a paucity of such research exists.

Keywords: Generation Z, tourism behavior, T&H students, employment aspirations.

Category of the paper: Research paper.

1. Introduction

Tourism is one of the key forms of spending free time (Niemczyk et al., 2019). In recent years, the number of tourist traffic participants has been growing year by year. Unfortunately, the Covid-19 pandemic temporarily slowed down the growth due to numerous restrictions that significantly prevented free travel around the world. Currently, one can observe a rebirth of tourism (UNWTO, 2022) with an increasing number of countries lifting restrictions and opening up to receiving more and more tourists.

It seems that in the near future people from Generation Z will probably be the main consumers of tourism services, as this generation is becoming an "up-and-coming" segment of the travel industry mass market (Chang et al., 2023, p. 50). In 2019, Generation Z was the most numerous generation on the globe, accounting for 32% of the world's population, i.e. 2.47 billion of the planet's 7.7 billion people, outnumbering both the millennial and the baby boom generations (Spitznagel, 2020). In Poland, in 2018, this generation accounted for 23.4% of the population (8.983 million), and it was also the most represented from among other generations (BB, X, Y) (Sadowski, 2018).

It should be noted that the behaviors and needs of this group differ from the previous generations, and thus Gen Z plan their trips and travel in a characteristic way. Among others, this is due to the fact that Generation Z has never known a world without immediate access to the Internet, free access to information and communication channels. They grew up during the global digital revolution associated with the rapid development of the Internet, the spread of Youtube, Facebook and Twitter, as well as eLearning and eCommerce (Caraballo, 2019). They are somehow integrated with social media in everyday life. On a personal level, representatives of Generation Z are looking for immediate acceptance and recognition in social media, because this is where they interact with their peers and maintain relationships and contacts (Nikiel, 2019).

The factors that distinguish Generation Z from the millennial generation include self-awareness, perseverance, a realistic view of life, an innovative state of mind and self-confidence (Merriman, 2015). Among others, the above features make the new generation perceive travel as a tool that can enrich and affect their lives and the search for their own identity. Young tourists are interested in contact with a different reality; they are fascinated by discovering different cultures based on their own taste, and they are used to organizing their own holidays. If they use tour operators' offers, they are very demanding towards offers in the tourism sector (Monaco, 2018).

They live in the times of the so-called fourth industrial revolution, which leads to a transformation of the global market (including tourism). This global evolution and the development of tourism are constantly accompanied by economic, social and political changes. Generation Z, with its needs, mentality and values, is also constantly undergoing transformation (Dimitriou, AbouElgheit, 2019). Therefore, it is undoubtedly worth following them closely (Świerkosz-Hołysz, 2016), especially because this young part of society still remains not fully diagnosed and is still in the process of creation. Thus, there is a need for continuous research on generations, including Gen Z, in order to effectively respond to their needs and demands (Robinson, Schänzel, 2019).

It is widely recognized that tourism activity may influence one's life (McCabe, Johnson, 2013; Yeh, 2013). Among the many benefits of tourism, the literature mentions rest and regeneration, an impact on well-being, gaining new experience, creating opportunities for learning, personal growth, and development (Li, 2000; McCabe, 2009; McCabe, Johnson, 2013; Gilbert, Abdullah, 2004; Yeh, 2013). Participation in holidays gives people an opportunity to get away from their daily environment, to solve their problems actively, to recover from difficulties, and to face the future more optimistically (McCabe, 2009). Moreover, with an open-minded approach, tourism is an irreplaceable factor of self-education (Global Code of Ethics for Tourism), providing an opportunity to see more of the world, to learn about other cultures, to experience new and different places (Li, 2000) – simply put, travel broadens the mind.

It is empirically proven that tourism involvement defined as “a person's perceived relevance of tourism activities and the motivational state with regard to them” (Havitz, Dimanche, 1990, as cited by Yeh, 2013, p. 215), may influence people's feelings and attitudes in different life domains, including the work domain (Grobelna, 2018). Recognition of positive effects of tourism on tourists as employees is clearly visible. For example, there is extensive empirical evidence in tourism and hospitality (T&H) that tourism involvement may have a positive impact on employees' customer orientation (Grobelna, 2018), service performance (Suhartanto et al., 2018), work engagement and job satisfaction (Yeh, 2013).

At the same time, the positive effects of tourism on tourists as students (non-occupational individuals and Gen Z members) seem to be insufficiently investigated in both theoretical and conceptual work, as well as in empirical research. Specifically, there is a cognitive gap referring

to students' tourism activity and its influence on their attitudes towards their field of study as well as their future career intentions, especially that the literature underlines that although students are not employees, their core activities require their involvement in structured and mandatory activities (e.g. completing assignments or attending classes), which may be regarded as "work" (Zupančič et al., 2023). Thus, if life outside work, such as participation in tourism, may affect employees' work (Grobelna, 2018; Sonnentag, 2003), by analogy, it seems reasonable that T&H students' participation in tourism may also potentially influence their attitudes towards the undertaken studies and their perception of future careers in T&H. Gaining such knowledge is important for several reasons.

Since T&H is perceived as a people-oriented industry (Breen et al., 2004; Haldorai et al., 2019), dependent on top-quality employees (Zagonari, 2009), high staff turnover (Glińska-Noweś, 2020; Sibanyoni et al., 2015; Zagonari, 2009) results in a continual challenge of finding and retaining high-quality staff (El-Houshy, 2014; Song, Chathoth, 2011; Wan et al., 2014). Moreover, tourism education suffers from poorer enrolment combined with the candidates' low levels of aspiration, which leads to their low long-term career engagement in the industry (Ramakrishnan, Macaveiu, 2019). Many T&H graduates do not enter the industry upon graduation (Barron et al., 2007) and perceive tourism jobs as "short-lived professions" (Jiang, Tribe, 2009, p. 7). Thus, unsurprisingly, there are many countries, including Poland, with projected talent deficit trends at the university level (Global Talent Trends..., 2015).

Additionally, the outbreak of the COVID-19 pandemic and its consequences placed extreme challenges on the already fragile T&H sector raising serious doubts as to its survival (Kaushal, Srivastava, 2021). Staff shortages have been identified as one of the key challenges for travel and tourism on its path to recovery from COVID-19 (Travel & Tourism Economic Impact, 2022; Leung et al., 2021). If future talent supply falls short of talent demand, below-potential growth and foregone investment, higher wage costs, and eroded competitiveness may be its consequences (Understanding Future Talent..., 2021). Moreover, higher workload, lower morale, and less creativity among the current workforce (Global Talent Trends..., 2015) may lead to a deterioration in customer service and standards (Understanding Future Talent..., 2021).

Thus, it is of paramount importance for educators and practitioners to discern T&H students' employment intentions (Grobelna, Marciszewska, 2016; Roney, Öztin, 2007), as based on the premise of the Theory of Planned Behavior (TPB) (Cameron et al., 2012), understanding their attitudes towards their future careers might predict their future behavior (Kusluvan, Kusluvan, 2000; Teng, 2008) providing support in winning the war for talents (Wong et al., 2017). Therefore, it is timely to gain a current understanding of the perception of studies and careers from future T&H employees, who are now Generation Z representatives, via a new prism of their tourism activity. Thus the aim of this study is to examine T&H students' tourism activity (as representatives of Generation Z) and the way it may affect their attitudes towards their studies as well as their intentions towards working in the T&H upon graduation.

Despite the increasing focus on Generation Z (Agnes, 2020), including T&H (Chang et al., 2023; Dimitriou, AbouElgheit, 2019; Entina et al., 2021), empirical research explaining the potential consequences of their tourism activities for their studies and employment aspirations within T&H fields seems to be overlooked. Hence this study context fills the cognitive gap and adds to the management literature, particularly within T&H, by shedding new light on a better understanding of Generation Z's attitudes and behaviors both as tourists, T&H students and future qualified T&H workforce. Both the recovery and spillover theories provide a theoretical framework for this study concept.

2. Literature review

Characteristics of Generation Z

Generation is a term describing a group of people born around the same time (Wiktorowicz, Warwas, 2016). In the sociological sense, the word “generation” refers to a population which differs from other populations not only in age but, above all, in attitudes, views, recognized values, aspirations or lifestyle (Karmolińska-Jagodzik, 2012). The literature underlines that a generation acquires values and a belief system principally during its formative years (Pendergast, 2010). The generational theory seeks to understand and characterize cohorts of people according to their membership in a generation, which is objectively assigned according to the year of birth (Pendergast, 2010). Currently, society can be divided into the following generational groups (Warwas, Rogozińska-Pawełczyk, 2016; Wiktorowicz, Warwas, 2016):

- generation of traditionalists (Veterans) – born in 1922-1945,
- generation of Baby Boomers – born in 1946-1964,
- generation X – born in 1965-1979,
- generation Y – born in 1980-1989,
- generation Z – born after 1990.

Generations move as a collective through society maintaining their unique generational characteristics (Pendergast, 2010). For example, representatives of generations X and Y tend to lean much more towards what is old and proven, and they are reluctant to change. Generation Z is a complete opposite; for them changes are not a major problem. They perfectly find themselves in new and unusual situations. They are curious about the world and the ever-changing reality. Comfort and satisfaction come first for them. The new generations are generations of ideas and changes (Lechowicz, Pikuła, 2013).

Generation Z, is also called as Gen Z, post-millennials (Niemczyk et al., 2020) or Gen Zers (Dimitriou, AbouElgheit, 2019). So far, it has been noticed that people from this generation are characterized by extraordinary openness, self-confidence, independence and high self-esteem.

Highly developed tolerance at every level plays a particularly important role in their lives (EY Polska, 2022). These are assertive people who care about the so-called work–life balance and living in accordance with their own values. For Gen Zers work is not an end in itself, but a means to functioning independently and pursuing their passions. They do not get attached to one workplace, and it is easy for them to change it (Bebłot, 2023).

On the other hand, they look anxiously to the future. They face many challenges to which their parents could not find solutions, such as the climate crisis, the migration crisis, or social unrest (Broadbent et al., 2017). Representatives of Generation Z are mainly guided by humanistic values, morality and ethical behavior and are more interested in the human impact on the environment than any other generation before. In addition, they are more likely to accept responsibility for the negative effects of climate change, which is manifested in many pro-ecological behaviors, for example, limiting broadly understood consumption (Dimitriou, AbouElgheit, 2019).

It is also the first generation that does not know a world without the Internet. Generation Z grew up during the ever-rising popularization of the Internet and the boom of social media. Due to the fact that modern technologies have accompanied them since an early age, the Internet plays an important role in their daily lives. For this formation, it is a natural environment of spending their leisure time – both communicating and looking for information and entertainment (Caraballo, 2019). Therefore, interest in reporting their lives on social media, mainly such as Facebook (Messenger), Instagram, Whatsapp or Snapchat, is a popular phenomenon in their environment (Seitz et al., 2014). Thanks to social media, they have an opportunity to immortalize and share important moments with the world, such as traveling (Chang et al., 2023), which plays an important role in this generation's life in the process of self-development and self-realization (Niemczyk et al., 2020).

Tourism activity of Generation Z and its potential consequences for their study and perception of future work in T&H

Gen Zers are eager to travel, they do not fear leaving their place of residence or getting to know new places; they tend not to put down roots. At the same time, they quite easily succumb to market trends. Due to the dynamically developing means of transport, mainly low-cost airlines, Generation Z is increasingly eager to take a tourist trip. Using online comparison websites available on the market, they search for the most attractive price deals, owing to which they travel even several times a year.

They abandon package tours prepared by travel agencies in favor of independent reservations (Monaco, 2018; Niemczyk et al., 2020). Gen Z are individual tourists who do not need professional preparation. If they use tour operator offers, they focus on buying customized offers. In addition, they are characterized by a lack of loyalty to the seller's brand and by high substitutability and competitiveness in the selection of a tourism product (Dimitriou, AbouElgheit, 2019). They love a sense of freedom and independence, thus travel is

an indispensable part of their lives. Generation Z are curious about the world and ready for new experiences (Niemczyk et al., 2020).

Due to the fact that the Internet is an indispensable part of Generation Z's lives, they often look to it for inspiration regarding their trips. Influencers play an important role in creating travel needs and indicating new destinations (Dimitriou, AbouElgheit, 2019). Generation Z are looking for more authentic and personal experiences than visiting typical tourist attractions (Monaco, 2018). They often decide to visit less popular destinations. Interest in culture, history or local cuisine is an important aspect of Generation Z's travel. This is a generation that is also open to broadly understood diversity (Wanagos et al., 2023).

Many persons from this generation also value sharing their travel experiences online, which develops the popularity of social media. In addition to the above-mentioned social media, Gen Zers are very interested in innovative technologies, e.g. mobile applications that facilitate planning a trip and the trip itself (Dimitriou, AbouElgheit, 2019), or multimedia exhibitions that inspire them to visit new places (Kugiejko, Kociszewski, 2021).

Generation Z travel is also characterized by an ecological approach. Many young people are aware of the impact of tourism on the environment (Bogalecka, Grobelna, 2023) and try to choose more sustainable forms of travel, such as ecological tourism, cycling or trekking.

Generation Z's traveling is also related to education and personal development. Many young people travel to gain new experiences and meet new people (Stańczyk, 2021). Thus, unsurprisingly, participation in tourism may affect these individuals' lives. In the case of T&H students as representatives of Generation Z, life outside the university, including their tourism activity, may have a potential impact on how they feel about their studies and future careers in the studied fields (Grobelna, 2022). This may be due to several reasons.

Firstly, it is well known that tourism answers human's cognitive needs via meeting different people, experiencing new places, other cultures, religions, and nations (Przećławski, 1996). It also provides a great opportunity to experience many different service relationships, as T&H belongs to high-contact service industries (Lin, 2007). Such experiential learning through traveling opens eyes to a broader picture of world lives and may be significant for personal growth and development (Li, 2000). This unique, positive experience of tourism may also have learning and motivational potential for T&H students (Generation Z members), who through the lens of their own direct and authentic experiences may enrich their knowledge of the studied field of T&H, which, in turn, may consequently lead to a more favorable perception of T&H as a place of their future careers (c.f. Grobelna, Dolot, 2018; Grobelna, Wyszowska-Wróbel, 2021).

Secondly, tourism can also be considered as a short break from daily duties (Yeh, 2013). Thus, by analogy, if periods of rest from work may help maintain well-being at work (Sonnentag, 2003), the same can be assumed for students who via a recovery process of participating in tourism may enhance their well-being in the study domain. If recovery processes that occur during vacations and other breaks bring some relief from negative

experiences at work (Sonntag, 2003), they can also bring students some relief from their study demands, especially that T&H students experience excessive study loads characteristic of most T&H programs which, apart from classroom learning, require extensive practical exposure (Grobelna, Tokarz-Kocik, 2018). Thus, it can be stated that participating in tourism may provide students with a sense of escapism and release from their study tension contributing to their recovery and acquisition of new resources which may influence their approach towards their studies and career aspirations within T&H.

Thirdly, as mentioned above, tourism is an activity most often associated with rest and relaxation (Global Code of Ethics for Tourism), and indeed, leisure is an important facet of young people's lives (Hultsman, Kaufman, 1990). Holiday-making as a form of leisure activity and experience can help individuals to enhance their sense of happiness (Gilbert, Abdullah, 2004). Thus, tourism activity may provide satisfaction, generate positive moods and, consequently, enhance individuals' well-being (Gilbert, Abdullah, 2004). Moreover, satisfaction within a specific life domain, such as leisure, may spill over into other domains (Yeh, 2013). The spillover theory insists that a person's attitudes, emotions, skills, and behaviors in one domain flow into another one and vice versa, as the process can occur in both positive and negative ways (Lee et al., 2021). Therefore, it is assumed that positive experiences in tourism may also have a positive spillover effect on how students feel in other domains, such as their T&H studies and future work within T&H.

Generation Z as a challenge for human resource management in the T&H industry

T&H has been called the "the world's leading employer" (Tribe, Lewis, 2003, p. 67) and labor-intensive industry (Kusluvan, 2003; Sibanyoni et al., 2015; Zopiatis et al., 2014). Being a service-related industry, T&H depends on human workforce (Datta, Jha, 2015), which means that most services are based on human (employee) performance (Kusluvan, Kusluvan, 2000), and thus the role of personal service in the service delivery process is crucial and irreplaceable (Kusluvan, 2003).

Before the COVID-19 pandemic, the travel and tourism sector accounted for 1 in 5 new jobs created across the world during 2014-2019, and 10.3% of all jobs overall (334 million). Unfortunately, in 2020, 62 million jobs were lost. In 2021, a rise in the number of jobs was observed to 289.5 million, which means that the sector supported 1 in 11 jobs across the entire economy in 2021 (Travel & Tourism Economic Impact, 2022).

When competitive advantage is attained through people (employees), their motivation to work and their commitment to the industry become of particular importance (Kusluvan, Kusluvan, 2000). Unfortunately, many T&H organizations around the world have faced a chronic problem of attracting and retaining high-standard employees (Grobelna, Wyszowska-Wróbel, 2021; Lee 2014; Wan et al., 2014) leading to a shortage of skilled personnel to staff the large and still growing number of T&H businesses (Baltescu, 2016; El-Houshy, 2014; Richardson, 2009; Richardson, Butler, 2012). Moreover, the high rate of

labor turnover (Brown et al., 2015; Choi, 2006; Davidson et al., 2010; Glińska-Neweś et al., 2020; Gordon et al., 2019; Kusluvan, 2003; Lu et al., 2016; Robinson et al., 2014; Sims, 2003) and post-pandemic shortages of employee (Travel & Tourism Economic Impact, 2022) creates one of the greatest challenges for the industry today.

Thus, Generation Z entering the market is an opportunity for employers to develop their company through the special potential that this generation can offer. Gen Z is not only a breath of freshness and new energy, but also a different, broader look at the company's opportunities. They prefer unconventional solutions and thinking outside the box to provide innovations and creativity so characteristic of gen Z (Chang et al., 2023; Tyszkiewicz). Achieving their goals comes easily to them. It is a generation group saturated with high ambitions and focused on professional success (Ratajczak, Świerkosz-Hołyś, 2014; Świerkosz-Hołyś, 2016).

However, this generation's expectations regarding working conditions significantly differ from the requirements of the older generation (Czubasiewicz, 2020). Generation Z are looking for jobs that will provide them with continuous development and new challenges. They value a good atmosphere, decent remuneration, attractive benefits, job security, as well as professional development opportunities (Dolot, 2017). Therefore, for this generation, the essence is in the constant acquisition of new skills and in job satisfaction (Dolot, 2017; Czubasiewicz, 2020).

Unfortunately, however, young people are not attached to the workplace; they are accustomed to changes and feel fulfilled in them (Jęczmionka-Majchrzak, 2023). No wonder then that they are also particularly prone to change an employer quickly, especially when their expectations are not met and their self-esteem is disturbed (Dolot, 2017; Jęczmionka-Majchrzak, 2023). Moreover, it is important for "Zs" to maintain a work-life balance (Czubasiewicz, 2020) – work is important to them – but not the most important (Jęczmionka-Majchrzak, 2023).

Therefore, considering the above, it can be concluded that meeting the requirements set by the youngest generations may prove to be a considerable challenge for T&H employers, the more so, as the results of previous research show, that T&H students do not believe a career in the TH industry offers them the factors they find important when choosing a career (El-Houshy, 2014; Grobelna, 2017; Richardson, 2009; Richardson, Butler, 2012; Richardson, Thomas 2012). Specifically, studies reveal that students still do not see the industry as an appealing career path (Richardson, Butler, 2012), and their commitment to work in the industry is negatively affected by many aspects, such as social aspects, lack of family life, long working hours and heavy workloads, stressful, exhausting and seasonal (unstable) jobs as well as low remuneration insufficient to lead satisfactory life and poor promotion opportunities and prospects, etc. (Aksu, Köksal, 2005; Mannaa, Abou-Shouk, 2020; Kusluvan, Kusluvan, 2000; Kusluvan, Kusluvan, 2003; Richardson, 2009; Tan et al., 2016). These specific job characteristics may result in the industry's failure to recruit and retain qualified T&H graduates

(Gen Z members) who will be discouraged from finding employment within the industry, and instead put their transferable skills to use across other occupations (Kusluvan, 2003).

To sum up, although “Zs” have many common features, it should be remembered that this is a generation with high self-awareness and a different worldview. Therefore, it seems that skillful recognition of their needs and an individualized approach to each person is a recipe for attracting employees from the Z population (Walaszczyk, Mnich, 2020) to ensure that potential employees – current T&H students– do not fail to enter the industry upon graduation.

3. Methods

This study was conducted among T&H students from higher educational institutions (HEIs), both public and private, located in the Tricity agglomeration (Pomeranian Voivodeship, Poland). Tricity is perceived as an important academic center of Northern Poland (Grobelna, Marciszewska, 2016; Grobelna, Dolot, 2018), where T&H is crucial for regional economy and contributes to creating a growing number of new workplaces within T&H and the related sectors (Bogalecka, Grobelna, 2023; Grobelna, Tokarz-Kocik, 2018; Marciszewska et al., 2017; Wrona, 2018). The selection of students from the respective HEIs as the study sample was based on convenience and access to students enrolled in T&H courses continuously on educational offer within these T&H and on well-established cooperation/familiarity between researchers and these HEIs. Lecturers of the participating HEIs to whom the study aim was explained and who agreed to cooperate in data collection were contacted for their support in ensuring a reasonable number of responses and data reliability (Kim, Park, 2013)

Data were collected through an online questionnaire created in the Google Forms application and distributed to students via the Microsoft Teams platform. The respondents were requested to open the link sent to them and fill in the questionnaires during their classes, as agreed with the teachers of the participating HEIs. The students were assured of their voluntary participation in this study and of the anonymity and confidentiality of their answers. Moreover, they were also informed that their participation did not constitute a formal part of their study program (Barron et al., 2007). A pilot test had been conducted beforehand to verify a good understanding of the survey instrument, and its appropriateness was confirmed by feedback. Ultimately, 190 usable surveys were obtained. The Statistical Package for the Social Sciences and Microsoft Excel applications were used to extract the data and results.

4. Results

Respondents' profile

An analysis of the respondents' profile shows that female respondents accounted for the majority (75.8%) of all surveyed students; they were mostly born within the years 2000-2003 (83.2%), so they were mostly between 20 and 23 years old. Much fewer respondents (16.8%) were slightly above 23 years of age. They were mostly full-time students (74.7%) of the first cycle program in Tourism and/or Hospitality (96.8%).

Characteristics of Generation Z tourism activity

4.1.1. The frequency, length, and directions of trips

As regards the frequency of students' tourist trips, almost half of them (49.5%) declared that they travel 2-4 times a year (Table 1), with an average length of stay of 4-6 days (Table 2).

Table 1.

Characteristics of students' trips: the frequency of trips

Question	Answer	Once a year or less	2-4 times a year	More than 4 times a year
How often do you travel for tourist purposes?		66 34.7%	94 49.5%	30 15.8%

Source: own study.

Table 2.

Characteristics of students' trips: the length of trips

Question	Answer	1-3 days	4-6 days	More than 6 days
How long does your trip take on average?		60 31.6%	94 49.5%	36 18.9%

Source: own study.

Most students pointed to domestic trips (53.7%). However, a large percentage of the respondents (44.2%) also indicated trips to other European countries (Table 3), although a small percentage (2.1%) of students also made trips to non-European countries.

Table 3.

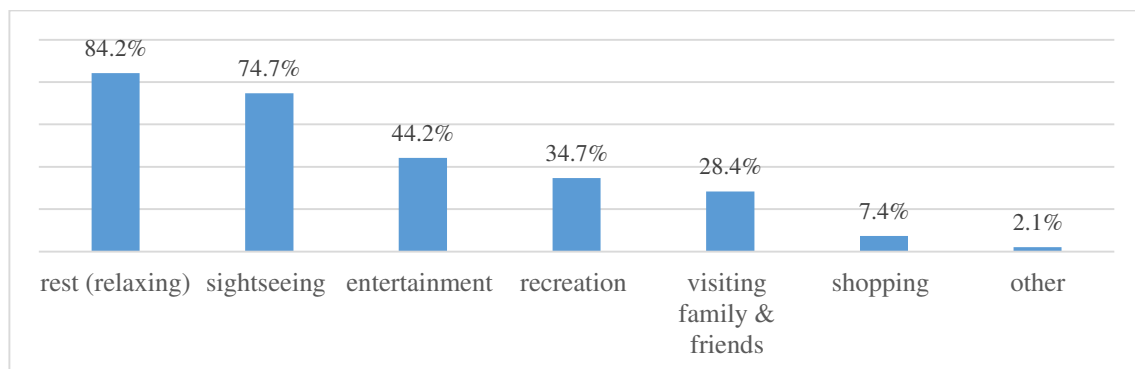
Characteristics of students' trips: directions of trips

Question	Answer	I travel all over the country	I travel to European countries	I travel to non-European countries
Where do you usually travel?		102 53.7%	84 44.2%	4 2.1%

Source: own study.

Analyzing the aims, company, and seasons of students' tourist trips, is worth noting that rest (relaxation) and sighting are among the most frequently indicated aims of their trips (84.2% and 74.7%, respectively). Students also marked entertainment (44.2%) and recreational

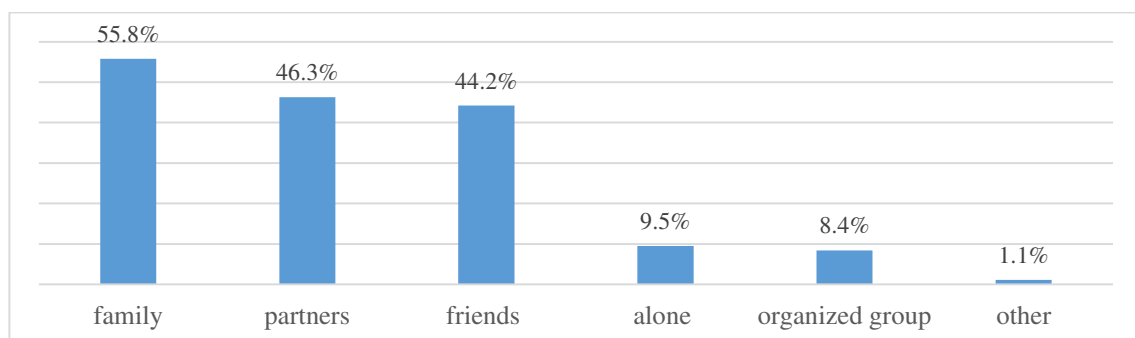
purposes (34.7%) (Fig. 1). Analyzing their company during the trips, respondents pointed to traveling mostly with family (55.8%), partners (46.3%), or friends (44.2%). They rarely traveled alone (9.5%) or in organized groups (8.4%) (Fig. 2).



Note: Responses do not sum up to 100% as this was a multiple-choice question.

Figure 1. Characteristics of students' trips: aims of trips.

Source: own study.

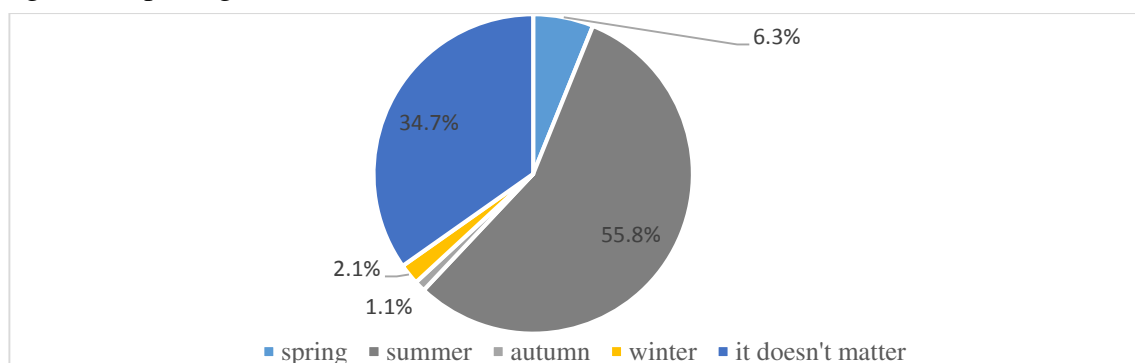


Note: Responses do not sum up to 100% as this was a multiple-choice question.

Figure 2. Characteristics of students' trips: the company during trips.

Source: own study.

More than half of the investigated students (55.8%) indicated that they traveled mostly during the summer; however, for one-third of them (34.7%), the season does not matter in taking such trips (Fig. 3).



Note: Responses do not sum up to 100% as this was a multiple-choice question.

Figure 3. Characteristics of students' trips: the season of trips.

Source: own study.

4.1.2. Planning, organizing, and reporting tourist trips: the critical role of social media

Given the form of organization of the trip (Table 4), students mostly (83.1%) declared that they definitely or rather booked individual tourist services, such as transportation, hotel, insurance services, etc. Thus, unsurprisingly, the majority of them (69.5%) partly plan their tourist trips, whereas one in five students (21.1%) completely plans her/his trips (from A to Z). Only 9.5% of the Generation Z respondents described their trips as spontaneous (Fig. 4). Answering the question of how long before the departure they start to organize their trips, half of these respondents (50.5%) indicated more than 30 days in advance. 27.4% of students indicated the period of 30–15 days before it, whereas the remaining ones (22.1%) declared that they planned their trips 14 and even fewer days before the departure.

Table 4.
Forms of trips organization

Question	Answer	Definitely yes	Rather yes	Neither yes nor no	Rather no	Definitely no
Do you book individual tourist services by yourself (transport, hotel, insurance, etc.) while organizing your tourist trips?		92 48.4%	66 34.7%	18 9.5%	14 7.4%	- -

Source: own study.

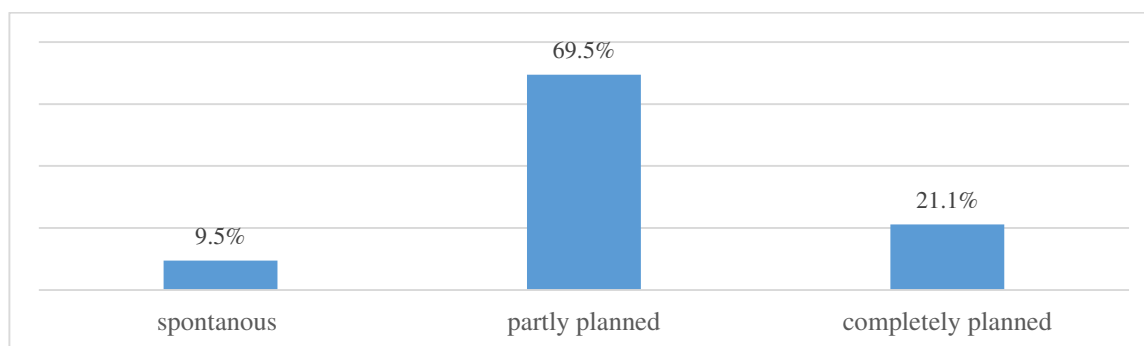


Figure 4. Character of trip planning.

Source: own study.

What really matters for the overwhelming number of respondents (93.7%) while organizing a trip is its price (Table 5). Moreover, apart from the price, young people also pay great attention to service employees. For more than half of the respondents (52.6%) that aspect was definitely or rather important (Table 6). Therefore, these findings revealed that students primarily look for affordable offers and pay attention to service relations.

Table 5.
The importance of trip prices for Generation Z travelers

Question	Answer	Definitely yes	Rather yes	Neither yes nor no	Rather no	Definitely no
Do you usually look for attractively priced offers while organizing your tourist trip?		126 66.3%	52 27.4%	10 5.3%	2 1.1%	- -

Source: own study.

Table 6.*Characteristics of students' trips: the frequency of trips*

Question \ Answer	Definitely important	Rather important	Neither important nor unimportant	Rather unimportant	Definitely unimportant
How important a role do tourist service employees play during your trips?	24 12.6%	76 40.0%	64 33.7%	18 9.5%	8 4.2%

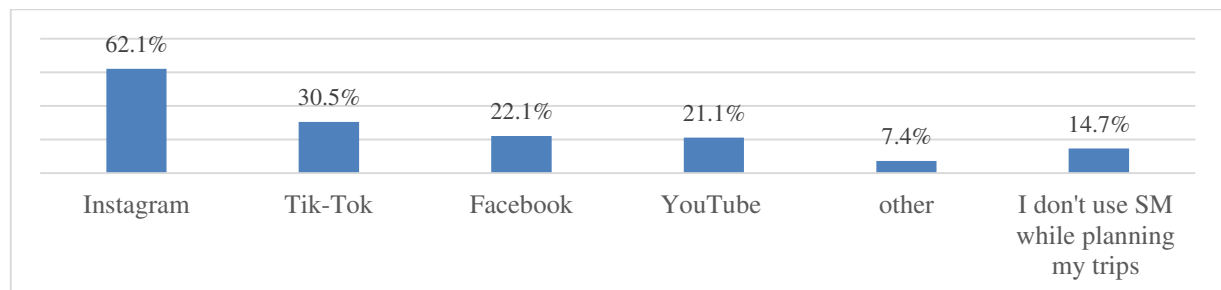
Source: own study.

The question of whether social media (SM) play an important role in planning students' tourist trips was answered positively by more than half of the respondents (53.7%) (Tab. 7), with an indication of mostly Instagram (IG) (62.1%), Tik-Tok (30.5%) and Facebook (FB) (22.1%) (Fig. 5). They scroll SM for a variety of information, mostly to read opinions/comments about particular tourist destinations (68.4%), to see movies/pictures (52.6%) and to receive information relating to tourist attractions (51.6%) (Fig. 6).

Table 7.*Planning tourist trips: the importance of social media*

Question: \ Answer	Definitely yes	Rather yes	Neither yes nor no	Rather no	Definitely no
Do social media (SM) play an important role in planning your tourist trips?	40 21.1%	62 32.6%	48 25.3%	32 16.8%	8 4.2%

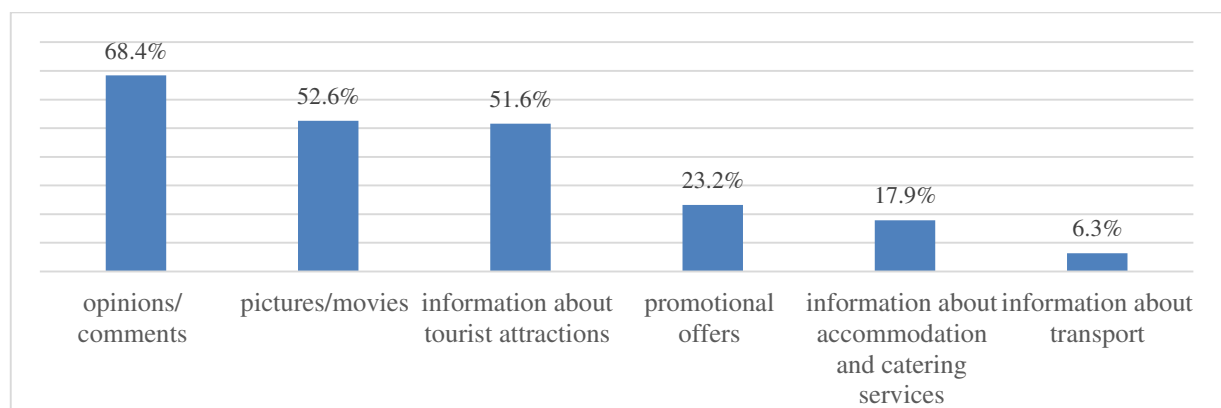
Source: own study.



Note: Responses do not sum up to 100% as this was a multiple-choice question.

Figure 5. Planning tourist trips: types of SM as a source of tourist information.

Source: own study.

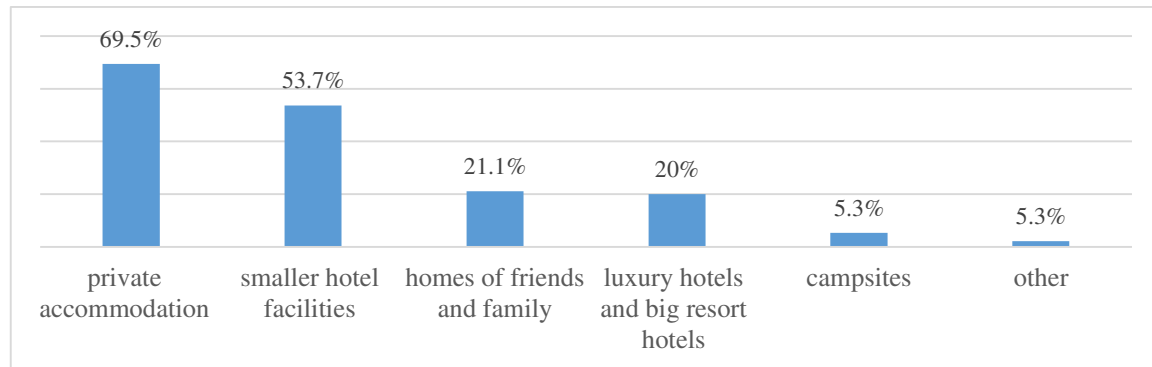


Note: Responses do not sum up to 100% as this was a multiple-choice question.

Figure 6. Types of information looked for in SM while planning tourist trips.

Source: own study.

Analyzing accommodation and transport services chosen by Generation Z (Fig. 7), it is worth noting that respondents mainly preferred private accommodation (rooms, apartments, holiday homes) (69.5%) and smaller hotel facilities (53.7%).

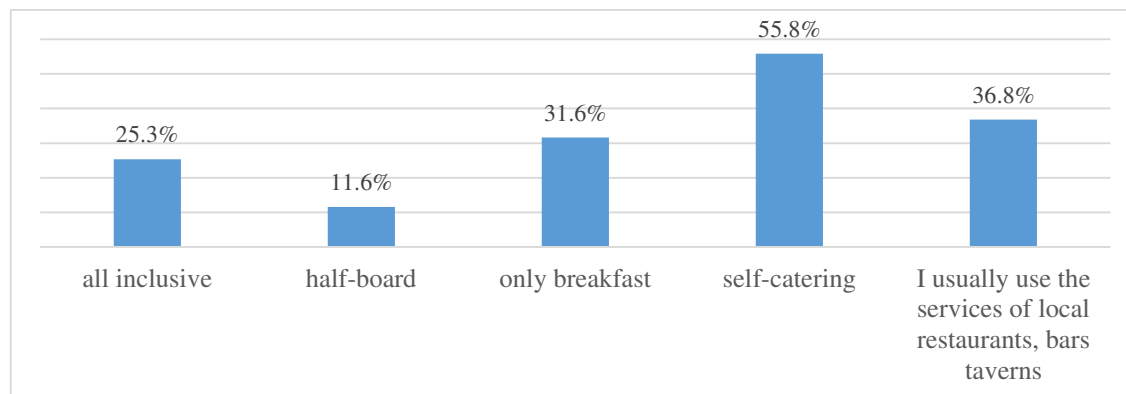


Note: Responses do not sum up to 100% as this was a multiple-choice question.

Figure 7. Preferred accommodation.

Source: own study.

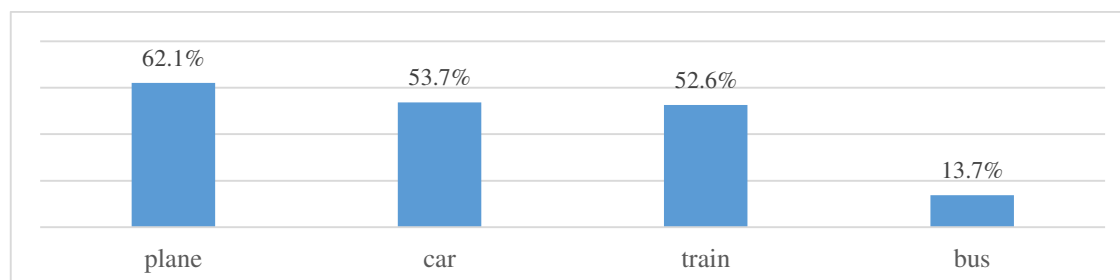
Moreover, given the form of catering (Fig. 8), students mostly prefer self-catering (55.8%); however, they also indicated visiting local restaurants, bars, taverns (36.8%), which may have a positive impact on the destination's tourist market. Regarding transportation services, although the plane is the most preferred means of their transport (62.1%), they also indicated traveling by car (53.7%) and by train (52.6%) (Fig. 9).



Note: Responses do not sum up to 100% as this was a multiple-choice question.

Figure 8. Preferred catering.

Source: own study.

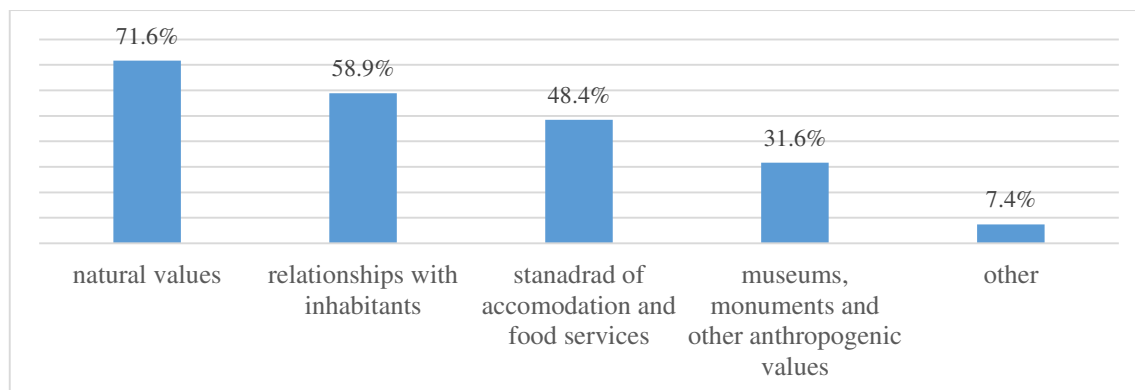


Note: Responses do not sum up to 100% as this was a multiple-choice question.

Figure 9. Preferred means of transport.

Source: own study.

Finally, while asking young respondents what has the greatest impact on their impressions from their tourist trips (Fig. 10), Generation Z mainly pointed to natural values (71.6%) and relationships with inhabitants of the visited destinations (58.9%). Thus, it can be said that for the young generation direct contact with nature and with people may create the unique tourist experience of their travels.



Note: Responses do not sum up to 100% as this was a multiple-choice question.

Figure 10. Factors influencing the unique experience of participation in tourism from the Generation Z perspective.

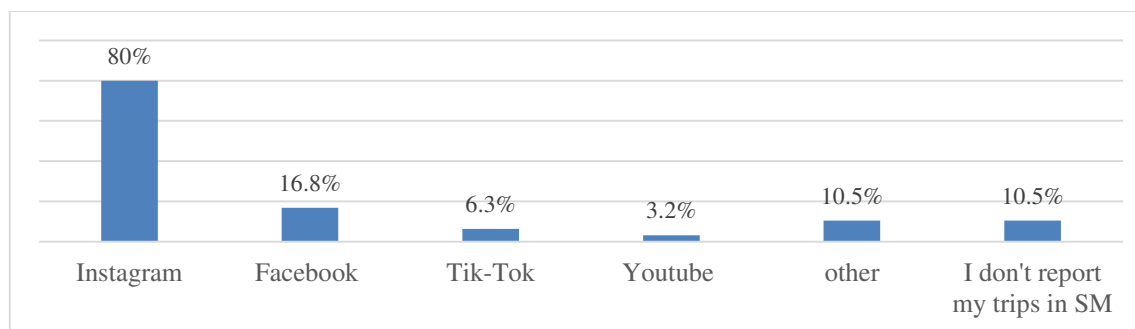
Source: own study.

Interestingly, when asked whether young people report their experiences from tourist trips on social media (in the forms of posts, photos, videos, etc.), most of them (67.4%) admitted that they definitely or rather often did so during their trips (Tab. 8), most frequently on IG (80%) (Fig. 11).

Table 8.
Reporting tourist trips in SM

Question	Definitely yes	Rather yes	Neither yes nor no	Rather no	Definitely no
Do you often report your experiences from tourist trips on social media?	50 26.3%	78 41.1%	20 10.5%	24 12.6%	18 9.5%

Source: own study.



Note: Responses do not sum up to 100% as this was a multiple-choice question.

Figure 11. Reporting tourist trips: types of SM.

Source: own study.

Additionally, Spearman's rank correlation revealed that students for whom SM play an important role in planning their tourist trips significantly more often than others use them in reporting their tourist experiences ($r_s = 0.312$, $p = 0.002$).

4.1.3. Tourism activity and its relationships with Gen Z's perception of their studies and future careers within T&H

The question whether tourism activity might increase students' interest in their study within T&H and whether it might also increase their employment aspirations in the industry upon graduation was also an interesting issue (Tab. 9). Most of the students agreed that their tourism activity increased interest in their study and strengthened their willingness to work in T&H (67.4% and 68.4% respectively). Additionally, nearly 70% of this study respondents declared that they would plan their future employment within T&H fields.

Table 9.

Tourist activity, education, and employment aspirations of Generation Z respondents

Question	Answer	Definitely yes	Rather yes	Neither yes nor no	Rather no	Definitely no	Total
Does your tourist activity increase your interest in T&H studies?		68 35.8%	60 31.6%	40 21.1%	10 5.3%	12 6.3%	190 100%
Does your tourist activity strengthen your willingness to work in Tourism and Hospitality?		70 36.8%	60 31.6%	36 18.9%	10 5.3%	14 7.4%	190 100%
Would you plan your future career within tourism and hospitality industry upon graduation?		46 24.2%	86 45.3%	30 15.8%	12 6.3%	16 8.4%	190 100%

Source: own study.

Additionally, Spearman's rank correlation showed that students who declared that their tourism activity increased both their interest in T&H studies and willingness to work in T&H statistically more often than others planned their future employment upon graduation within T&H fields ($r_s = 0.400$, $p < 0.001$; $r_s = 0.641$, $p < 0.001$, respectively).

5. Discussion

This study provides a closer look at Generation Z as T&H students, tourists, and tomorrow's practitioners. On the one hand, this generation creates an important and still growing market segment for the travel industry (Chang et al., 2023). On the other hand, it creates new entries into the T&H labor market (Bebłot, 2023; Tyszkiewicz) that is still facing a high employee turnover (Brown et al., 2015), leading to reducing the organizations' performance and threatening its long-term competitiveness (Özbağ et al., 2014). Thus, this study answered a call for more research to better understand the new generation (Gen Z) as travelers (Chang et al., 2023) and for more research on what may have an impact on students' approach towards their future careers within T&H (Erdinc, 2012) simultaneously seeking an answer to the question about how to reduce students' turnover intentions towards their future employment within the industry (Brown et al., 2015).

Specifically, this paper focuses on T&H students as representatives of Generation Z and future qualified employees and contributes to a better understanding of their tourism activity and its relationship with students' attitudes and behavioral intentions towards T&H as a field of their study and as a place of their future career. The current study extends empirical results to the context of T&H students in East-Central Europe, where to the best of Authors' knowledge, there is a paucity of such research.

The results of this study reveal that most respondents travel several times a year, taking mainly domestic trips, usually lasting 4-6 days. They most often go on their tourist trip with family, partner or friends; they rarely travel alone. The characteristics of these trips also correspond with findings of previous studies (c.f. Wiczorek, 2020). Moreover, the examined students also declared that their tourism activity was the most frequently associated with rest/relaxation and sightseeing, which gives an opportunity to experience new places and cultures (Wiczorek, 2020).

More than half of the surveyed students indicated that they mainly travelled in the summer, although it is also worth emphasizing that for more than a third of them the time of year did not matter much, which may be due to the fact that they operate on a limited budget and may be sensitive to price, which is of particular importance to them. This corresponds with previous findings which identified economic conditions as one of the obstacles for students to start their tourism activity. Thus, a low price is one of the determinants for choosing a particular tourist destination (Wiczorek, 2020). At the same time, it is worth emphasizing a result of this research that the price is not the only aspect that students pay attention to when planning and implementing their tourist trips. Service is also of great importance to the respondents, as for more than half of them it plays an important role in the implementation of their tourist trips. T&H services are primarily supplied through labor, and service delivery with a human touch strictly affects customers' experiences and satisfaction (Choi, 2006).

In addition, students mostly declared booking individual travel services, such as transport, hotel or insurance services on their own, which was also confirmed in previous studies (Monaco, 2018). At the same time, they most often organize their tourist trips in advance.

When planning and implementing their tourist trips, they are also eager to use social media, which has a direct impact on their travel behaviors and decisions (Chang et al., 2023). As reported in previous studies (e.g. Xiang et al., 2015), social media and different forms of online communications significantly affect the young generation's travel planning (Chang et al., 2023). It is worth noting that Generation Z is the first one to have been using mobile devices since a very young age; therefore, social media have been an indispensable part of their social life (Chang et al., 2023). They take into account opinions posted on the Internet by other travelers, watch photos and videos of selected destinations and get information about tourist attractions. These opinions and recommendations on social media are a valuable source of information for planning the trip and for the decision-making process (Chang et al., 2023).

In addition, the widespread availability of mobile devices and social media services allow young tourists not only to search for information but also to update and share their own travel experiences as indicated in previous studies (Chang et al., 2023). The possibilities offered by technologies provide young people with convenient tools for communicating (Kugiejko, Kociszewski, 2021) and reporting their experiences (Kasperczak, 2018). This is also confirmed by this research, showing that the surveyed students are also eager to report their stays and share their tourist experiences and emotions in social media, which is very important for young people (Niemczyk et al., 2020). Moreover, young people may also seek acceptance and admiration from others in this way (Nikiel, 2019).

As regards the form of accommodation, the investigated students mainly prefer private accommodation (rooms, apartments, holiday homes) and smaller hotel facilities. In terms of the range of catering services, they most often choose self-catering options, although it is worth emphasizing that they also quite often declare visiting local restaurants, bars and taverns. As to transport services, the respondents of this study most often prefer air travel in their trips, but quite often also choose a car, which is also confirmed in the literature on the subject and in previous research (Niemczyk et al., 2020; Wieczorek, 2020).

Of particular importance in shaping satisfactory travel experiences for Generation Z are the natural values of the visited destinations and relations with local residents, which can also confirm that, despite stereotypes, Gen Z establish relationships very easily, especially with those who are important to them (Jęczmionka-Majchrzak, 2023). This also supports the view that young people are fascinated by contact with different realities and cultures and perceive their participation in tourism as a way of enriching their lives (Monaco, 2018). One can say that traveling becomes an important stimulus for Generation Z for self-development (Kugiejko, Kociszewski, 2021). Youth is a time of gaining new experiences, “finding one’s own identity” or building relationships (Kugiejko, Kociszewski, 2021).

Interestingly, the results of this study revealed that participation in tourism may increase young people’s interest in their T&H studies and strengthen their willingness to work in T&H upon graduation. Simultaneously, those students more often than others claim that they would plan their future careers within the T&H industry. Understanding students’ career intentions is an important issue both in predicting whether they will work in the T&H in the future (Kusluvan, Kusluvan, 2003) and in attracting and retaining them for the T&H industry in which availability of well-educated and engaged employees creates a competitive advantage of each operating enterprise (Kachniewska, Para, 2014).

Finally, it is worth underlining that although there are numerous previous studies that investigate factors influencing students’ attitudes and their behavioral intentions towards their future work within T&H (e.g. Baltescu, 2016; El-Houshy, 2014; Erdic, 2012; Kusluvan, Kusluvan, 2003; Lu, Adler, 2009; Ramakrishnan, Macaveiu, 2019; Sibanyoini et al. 2015; Tribe, Lewis, 2003; Wan et al., 2014), such as willingness to study tourism (Roney, Öztin, 2007), work experience (Grobelna, Tokarz-Kocik, 2018; Roney, Öztin, 2007), industrial

training (Chen, et al., 2011; Chen, Shen, 2012; Datta, Jha, 2015; Grobelna, 2016; Kim, Park, 2013; Koc et al., 2014; Kusluvan et al., 2003; Wang et al., 2014), participation in culture (Grobelna, Wyszowska-Wróbel, 2021), social and family background (Grobelna, Marciszewska, 2016), and personality (Teng, 2008), this study is among the first, if not the first one, to address a large research gap, by investigating whether tourism activity of T&H students may also play an important role influencing students' interests in their studies and intentions toward their careers within T&H.

The current study found that both the recovery and spillover theories may constitute a useful theoretical framework to explain the proposed relationships in a non-occupational setting, such as T&H students. In doing so, the existing knowledge has been developed, and a new insight has been provided.

Findings of this study may also have several implications for T&H stakeholders, especially T&H educators and practitioners, particularly those responsible for social media promotion and human resources management.

As for tourist entities, this research also shows the group of students (Gen Z) as a segment of tourism activity with their behaviors and characteristic preferences. This helps create tourism offers for a particular target group. Therefore, one should remember that Generation Z representatives integrate their daily lives with social media; hence communication via social media is crucial for this generation, also in tourism, as this results from the spread and availability of modern technologies on the tourism market (Urbańczyk, 2019). Thus, it is vital for retailers of tourist services to create short and understandable content that will satisfy Gen Z's need to obtain information quickly (Nikiel, 2019; Dimitriou, AbouElgheit, 2019). Well-designed social media websites of tourist attractions and other tourist entities should create a favorable image and attract Gen Z's attention.

Simultaneously, one should remember that the fact that members of Generation Z mainly use mobile devices is an important aspect of communication with them. They spend much less time watching TV, listening to the radio and reading printed publications, and less often use desktop computers. As a result, Gen Z consumers are also less open to advertising on these platforms. Therefore, tourism industry practitioners should share their message primarily through mobile devices (Southgate, 2017).

To sum up the above: the development of the global tourism market and the activities of T&H entrepreneurs should largely focus on the synthesis of modern digital technologies and social communication (Entina et al., 2021).

As for educators, it is worth remembering that, to meet the needs of Generation Z, tourism management can take place, among others, through an educational system (at different levels) (Dimitriou, AbouElgheit, 2019). In the context of this study, the following recommendations for supporting students in developing their interests in travel and possible future work in the T&H industry may be presented:

- creating scientific groups, clubs and other student organizations related to tourism. These groups can organize their own trips, meetings and events that maintain interest in tourism and promote activity in this respect;
- organizing lectures and guest presentations to which experts from the tourism industry or travelers will be invited to share their experiences and inspire students to travel themselves or run their own business in the T&H industry;
- organizing educational trips by universities, both at home and abroad. These trips could include such activities as sightseeing, participation in cultural festivals, or trips to areas of natural value. This type of experience can stimulate students to learn about new places and cultures. Trips could be realized with financial support from the university, at preferential affordable prices;
- dual education – a possibility to conduct part of the classes in cooperation with tourism market entities;
- organizing courses at the university to acquire competences in the field of tourist traffic, e.g. courses for tour guides, group escorts, leisure time animators;
- scholarships which could also include financial support for tourist trips. Students could apply for this type of support based on academic achievements, social activity or other criteria set out by the university;
- research grants – if students implement research projects related to tourism, universities may award grants to finance their trips and costs related to field research;
- sponsorship and cooperation with tourism market entities. Universities can establish cooperation with organizations from the T&H industry that could sponsor specific trips or educational programs of the university;
- international exchange programs that allow students to travel and study abroad;
- volunteering – universities could organize volunteering projects in various places, both locally and abroad (e.g. in areas of natural value requiring support in nature conservation).

Looking more broadly at the problem of supporting academic youth in the field of travel, taking into account global trends in the growing participation of young people in tourism, there is an urgent need to include funds for co-financing domestic trips for young people in the budget of the state and the local government (Dimitriou, AbouElgheit, 2019).

As regards T&H managers/employers, demand for travel and jobs starts to grow, and sufficient labor force is needed to fill the available vacancies and enable the sector to recover (Travel & Tourism Economic Impact, 2022). Due to the values held by Generation Z representatives, future employers should consider what to do to ensure that the employment conditions correspond to these values and needs. The results of previous studies indicate that a proper person–organization match increases the cognitive and emotional trust (Leung et al., 2021). Thus, it is also important to implement well-thought-out recruitment procedures to

ensure the right skills in the right job positions. It is especially important that the service experience in T&H comes from a direct interaction between the customer and employees; hence employees' adequate attitudes and behaviors, visible to the customer, are important for ensuring customer loyalty (Giacomel, Raveleau, 2020). Therefore, the issue of attracting and retaining well qualified and highly committed employees should be of high priority for the management (Glińska-Noweś et al., 2020), and the T&H industry must redefine its HR policy keeping in mind characteristics of young and qualified new entrants from Generation Z. If management follows current trends without any prejudices and falsely imposed stereotypes (Jęzmionka-Majchrzak, 2023), particularly in understanding Gen Z needs, then these young employees' talents are more likely to emerge and flourish within T&H organizations.

6. Summary

This study proposes new insights into theoretical concepts and empirical evidence by examining students' tourism activity (as representatives of Generation Z) and the way it may affect their attitudes towards their studies as well as their intentions towards working in the tourism and hospitality (T&H) industry upon graduation. In this study, both a desk-research method and an online questionnaire were used. Data were collected from students of Higher Educational Institutions in Northern Poland that offered T&H programs. This study has identified the main characteristics of Generation Z's tourism activity and proved that it may be a critical factor in determining their positive perception of T&H as their field of study and as a place of future employment.

The results of this research cannot be generalized, as the respondents came only from chosen HEIs and thus do not reflect a much larger world of higher education in Poland. Thus, future studies with a larger sample of T&H students from other HEIs located in different geographical regions are recommended. Regardless of that, findings of this study can constitute a basis for discussion and serve as a starting point for future extended research on Generation Z.

From this study results, researchers and practitioners can gain some information about how Generation Z (today's T&H students) travel and whether their tourism activity may potentially affect their attitudes or behavioral intentions towards their study and their future careers within T&H.

Future studies may take various directions. Given the fact that generational cohort members will also differ from one another (Jęzmionka-Majchrzak, 2023) in terms of such aspects as culture, place of residence, gender, social class, personality, etc. (Moscardo, Bencendorff, 2010), it could be interesting to include these variables in future studies to provide a much more detailed picture of Gen Z. Specifically, a study comparing Generation Z representatives in two perspectives: as travelers and as future employees of the T&H industry coming from different

backgrounds, nations or cultures would be an interesting area to explore. This could be extremely valuable especially for companies that develop and operate at an international level as sellers of travel services and as employers (Dimitriou, AbouElgheit, 2019).

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ADVANTAGES AND DISADVANTAGES OF TRADITIONAL AND AGILE METHODS IN SOFTWARE DEVELOPMENT PROJECTS – CASE STUDY

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Purpose: The article deals with the comparison of traditional and agile software development methodologies to evaluate their effectiveness in project management. The study aims to identify the challenges of communication and trust that occur in project management and how these challenges can be addressed. The literature review discusses various traditional and agile software development methodologies, their limitations, and the importance of project management, communication, and trust.

Design/methodology/approach: The study compares the effectiveness of agile project management and waterfall project management Software Development Life Cycle (SDLC). The objectives of the research were achieved by a questionnaire survey and interviews with software development teams. The results highlight the challenges of communication and trust in project management, and the study concludes that agile methodologies are more effective in project management as they provide more opportunities for communication and collaboration among team members.

Findings: The study recommends that teams working on software development should implement agile approaches to improve their practices regarding project management. Agile approaches offer an increased number of chances for communication, cooperation, and feedback, all of which can contribute to the successful completion of a project. In addition, the findings of the study suggest that future research should center on the development of solutions to address the issues of communication and trust in project management.

Research limitations/implications: The research limitations are due to fewer sample size of the data and the study is based on self-reported data which may not be entirely accurate. The study also has a limited scope, and the results may not be generalizable to other industries or project types.

Practical implications: The research proved that agile methods are challenging in IT project teams. Still, communication and trust in project management are of great importance to ensure effective development of IT projects.

Originality/value: The value of the research is the identification of the challenges of communication and trust that occur in project management and how these challenges can be addressed. The recommendations elaborated within the study to support the effectiveness of projects' development are dedicated to companies in an IT sector.

Keywords: Scrum, Waterfall, software, agile, project management.

Category of the paper: research paper, case study.

1. Introduction

In recent times, there have been notable changes in the software development industry, leading organizations to re-evaluate their approaches to project management. In the domain of software development project management, two prominent methodologies, namely traditional and agile, have surfaced as the primary contenders. In the pursuit of delivering software of superior quality within the constraints of budget and time, it is crucial to comprehend the inherent pros and cons of each methodology.

The article offers a comprehensive case study that analyses the complexities of conventional and agile approaches in software development initiatives. The objective is to offer a comprehension of advantages and constraints linked to each approach by scrutinizing practical situations and consequences. The aforementioned assessment is aimed at the support of software developers, project managers, and stakeholders in arriving at well-informed decisions that are in accordance with the distinctive needs of their respective projects.

This case study examines the attributes of the conventional waterfall approach and the agile methodology, analysing their effects on project planning, implementation, flexibility, client contentment, and overall project achievement. The conventional waterfall methodology adheres to a sequential and linear approach, while the agile methodology prioritises iterative development and ongoing collaboration.

Through a critical evaluation of the benefits and drawbacks of each methodology, the paper is aimed at explaining their impact on key project variables such as project schedules, cost-benefit ratios, risk mitigation, and stakeholders' involvement. By conducting a comprehensive examination, the aim is to furnish practical observations obtained from practical encounters, endowing readers with valuable expertise to proficiently traverse the software development terrain.

The paper provides a comprehensive case study that analyses the merits and demerits of conventional and agile approaches in software development endeavours, ultimately leading to a persuasive conclusion. Through an examination of various methodologies in practical situations, the paper is aimed at equipping stakeholders with the requisite information to make well-informed choices. The capacity to implement a suitable project management methodology can significantly impact the attainment of favourable software development outcomes in a constantly changing industry.

2. The characteristics of differences and similarities of waterfall and agile methodology in an IT sector

2.1. Traditional/Waterfall Model

The traditional model, commonly called the waterfall model, is a static paradigm that takes a linear, sequential approach to systems development, finishing one task before beginning the next. The waterfall method divides projects into the following activities: requirement analysis, design, coding, and testing. According to Pressman, these include the following activities: communication (including project start-up and requirements gathering), planning (estimating, scheduling, and tracking), modelling (analysis and design), construction (code and testing), and deployment (delivery, support, and feedback) (Pressman, 2005). The phases of the model presented by Pfleeger and Atlee are requirement analysis, system design, program design, coding, unit and integration owner/user of the proposed system, and so forth (Pfleeger, Atlee, 2006).

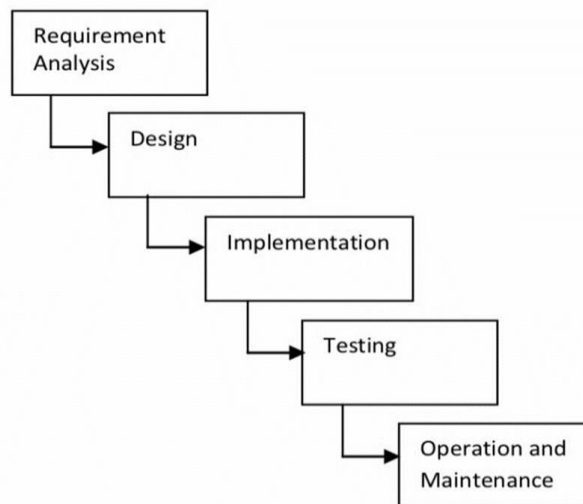


Figure 1. Waterfall Model Phases.

Source: Pfleeger, Atlee, 2006.

According to Othman et al., the waterfall model entails that one phase must be completed before the next can begin, with a high risk that errors from the previous phase will be transmitted to the next, as verification occurs at the end or near the end of software development.

Modifications cannot be made using a waterfall development process, which is a drawback of the conventional method. Furthermore, there is no overlap between stages in the typical waterfall approach to development. The model can support iteration, but it only does so indirectly (Pressman, 2005). A phase cannot be repeatedly reviewed to look for flaws after it has been completed. Since the phase cannot be reopened, no improvements are possible. This methodology is particularly helpful for developing structured systems because it is strictly forbidden to change the program once it has been coded. Additionally, the waterfall approach typically separates processes from data, so if data need to be changed, the code must also be

adjusted (known as software coupling). This renders software unusable and makes system upgrades difficult because all processes need to be changed in order to make any adjustments, which can be time-consuming and expensive.

There have been new improvements made to the waterfall model that are meant to address the shortcomings of the traditional waterfall model. The result of these adjustments is what McConnell calls "Modified Waterfalls," an improved version of Rapid Development models. This is according to research. Requirement analysis, design, implementation (or coding), testing, and maintenance are all still present in the updated version of the waterfall methodology. The overlap of phases makes the software engineering process adaptable. This ensures that any problems with the software system are addressed early on in the development process, saving money on post-implementation modifications. As a result, the modified waterfall model is now widely used in many industries, particularly manufacturing and construction, for both the management of information systems and the execution of projects.

The waterfall model has several advantages, including structuring the work, simplifying follow-up, clarifying objectives, improving communication, and traceability. The model also creates a clear and precise structure, enables smooth information transfer, simplifies project management, makes it easy to set goals, helps examine each stage's output, stabilizes a project, and prioritizes project timelines. However, the model has some disadvantages, such as inflexibility, limited customers' involvement, late feedback and testing, high risk of project failure, long delivery cycles, lack of visibility and control, limited room for experimentation, and difficulty in managing complex projects.

2.2. Agile Methods

Agile development is based on the concept of incremental and iterative development, in which the stages of a development life cycle are reviewed repeatedly. Software is enhanced iteratively by identifying solutions based on user feedback (Szalvay, 2004).

Agile methodologies require a shift from command-and-control management to leadership-and-collaboration. The organizational form that facilitates this shift needs the right blend of autonomy and cooperation to achieve the advantages of synergy while providing flexibility and responsiveness.

In agile development, the development life cycle is broken up into smaller portions that are referred to as "increments" or "iterations". Each of these "increments" or "iterations" touches on each of the conventional phases of development, as opposed to the implementation of a single massive process model that is used in conventional software development. The following four are among the four main agile factors, according to the Agile Manifesto:

1. Early customer participation
2. Iterative design
3. Self-organizing groups
4. Change adaptation

These six techniques - crystal approaches, dynamic software development method, feature-driven development, lean software development, scrum, and extreme programming - are currently recognized as agile development methods (Leau et al., 2012).

Some of the agile software development methodologies are: Scrum, Lean, Adaptive Software Development (ASD), Crystal and Extreme Programming (XP).

Agile methodology can be applied everywhere such as teaching, research and service.

Below, you find the list of agile practices:

- Product Backlog.
- Sprint Backlog.
- Daily Scrum.
- Scrum Master.
- Sprint Review.
- Sprint retrospective.

2.2.1. Scrum

Scrum is an agile methodology that uses iterative and incremental methods whose purpose is to help development teams to concentrate on established goals and minimize the work done on less important tasks. Scrum aims to keep simplicity in a complicated business environment.

The term comes from rugby, where it is a strategy to return a lost ball into the game by teamwork. Scrum does not provide implementation-level techniques; it focuses on the way the members a development team should interact to create a flexible, adaptive and productive system in a constantly changing environment. The method was presented in detail K. Schwaber and M. Beedle, Prentice Hall (2002). Scrum is based on two elements: team autonomy and adaptability. Team autonomy means that project leaders establish the tasks the team must perform, but in each iteration, the team is free to decide how to work, with the goal of increasing team productivity. To prevent the uncertainty caused by project complexity and unpredictability, Scrum does not suggest specific software development approaches, but rather strategies and instruments for the management for various phases.

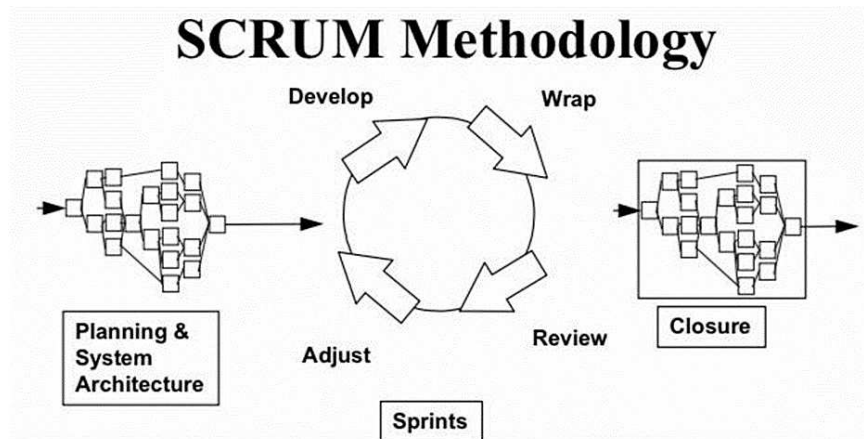


Figure 2. Scrum model.

Scrum is a very adaptable paradigm that can be used for any project in any industry. Both small and large projects can benefit from using it. The product owner, scrum team, and scrum master are all involved in scrum processes. It also includes sprints, the smallest time frame in which a team can assign tasks that must be completed in three to four weeks. The sprint backlog, which comprises all the requirements for the current sprint and any potential changes throughout development, determines the tasks for each sprint. The product backlog is regarded as the majority of requirements and is evaluated by the product owner. It is divided into sprints and then has a sprint planning structure that outlines various strategies for completing a sprint on schedule. Delivering a potentially organized and error-free product is the goal of each sprint (Abdulbaqi Badru, 2017).

2.2.2. Lean Model

Womack et al. (1990) introduced the lean concept based on many studies of the automotive industry conducted by researchers at the Massachusetts Institute of Technology (MIT) International Motor Vehicle Program (IMVP). This idea builds on TPDS and falls under the more general category of lean production. They concluded that there were differences between mass and Japanese lean producers in terms of strong leadership, teamwork, early communication and coordination across departments, and concurrent development procedures in addition to differences in the production processes. Lean manufacturing has been adopted by many businesses that create huge software-intensive systems, but in order to fully exploit this competitive advantage and squeeze out additional waste from the manufacturing processes, lean also needs to be applied to the PD processes, Liker, J.K., & Morgan, J.M (2006). Several businesses have begun to use some underlying LPD concepts and practices in order to improve the effectiveness of the PD processes. Continuous improvement (Kaizen), Kanban, concurrent engineering, inclusion of customers and suppliers, visual management, group work, and cross-functional teams are some of the techniques utilized to achieve the goal of LPD. However, implementing a small number of the techniques is insufficient to achieve LPD. According to Womack and Jones (2003), the entire enterprise needs to adopt the lean philosophy. Five categories are used to conceptualize lean thinking: value, value stream, flow,

pull, and perfection. Value establishes the purpose that a product serves for a consumer and builds business operations from there. Each process step is described in a value stream, which classifies them according to the value added (e.g., value adding, necessary non-value adding and non-value adding steps). Processes are organized by flow to ensure that products move easily through the value-generating steps. Each customer calls the output from the prior phase using the pull method. Finally, perfection requires continuous process improvement to fulfill client expectations and has no flaws.

Studies on TPDS are often cited in literature that explicitly addresses LPD (Kennedy, Widener, 2008). A thorough study on LPD is presented by Liker, J.K., & Morgan, J.M (2006). They define the core and substance of LPD in a model called Lean Product Development System using the Sociotechnical Systems Theory (STS) (e.g. Miller, Rice, 1967) and the principles and practices of TPDS (LPDS). The foundation of LPDS is the idea that LPD is a philosophy being adopted throughout the entire enterprise rather than a few lean principles and practices being superficially applied to different areas of an organization.

The three main subsystems of the LPDS paradigm are process, talent, tools and technology. 13 concepts are used to define them.

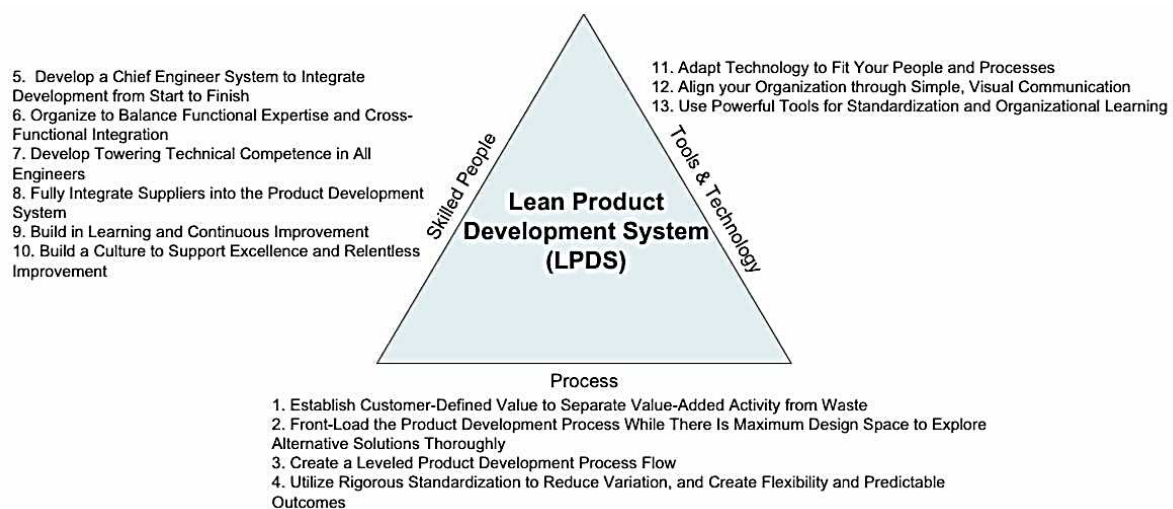


Figure 3. LPDS model.

Source: adapted from Liker, Morgan, 2006.

The advantages of the Agile approach include the following:

- It's adaptable and flexible.
- It encourages creative approaches.
- It involves low costs: Adopting the Scrum approach can be cost-effective for an organization, as it usually requires less documentation and control.
- It usually leads to better quality work.
- It improves customer satisfaction.
- It typically results in more satisfied employees.

Despite the advantages that can be gained from using agile approaches, many businesses are hesitant to completely abandon their standard practices. Their reluctance stems from a number of sources, including the following:

- the agile methods drastically cut down on documentation and heavily rely on tacit knowledge;
- the agile methods have not been adequately tested for mission/safety-critical projects;
- the belief that the agile methods are not adequate for highly stable projects;
- the belief that the agile methods can be successful only with talented individuals who favour many degrees of freedom;
- the belief that the agile methods can only be successful with talented individuals who favour many degrees.

2.3. The comparative analysis of agile versus traditional methodologies

A software program or information system is made to carry out a specific set of tasks. This group of jobs that the system will carry out frequently produces results that are well-defined and involve complicated computing and processing. Therefore, it is a difficult and time-consuming task to oversee the entire development process in order to guarantee that the final product has a high level of integrity and resilience, as well as user approval. To accomplish the aforementioned "characteristics of a successful system," a systematic development approach that may place an emphasis on comprehending the scope and complexity of the whole development process is therefore crucial.

The majority of system developers currently use either traditional development or agile development as their SDLC approaches. The following analyses the comparison between agile and traditional methodologies:

1. Primary objectives: According to Boehm, predictability, repeatability, and optimization have been a key set of goals for more traditional plan-driven techniques. While Agility is more concerned with delivering quick value and adapting to change (Fowler, Highsmith, 2001).
2. Size: Compared to Agile initiatives, plan-driven approaches scale to huge projects better. However, a bureaucratic, plan-driven organization won't be very effective on minor initiatives if it takes an average of one person-month merely to have a project authorized and begun (Boehm, 2002).
3. Relationships with customers: Agile approaches function best when customers work closely with the development team and when their tacit knowledge is adequate for the entire program. This approach runs the risk of tacit knowledge gaps, which plan-driven approaches minimize by using documentation, architecture review boards, and independent expert project evaluations to make up for on-site client gaps (Boehm, 2002).

4. **Planning and oversight:** Formal project management, according to Unhelkar, is crucial to the effective conclusion of a software project. Careful planning, estimation, coordination, tracking, and control are necessary for project management aspects that the Waterfall model officially covered. Agility gives the planning stage more weight than the final paperwork (Boehm, 2002).
5. **Communication:** While the Waterfall model prefers explicit documented information, Agility encourages face-to-face communication (Casteren, 2017).
6. **Requirements:** Pure Agile practitioners do not explicitly apply formal, upfront, solution-independent requirements engineering. The formal, cumbersome Waterfall model will struggle to keep up with the requirements' constant change. On the other side, plan-driven approaches can maintain even million-line systems under budget and schedule if the design foresees and accommodates required changes (Unhelkar, 2016).
7. **Development:** Agility maximizes the amount of work that is not done by valuing functioning software over thorough documentation. While the Waterfall model strongly relies on software architecture because it is a necessary step in the development process.
8. **Test:** Beznosov and Kruchten claim that traditional assurance procedures include assessment, vulnerability testing, internal and external reviews, dynamic testing, static analysis, and design and architectural principles. These techniques are significantly more suited to architecture-focused, well-documented waterfall development. On the other side, agile methodologies lack the emphasis on architecture or documentation but instead promote internal design and code review and encourage developers to follow coding standards.
9. **Clientele:** Agility requires devoted, nearby, knowledgeable clients. The Waterfall model needs customers who are sufficiently knowledgeable and skilled.
10. **Developers:** Agile, knowledgeable, collocated, collaborative, friendly, talented, skillful, and communicative developers are required in agile projects (Boehm, 2002).

3. The brief characteristics of the selected company's activities

The name of the analyzed company is Youverify, a RegTech100 company. Youverify is a Nigerian-based technology company that specializes in identity verification and background checks. The company's services include identity verification, address verification, document verification, facial recognition, and background checks. These services are designed to assist organizations/businesses and individuals in onboarding customers, validating their identities, minimizing the risks associated with fraudulent activities, and providing innovative solutions to ensure trust in online transactions.

Characteristics of the company's main activities are listed as follows:

1. **Know Your Customer (KYC) Solutions:** Youverify's solutions help businesses comply with KYC regulations by verifying the identities of their customers. They assist in preventing identity theft, fraud, and unauthorized access to services.
2. **Digital Onboarding:** Youverify offers solutions that facilitate smooth and secure digital onboarding processes for businesses. By automating identity verification, they help streamline the customer registration and account opening procedures.
3. **Fraud Prevention:** The company's services are designed to detect and prevent fraudulent activities. By analyzing data from multiple sources and conducting risk assessments, Youverify helps businesses identify suspicious behavior and mitigate the risk of fraud.
4. **Identity Verification:** Youverify specializes in providing identity verification services to businesses and individuals. They use advanced technologies like AI, machine learning, and computer vision to verify the authenticity of identification documents and validate the identity of individuals.
5. **Document Authentication:** Youverify utilizes optical character recognition (OCR) and document authenticity checks to validate the legitimacy of identification documents such as passports, driver's licenses, and national ID cards.
6. **Facial Recognition:** Their facial recognition technology enables businesses to compare live images or videos of individuals with their photos on government-issued ID documents. This helps confirm the person's identity during various online interactions.
7. **Risk Assessment:** Youverify performs risk assessments by analyzing data from different sources, including government databases and credit bureaus. This helps businesses evaluate the risk associated with individuals or transactions and make informed decisions.
8. **Industry Applications:** Youverify's services find applications in various industries such as banking, finance, e-commerce, ride-hailing, telecommunications, and online marketplaces. Their solutions help businesses enhance security, improve compliance, and build trust with their customers.

By leveraging advanced technologies such as artificial intelligence, machine learning, and data analytics, Youverify aims to enhance security and enable seamless user experiences in various industries, including financial services, e-commerce, sharing economy platforms, and recruitment.

The company has 32 employees who work in the engineering, sales, marketing, design, and legal departments. Key values of the company include customer focus, clear communication, transparency, and integrity. Notable clients of the analyzed company include Fidelity Bank, Wema Bank, Bolt, and Leadway Assurance.

4. The research analysis on applied project management methods in an analysed company

4.1. The form and source of data collection

The current study aimed to compare traditional (waterfall) and agile (scrum) methods of software development. The aim was to identify how these methods are used in software development and their performance. The respondents were asked the size of their project teams, the duration of past projects and other key questions related to the study.

The form was sent to 20 respondents to find out how familiar they were with the methods shown. A set of questions was chosen to see how the candidates used the agile method (Scrum) and traditional method (Waterfall) in different situations.

The study was about people in the field of software development. 90 percent of the participants had at least one year of work experience and 45 percent had more than four years of work experience while the most popular method used by the respondents is Scrum, with 70 percent of them using Scrum very well and 40 percent of the respondents are software engineers, 15 percent are quality assurance engineers, and the rest are either business analysts, project managers, product designers, or scrum experts.

4.2. Communication challenges in project management

In a survey conducted by Demir, 2007, communication was on the list, which isn't usually covered in other surveys. Smaller project groups were thought to have no trouble communicating. But the survey results show that there is almost no difference between project organizations with 1-10 people and those with 11-100 people in terms of ratios. Also, the results show that communication is hard no matter what kind of organization you work for. Compared to other types of organizations, it is a little bit higher in those that work with the government. Half of the projects in these groups had trouble with communication. It was a little lower than the other categories in small application projects (Demir, 2007).

In another survey conducted by Alzoubi and Gill, 2014, it was discovered that not enough attention has been paid to communication particularly with the customers. Only 14% of the studies that were chosen have talked about the challenge of communication (Alzoubi, Gill, 2014). In agile development, customers have to be involved in the process, and they can't be kept in the dark about project details (Korkala et al., 2010).

The final questionnaire consisted of four main sections: the technical background of respondents, new product development with scrum, new product development with the waterfall model, and their personal opinions. Questions were developed using 5-point Likert scales. In order to examine the use of software development methodologies, the Likert scale ranged from "never" to "always" and for performance, the range was from "much worse" to "significantly better".

In this current study, only 20 percent of the respondents mentioned customer satisfaction as an advantage of agile method (scrum). This relatively low percentage could be because of poor communication between the other teams and their customers.

4.3. Trust Challenges in Project Management

In a study by McHugh et al., (2012), it was found out that agile methods increased trust by making things clearer, accountable, communicative, open to feedback, and sharing of knowledge. Using agile practices made their projects more open and clearer, both within the team and throughout the organization. For example, during the iteration/sprint planning meeting, team members can see what tasks each person is responsible for and how much time they will take. "Everyone hears the news at the same time, not from someone else" (McHugh et al., 2012).

This is in consistency with the results from the survey. 30 percent of the respondents mentioned teamwork as an advantage of working with scrum method. This relatively high percentage has resulted because agile methods including scrum have been able to deal with the challenges of trust in project management.

4.4. Results Achieved

When respondents were asked about the advantages of the waterfall method, 25 percent of them said it was easier to use and probably the only advantage they know. In fact, another 25 percent of the respondents have never worked with the waterfall method. Out of the 8 software engineers among the correspondents, only 1 software engineer said Waterfall was easy to use.

It was discovered that agile software development life cycle processes are superior to the waterfall model. However, it is essential for the development team to select the SDLC that would work in the most effective manner for the project.

The results of the questionnaire survey and interviews highlight the challenges of communication and trust in project management. The study concludes that agile methodologies are more effective in project management as they provide more opportunities for communication and collaboration among team members.

4.5. Recommendations dedicated to analysed IT company

It was discovered that agile software development life cycle processes are superior to traditional SDLC. However agile software development life cycle also has a few drawbacks. So, it is essential for the development team to select the SDLC that would work in the most effective manner for the project.

The size of the development team, where it is located, the size and complexity of the software, the type of project, the business strategy, the engineering skills of the team, and any other relevant factors are some of the things that could be used by the team to determine what SDLC they want to use. Other factors may also be taken into consideration as necessary. It is essential for the team to take into consideration the distinctions between each SDLC, as well as its advantages and disadvantages, before settling on one. The team needs to conduct additional research on the company context, the requirements of the industry, and the business strategy before they will be able to compare the candidate SDLC to the selection criteria.

The Agile approaches offer an increased number of chances for communication, cooperation, and feedback, all of which can contribute to the successful completion of a project.

The study recommends that teams working on software development should implement agile approaches in order to improve their practices regarding project management and achieve higher effectiveness level of projects' development.

5. Conclusions

1. After analysing the results of the survey, it is clear that Scrum, a type of agile methodology, is becoming more and more popular in software development. People in professional organizations prefer to use Scrum, for different reasons. It was found that 95 percent of the people who took part in the study use agile methods, and about 74 percent of them use Scrum.
2. 30 percent of the respondents said that working with the scrum method made it easier to work as a team. This relatively high percentage is because agile methods like scrum have been able to deal with the problems of trust in project management.
3. Scrum also has a high success rate because the process of testing is done all the way through the product's lifecycle. It lets the product be constantly checked as it is being made. Agile also thinks that each member of the product team should do more and be more involved, so that people are not tied to their job descriptions. The team is also given the power to make decisions, and most of them have a clear idea of what they will do in their next sprint. Agile gives the opportunity to change requirements when it is needed.
4. When it comes to relationships with customers, only 25 percent of the respondents agreed that waterfall does a better job. Meanwhile, 75 percent agreed that scrum does better, and 40 percent even agreed that scrum does much better.
5. Agile methods increased trust by making things clearer, accountable, communicative, open to feedback, and sharing of knowledge. Using agile practices made their projects more open and clearer, both within the team and throughout the organization.

6. 30 percent of the respondents mentioned teamwork as an advantage of working with scrum method. This relatively high percentage has resulted because agile methods including scrum have been able to deal with the challenges of trust in project management.
7. The research has identified the challenges of communication and trust in project management and how these challenges can be addressed. Through a questionnaire survey and interviews with software development teams, the study has demonstrated that agile methodologies are more effective in project management as they provide more opportunities for communication and collaboration among team members.

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APPLICATION OF VIRTUAL AND AUGMENTED REALITY IN FLIPPED CLASSROOM – TEACHING AND TRAINING IN UNDERGROUND ENGINEERING: MUSEUM MINES AND EXPERIMENTAL LABORATORIES

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Purpose: this article explores how virtual reality can be used as a medium for teaching and training especially in the mining industry. It focuses on the topic of using virtual reality (VR) to facilitate collecting data from mine galleries. The issue is of significant importance considering the necessity of access to the mine by non – authorized people (students supplementing theoretical knowledge with field practice, potential employees, trainees). The proposed method of using the VR in such situations could be considered a geotechnical simulator. The selection criteria were mainly based on safety, accessibility and underground conditions.

Methodology: since 2019, a flipped classroom learning method based on virtual field trips has been developed. Different platforms were used to create virtual scenarios (Kahoot, Edpuzzle Cospaces), some with 360 panoramic images, others with 3D image repositories. In both cases, the images were accompanied by clues in which the students would find information and from which they would answer the class's questions – as if they were visiting a real mine.

Result: this type of virtual tour is fully aligned with the face-to-face hybrid teaching or blended learning that seems to be the near future of global education and an invaluable tool to be used in the mining industry. The collection of data from mines of other raw materials: with different extraction and deposit technology, should form the basis for the development of virtual teaching methods used in training future engineers or improving the skills and qualifications of the active miners.

Originality: the virtual tours were first designed during the COVID-19 pandemic lockdown. Since then, the layout and content of the virtual scenarios have been significantly improved. These types of scenarios and virtual tours proved to be very well received by students, pleased that even though they could not always visit certain places themselves, they could partially participate in the measurements and exercises.

Keywords: mining, virtual reality, engineering, teaching, training, virtual classrooms.

1. Introduction

1.1. Background

The concept of virtual reality (VR) is not a new topic. As early as the 1960s, researchers were attempting to formulate the idea itself and the first commercial VR tools appeared in the late 1980s (Cipresso et al., 2018). In 1965, Shuterland compared virtual reality to a window through which the user perceives the virtual world as if it looked and sounded real and in which one can act realistically (Sutherland, 1965). Since then, many other definitions of VR have emerged, usually explained in terms of the area in which the technology was used. Thus: Fuchs and Bishop in 1992 defined VR as real – time interactive graphics with 3D models, combined with display technology that gives the users the opportunity to immerse themselves in the world of the model and manipulate it directly (Fuchs et al., 1992). A year later, Gigante described virtual reality as the illusion of participating in a synthetic environment rather than external observation of such an environment (Gigante, 1993), while Crus – Neira, the same year, defined virtual reality as a specific environment: interactive, multisensory, three – dimensional and viewer – centered (Cruz-Neira, 1993). It can be noticed that these definitions, although different, emphasize three common features of VR systems: the number of senses stimulated, the perception of presence in the environment and the interaction with that environment (Slater, 2009).

As shown above, virtual reality is not a topic that has developed over the past few years. However, the COVID-19 pandemic has created space for VR technology to develop much faster. Physical distance, quarantine with a strong need for social interaction – all of this has led to an increase in the use of new communication techniques and virtual presence. The COVID-19 pandemic changed our lives irreversibly, nonetheless, it has greatly accelerated the use of remote solutions and new technologies in education, training and as a work tool adapted for many industries. Employees and students have been given a range of new opportunities to gain knowledge and experience without having to appear in person at a specific place and time, and without risking exposure to any real danger.

The pandemic time was very difficult on various levels. In the early stages, it was assumed that industries exposing many people to a contact in a relatively limited space posed the greatest threat to society. For instance, the occupational group particularly negatively perceived in this aspect, in Poland (Hildebrandt et al., 2021), were miners. They were considered to be a source of disease transmission due to the high density of people and their close contact in the workplace. Studies of aerosol dispersion in the mine workings have been carried out to confirm or refute this thesis (Hildebrandt et al., 2021). Therefore, the opportunity of accessing mines without the need of physical contact and the possible virological exposure could not be overestimated.

Many industries are using virtual reality technology to make their operations more efficient and safer. The mining industry is one of the most dangerous areas of employment, so the need for improved safety and access to training is significant (Stothard, 2007). In the mining sector, the technology is particularly valuable. Access to the underground part of the mine by non-authorized individuals is practically impossible for safety reasons and the continuous nature of the plant's operations. Training on simulators instead of expensive equipment, mapping mine galleries and presenting these plans to students and employees as well as virtual exercises of high-risk tasks (e.g. fire escape, VR blast wall (Virtual technology..., 2022) are the future of the mining.

A good example of the use of VR in the mining industry is the planting of explosives in a wall. When explosives are not placed in the right places without accurate measurements, the rocks can fracture uncontrollably. This creates a potentially dangerous situation, not only underground but also on the surface, and yet could be avoided by using VR techniques.

It should also be noted that virtual reality training has a definite advantage over traditional methods. Firstly, it effectively cuts the user off from the distracting environment, increasing concentration levels. Secondly, the trainee gets 'into character', perceiving the situation with all their senses. The course becomes a challenge, allowing the trainee to pay attention to details that they might not notice during standard training.

Additionally, training and educational implementation of the VR is simply more interesting for the apprentice. In the age of ubiquitous technology, computers or mobile phones the traditional methods using printed materials, slides and a speaker imparting knowledge seem unattractive and monotonous.

In summary, virtual reality significantly improves the way future employees might be trained, especially in occupations that require working under hazardous conditions. As demonstrated above, the potential for the mining industry is enormous: from training future engineers to improving the skills and qualifications of the active miners.

1.2. Objectives

There are many publications on safety in mining, training programs for current employees and potential employees. Miners are constantly exposed to a range of hazards that may cause serious injury or death. These hazards include: fire, underground explosions, toxic gases, geotechnical hazards and the ones associated with working in close proximity to mining machinery. In addition to the external factors mentioned above, there is also the possibility of human error caused by stress, inadequate training, or inexperience. This is where proper teaching and training are invaluable and VR is a perfect medium for carrying out these processes.

The mining industry is trying to make the most of the opportunities that the new technology offers. At the beginning of the 21st century Schofield pointed out in his research that virtual reality simulation offers the potential to improve safety – related training in mining.

He highlighted that the ability to remember safety information from a three – dimensional world is significantly greater than the ability to absorb information from traditional media (Schofield et al., 2001).

There is no doubt that, looking forward these 20 years, VR offers the opportunity to develop both perceptual – motor skills and cognitive skills, such as problem solving, decision making and hazard perception, without exposing trainees to unacceptable risks.

To date, much attention has been given to enhancing the skills and knowledge of people employed in the mining industry. In this paper, the main focus is put on the possibility of using VR for the learning process.

In teaching practice, the authors have carried out classes in operating mines to train new engineers that were meant to join the mine personnel. It is utterly difficult to find suitable areas for mapping not to interrupt daily activity in the active mines. Therefore, the conducted works (in Peru-Rinconada and Ecuador-Ponce Enriquez) result in the most realistic scenario performed so far in operating mines. In tunnels however, it has not been possible to carry out training in active workings; it was organized in abandoned ones. Nonetheless, accessing abandoned workings still creates some obstacles as students' safety is a great concern for their Universities. Fig.1 demonstrates a training conducted in active mines in Peru.



Figure 1. Training in active mines in Peru (2013-2015).

Mining is a broad field of study. When considering the training of future engineers, for example, it is important that the knowledge imparted covers all the main branches of mining. Such an assumption is difficult to implement in small and medium-sized resource-poor countries, where there are no opportunities for practical apprenticeships. VR technology offers such potential.

The mapping of exemplary coal, ore and salt mines would provide an opportunity for a no-cost and holistic study and explanation of the phenomena occurring during mineral exploitation (e.g. rock mass movement, occurrence of water and gases) and the establishment of rules for the rational and safe extraction of many types of aggregates.

2. Materials and methods

2.1. From the mining museums (show mines) and underground experimental laboratories to virtual reality

In a research process, trying to guarantee both the mapping requirements in realistic conditions and a safe location, it was noticed that visitable or tourist mines could be the ideal place to train underground geotechnical analysis since it is possible to introduce numerous students in secure conditions there. The environment is realistic and yet it lacks inconveniences caused by dispersed dust, poor visibility and circulating machinery of a real tunnel or mine. In the museum mines it is easier to reach the workings, and therefore, it is possible to reach the destination faster. Spacious areas can be searched for explanations. Before entering, a briefing in the access lobby can be given, a benefit that operating mines cannot provide. There is also a possibility to use classrooms and Wi-Fi connection in the facility to complement the practical sessions.

At the beginning of the research in the presented area there was a project launched that consisted of virtualizing the previously mentioned environments and also the real mines and tunnels that could be entered at the time. To virtualize these environments, students did not have to enter into the real mining environments. It was a small group of people, taking data while "scanning" the workings. For an hour or two, it was possible to choose a real face where the work would not be disturbed by the visit.

Fortunately, the work was done in advance because, in March 2020, the COVID-19 pandemic confined the world. These virtual mappings turned from being complementary into the only way of accessing real environments that the students had been using for months. The overall assessment of this virtual teaching material was very positive (García-Vela et al., 2020; Jordá Bordehore et al., 2020; Garcia-Vela et al., 2021).

2.2. Mines sites selected for the research

Until 2020, the work was mainly carried out in abandoned mines and tunnels, obtaining different virtual scenarios, and mapping didactic places. For this stage of the project, particular mines would be sought, in which work could be carried out at ease, virtualizing with the best quality and taking detailed geomechanical data focused exclusively on teaching. Three mines were selected for this task, two in Spain and one in Poland. The chosen mines had to fulfil several requirements: meet the safety conditions (difficult to find in the abandoned mines), relatively easy access, and a certain comfort to take much data and virtualize the environment. The latter is not met by operating mines and tunnels, as there is little time to take data. The images are also of a bad quality due to the suspended dust. Therefore, the chosen locations are tourist mines and laboratories – experimental tunnels.

2.2.1. Study site #1: *Experimental Mine ‘Barbara’*

One of the most important research facilities at the Central Mining Institute (Poland) is the testing ground of the Experimental Mine Barbara. “The EM ‘Barbara’ in Mikołów used to operate as an ordinary coal mine but after the WW II it became the only research and scientific post in Poland with an experimental infrastructure for testing devices, equipment, materials and procedures in real-scale underground conditions” (<https://undergroundlabs...>, 2023). The underground infrastructure enables numerous types of innovative research and projects, especially orientated on effectiveness and safety in mining as well as on environmental protection. The network of underground experimental galleries is a world class test stand for a real-scale testing. The mine includes a 53 meters deep shaft with two levels: 30 m and 46 m of different tunnels and galleries where tests can be carried out. The system of experimental headings includes several mining excavations with modern measurement systems installed and their dedicated sensors to check parameters of tested phenomena. A net of underground installed cameras provide real-time visualisation from the surface that guarantee a complex monitoring of the experiments. There is also a modern ventilation system of the workings that enables an adequate regulation of the airflow parameters according to what is best for the purposes of tests. The mining infrastructure and the external office and facilities are ideal for mining and laboratory practices, tests, and training.

The Experimental Mine ‘Barbara’ was excellent for the research and experimentation: to obtain in-situ geomechanical data, see different reinforcements and virtualize the galleries by taking 360° photos and photogrammetry with the Structure From Motion technique. Different areas of the mine, not very far from the main shaft, were chosen for their characteristics: mainly aimed at being able to analyse the live rock and obtain its properties. In addition, the places to be mapped had to be of good photo quality so that later the students in the images could virtually determine what the teacher had obtained in the field. A team of professional miners was available to facilitate investigation to work efficiently in the mine.

2.2.2. Mine School Saint Barbara Foundation (El Bierzo county, León Spain)

The Bierzo "School Mine" is located in former anthracite exploitation in El Bierzo, Spain, with a great coal mining tradition. The school mine is a part of the Santa Bárbara Foundation and one of its main objectives is the professional training of technical personnel – supervisors and mining machinery operators. An interesting extensive mining part was perfect for taking structural data in stable unsupported galleries and stopes. Next to the mining part, modern tunnels were developed (the New Austrian Tunnelling method) with different excavation techniques: blasting, roadheaders, etc. Research projects are carried out in this area. The tunnel faces are adequately supported and accessible for a longer period of time than the conventional workings, making it easy to introduce them into a virtual database. With good lighting and the absence of dust and noise, taking geomechanical data also makes it easy to take many adequate measurements for the students' notebooks.

2.2.3. Escucha mining museum and show mine (Utrillas county, Spain)



Figure 2. Mines visited for this project: a) 360 panorama in lignite galleries, Utrillas Spain, b) rock mass characterization in Experimental Mine 'Barbara' (Mikołów, Poland) c) fracture and RMR-Q index determination in advancing front in a tunnel, Mine School El Bierzo (Spain).

The Escucha mine museum is one of the few tourist mines in Spain where you can see a coal excavation face. It is located in a lignite mining region in the central–eastern part of Spain. The mine is of great educational interest at all levels, from the general public and high school students to university students. Different methods of support, metal arches, wooden frames, both in galleries and in mineral advances, can be seen. A ramp and a cable train enable access to the mine, which is also provided with a modern emergency gallery outlet. The view of the visited mines can be seen in Fig. 3.

2.3. The current state of virtual mines research- reasons for the post-pandemic application

The pandemic period led to a significant increase in the use of VR tools. Data collection through these virtual applications is still taught in collaboration with many countries such as Bolivia, Peru, or Ecuador that continue to have important pandemic restrictions and teaching is almost entirely conducted online. It is believed that even when the restrictions have disappeared, this type of activity and material would be very valuable.

The virtual environments could be used as a kind of practical geotechnical simulators. It was decided therefore, to go one step further and virtualize very different mines and tunnels, looking for particularly didactic environments. With all the experience gained and with clearer objectives, two types of virtual environments were chosen: 3D images with comments and 360 immersive environments. These scenarios are utterly useful for educational purposes in some of the countries, where training centres are located far away or are very expensive. In addition, with the rise in fuel prices and the travel difficulties as well as competitive relocation environments, hybrid online teaching might be considered not as the matter of the future but of the present.

2.4. 3D images and online repositories

The first type of results after conducting the research is the digital repository. It was started with a project of 3D rock samples (Riquelme et al, 2019). The objective is to virtualize rocky outcrops and slopes through photogrammetry. The structure from motion technique is used to photograph a slope and convert it into a 3D element or a point cloud (Jordá Bordehore et al., 2017). These 3D blocks are later uploaded into a digital repository (in this case, Sketchfab).

This digital platform is very user-friendly, it is free of charge, and it also allows you to put a series of pop-up menus with keys and data on the slope that the students must take (a graphic scale is included in the image). Together with other purely observational data, the students carry out their calculations on the stability of the slope. The difficulty that appeared while using it, was that in the underground mines, without proper technique and lighting of the tunnel or mine, the software could not recognize the overlapping images. Tests in several mines and tunnels have been carried out and among the tests performed there were some performed during a one-week campaign in the Experimental Mine 'Barbara' in Mikołów and the 'Guido' Mine in Zabrze (Poland). The results of both are quite satisfactory.

2.5. Immersive virtual environments: 360 degrees images

To make the experience of taking data in outcrops or mines more realistic, it was necessary to have the students participate in the experience by going through various scenes where they collected different information and data, requiring a system that allows to move from one scene to another with ease. Compromise between realism, little time to prepare the scenes and to load

data as well as page opening speed (not to bore the student) was desired. The questions and templates in a teaching application were put to fill in outside the virtual environment. This way, the work is more realistic: students have a virtual screen, and they take data on a tablet or notebook. It is also the closest to the field trip situations because, in the actual tunnel, you do not have drop-down menus to fill in. Figure 3 below presents a methodological flowchart.

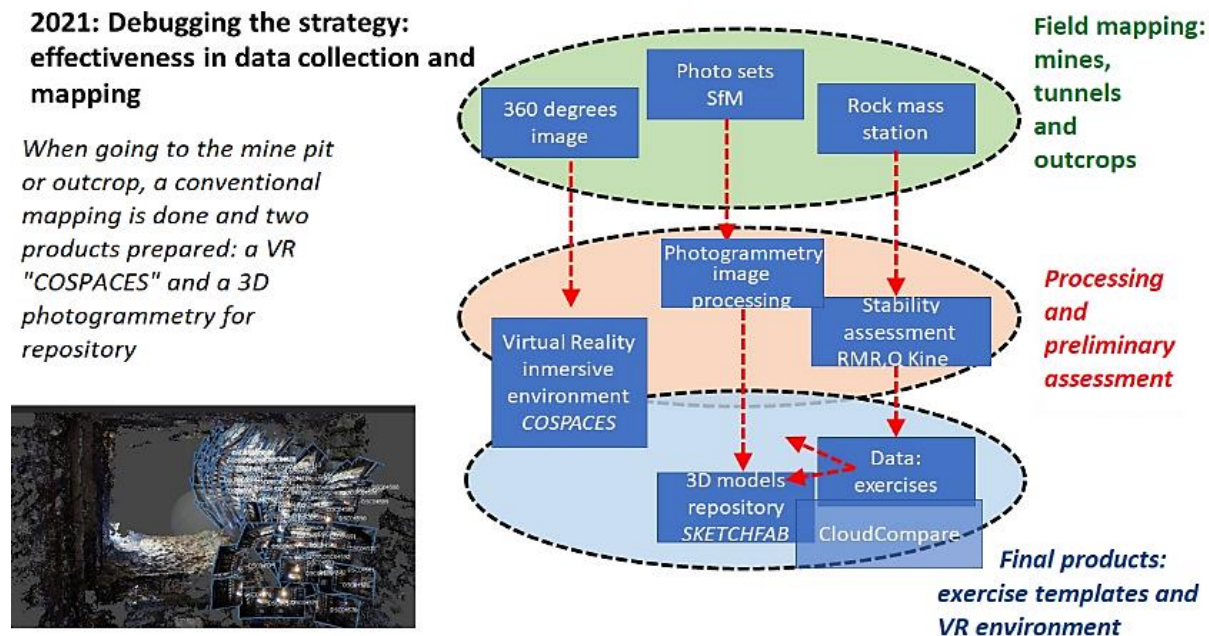


Figure 3. Methodological flowchart indicating procedures from field mapping to calculus and pedagogical material preparation.

3. Results and discussion (Quality indicators)

The aim of developing virtual scenarios, where students can access data and observations, was to make it available to as many people as possible. The most viewed virtual applications on the Internet (Kahoot, Edpuzzle, Cospaces) seem to be oriented towards secondary education students. Therefore, the authors' intention was to create a user-friendly but at the same time serious and professional tool. This innovative idea was successfully developed and introduced. The results have been used in classes at the University of Madrid, but also scholars worldwide included the created didactic material in their courses. As shown in table 1, the first of the scenarios was developed in tunnels and created shortly before the start of the pandemic confinement (March-May 2020), later more elements were added using commercial software and online applications such as Cospaces and Sketchfab (<https://sketchfab.com/ljbordehore>). Even in the post-pandemic times these virtual scenarios continue to be useful, since the hybrid model of teaching is becoming increasingly popular at universities and teaching centers. The scenarios are included as a part of classes on tunnels, mining, and rock mechanics in Ecuador, Peru, Bolivia, Spain (Master of CEDEX, Almadén, UPM, etc.).

Table 1 below indicates some of the scenarios and the number of accesses received since their creation by the end of 2020. It is important to note, that most visits are from the Spanish – speaking countries (Spain, Latin America), since it was first developed by the Polytechnic University of Madrid. Therefore, some scenarios are currently being translated into English to grant access to even bigger group of users.

Table 1.

Summary of the Cospaces virtual scenarios and visits to date

Virtual scenario link	Content	Languages	Total visits since 6/10/2022
https://edu.cospaces.io/TLS-TUT	Tunnelling and rock mass classifications for mining	Spanish and English	7418
https://edu.cospaces.io/NGF-LYM	Introduction to rock mechanics	Spanish	1613
https://edu.cospaces.io/KTU-APD	Rock slope stability	Spanish	3727
https://edu.cospaces.io/EPD-NHY	Laboratory testing	Spanish	1881
https://edu.cospaces.io/JNF-TVC	Mining: underground and open pit geotechnics	Spanish	953

Figure 4 demonstrates the virtual tour through mines and tunnels. The scenes allow students to find information and to solve different exercises. The degree of difficulty and reality depends on the scene and has a focus depending on the class involved.



Figure 4. Online technical tour at the ‘Barbara’ mine from the virtual university lobby and classroom where students can choose different scenarios depending on the topics and level of course.

Surveys have been carried out (Fig. 5) to determine how the scenarios were received by the users and how they could be improved. Sixty-six responses were received throughout 2020–2022. The vast majority find the system simple and intuitive (83.3% over 8/10 points). As for the avatars used, they were considered by 68.2% of responders to be amusing and give freshness to the exercises, while the rest of the responders indicated that they needed some improvement. 92.4% of the responders think it is appropriate to use this platform for home jobs commissioned or self-employment.

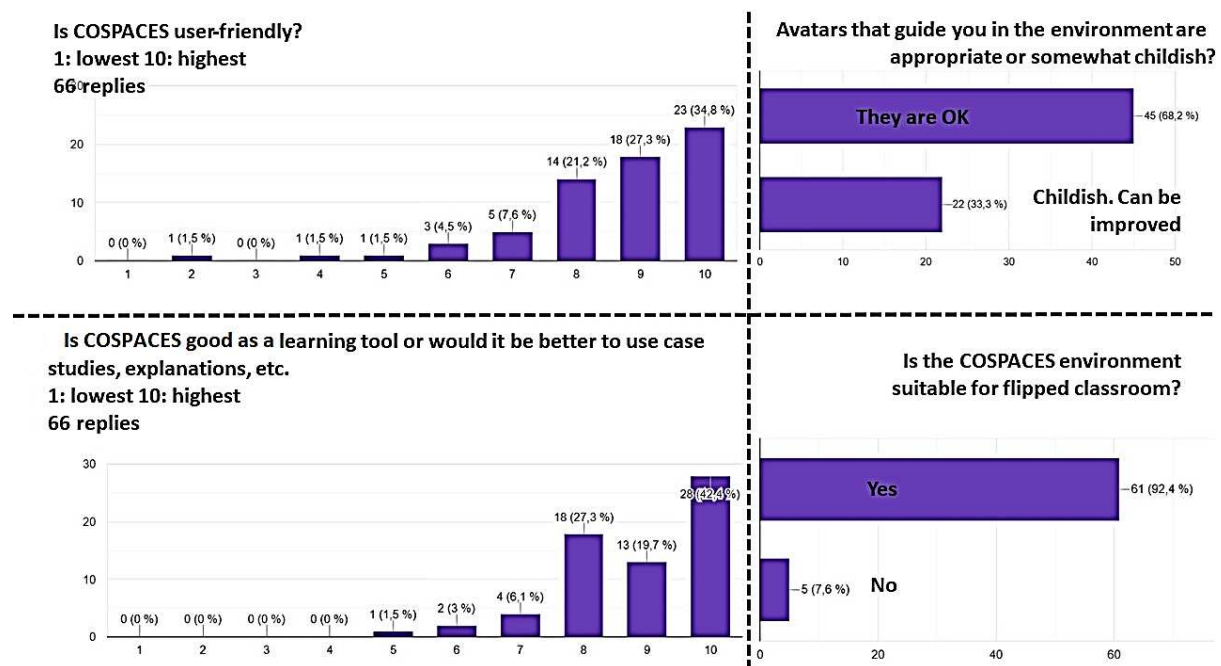


Figure 5. Evaluation of the Virtual Reality platform in training.

Throughout the two years of developing the inverted classroom with virtual reality, it has been noticed that the VR is a perfect addition for classical teaching methods. Even though it cannot replace field data collection, it can serve as an introduction or simulation before going into a real tunnel or mine. During the pandemic and the strictest confinements, it was observed that virtual reality became essential and, in various areas, the only access to the outside world. Even today, in many countries, face-to-face classes have not yet been resumed, and postgraduate classes even less so. Therefore, created virtual scenarios are very popular in Peru, Bolivia, and Ecuador, where what it more, great distances and logistical difficulties make virtual and online teaching extremely popular. The future of post-COVID education and training will probably be a hybrid face-to-face classes and online ones. Virtual and augmented reality seems to be a perfect link between the two. Nonetheless, the VR potential of prepared scenarios could be used not only for educational purposes but also to make the engineering world more accessible and more entertaining.

The results of the mapping carried out at EM 'Barbara' confirm the possibility of a virtual presentation of the most relevant issues of coal mining, as one of the branches of the mining industry. The presentation of how the deposit is located, the use of underground workings and their infrastructure in the form of emerging questions during the virtual tour enables the transfer

of practical knowledge to students and the testing of the skills acquired during theoretical classes.

4. Conclusions

This article explores how virtual reality can be used as a medium for teaching and training especially in the mining industry. The area of interest (mines, tunnels) is inaccessible to non-authorized people and therefore it creates barriers in both learning the job as well as preparing the potential employee. Virtual reality simulation offers the opportunity to develop perceptual knowledge, perceptual-motor skills and cognitive skills, such as problem-solving and decision-making in stressful situations, without exposing participants to unacceptable risks.

The virtual tours were first designed during the COVID-19 pandemic lockdown. Since then, the layout and content of the virtual scenarios have been significantly improved. These types of scenarios and virtual tours proved to be very well received by students, pleased that even though they could not always visit certain places themselves, they could partially participate in the measurements and exercises. This type of virtual tour is fully aligned with the face-to-face hybrid teaching or blended learning that seems to be the near future of global education and an invaluable tool to be used in the mining industry.

The collection of data from mines of other raw materials: with different extraction and deposit technology, should form the basis for the development of virtual teaching methods used in training future engineers or improving the skills and qualifications of the active miners.

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A NEW METHOD OF CORONAVIRUS VIRION DETECTION – INNOVATIVE METHOD OF IDENTIFICATION TRANSFORMING

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Purpose: the article presents the result of an attempt to assess the possibility of using scanning electron microscopy and energy dispersive spectroscopy (SEM/EDS) to identify silica nanoparticles (SiO₂), which, due to the size of individual particles (200 nm), can be used as coronavirus markers in simulation tests.

Methodology: SEM/EDS evaluation was performed using three different media types; namely membrane filters, sponge filters and graphite discs.

Result: SEM/EDS studies, consisting in determining the morphology and grain size of SiO₂ markers and X-ray microanalysis of their elemental composition, proved that this technique can be successfully used to identify markers.

Originality: due to their particle size, ease of handling with various types of surfaces, and biological and physicochemical neutrality, silica markers can act as coronavirus substitutes in experimental studies.

Keywords: SEM-EDS, silica nanoparticles, microbiological markers, virus marker, virus surrogate, Sars-CoV-2.

1. Introduction

COVID-19 pandemic, which originated in December, 2019 in the Hubei Province, China, afflicted over 298 million of people all over the world and seriously affected the socio-political situation of more than 213 countries (Bhardwaj et al., 2021; Lin et al., 2021). SARS-CoV-2 (*Severe Acute Respiratory Syndrome Coronavirus 2*) belongs to the betacoronaviridae genera which includes *inter alia* the highly pathogenic in human viruses such as SARS-CoV (*Severe Acute respiratory Syndrome Coronavirus*) or MERS-CoV (*Middle-East Respiratory Syndrome Coronavirus*) (Kwak et al., 2021). Epidemiological data proves the SARS-CoV-2 virus is much more contagious than SARS-CoV or MERS-CoV responsible for the epidemics in 2003 (SARs-CoV-1) and 2012 (MERS-CoV), respectively. According to WHO and CDC US, virus SARS-CoV-2 is transmitted predominantly by airborne droplets or as a result of the contact with the respiratory secretion of a COVID-19 infected people; however, the most recent evidence shows that contaminated air may constitute yet another mechanism of the pathogen transmission (Rieseberg et al., 2001; Zamora, Aguilar, 2018; King et al., 2020). The emergence of new airborne transmitted diseases (e.g. COVOD-19) is the rationale for conducting research studies to better understand the scale of the phenomenon of the airborne transmission of the pathogens. The measurement of airborne transmitted pathogenic viruses constitutes an interdisciplinary research area which necessitates the understanding of both the aerosol techniques and microbiological issues (Śliwińska, 2002). The majority of field literature concerning the detection of pathogens in bio-aerosols focuses on the presence of bacteria, fungi or allergens, while the reviews of virus sensors concentrate on the detection of the viruses in water solutions rather than in the air. What complicates the experimental research in this area is the fact that the SARS-CoV-2 virus, due to its rapid spread among the population and the high virulence, was considered as a particularly harmful biological agent (category III). This fact practically precludes using the virus in studies under *in-situ* conditions. The application of physico-chemical markers which may be used for marking of the pathogens (fluorescent markers) or which, due to their corresponding size, may constitute pathogen surrogates in laboratory research (the so-called markers) constitutes an alternative solution in airborne transmission studies. In the case where fluorescent markers are used in microbiological research, it is possible to apply small organic particles (≤ 20 atoms), small particles of sizes in the range of 100-100 000 atoms ($2 \div 10$ nm) – the so called quantum dots and fluorescent proteins (e.g. green fluorescent protein, GFP 26kDa, 238 aa). The fluorescent markers are applied in order to mark selected pathogen structures or to build complexes with other proteins, like in the case of GFP. In virological research, fluorescent markers are employed to create virus vectors to enable the observation of the created structures using such techniques as fluorescent microscopy of flow cytometry (Brickey, Zydneya, Gomezab, 2021). Apart from the fluorescent ones, the silica markers (SiO_2) may be also applied. The silica markers constitute nontoxic

particles which are safe for the research staff and the environment. Their sizes are in the range of 40-400 nm; homogenous solutions with silica markers may be sprayed in the form of aerosols in a dedicated space or on a research object in real conditions and in a non-isolated environment. Unlike viruses whose identification in laboratory scale is performed by means of ELISA tests, titration tests, *Western Blot* analysis or RT-qPCR method, the silica markers may be identified on the given carrier using both the qualitative and quantitative methods. It is worth mentioning that more and more often within the course of microbiological and virological studies, microscopic techniques are used because they facilitate detailed morphological characteristics of the pathogen. The Transmission Electron Microscopy (TEM), Epifluorescence Microscopy (EFM) and electron microscopy are examples of the techniques which have found application in research studies on virus particles. When a physico-chemical marker (silica marker) is used in the investigations, there is a possibility to apply Scanning Electron Microscopy (SEM) with an Energy Dispersive Spectroscopy system (EDS) for the purpose of the identification tests. This technique is mostly used in materials science in order to draw up the characteristics of surfaces or surface layers of the examined objects and materials, in particular the morphology and elemental composition. To date, the SEM technique has been widely applied in material engineering and metallurgy (Li, Liu, Du, Li, 2020; Bernardi et al., 2018). What is important, especially in terms of the phenomena discussed in this paper, literature sources confirm the possibility of silica nanoparticle imaging by means of the SEM and TEM techniques. For instance, Huseynov (Huseynov et al., 2011) used the SEM technique for the imaging of the adhesion phenomenon utilizing neutron irradiated nanoparticles of silica. Additionally, other author also carried out an analysis of the nanomaterial structure based on the techniques such as the Transmission Electron Microscopy (TEM) and Selected Area Electron Diffraction (SAED) (Kling et al., 2008; Schamm et al., 2008). In numerous publications, the authors emphasize the possibility of applying the TEM technique as a tool to observe and quantitatively identify nanomaterials (≤ 100 nm). However, it is worth mentioning that the authors point out certain limitations in applying the TEM technique to nanoparticle imaging which result from the problem of observing the distant background of samples caused by the high energy electrons of the TEM devices. In such cases, it is recommended that SEM systems should be used which operates with the stream of electrons of maximum energy in the range of 30-50 keV (Matuszewski, Sintorn, 2021). Rades demonstrated that techniques such as SEM (Scanning Electron Microscopy), T-SEM (Transmission Scanning Electron Microscopy, EDX (Energy Dispersive X-ray Spectroscopy) and SAM (Scanning Auger Microscopy) constitute effective and relatively inexpensive tools which enable to carry out a comprehensive morphological and chemical characteristics of a single nanoparticle of silica and titanium, representative materials recommended by OECD Guidelines because they are frequently applied as commercial nanomaterials (Rades et al., 2014). The experimental approach using Scanning Electron Microscopy, Transmission Electron Microscopy and FIB/SEM tomography was also applied to studies on the “evolution” of Mg-silicate particles during the process of producing optical

fibers. In these studies, the research objective was to characterize quantitatively the composition, size and shape distribution of Mg-silicate particles within the initial silica-based preform and the final product – the fiber (Cabiéa, Neisius, Blanc, 2021). The application of SEM technique in studies where silica nanoparticles were used became the subject of works conducted by Reghioua (Reghioua et al., 2019) and Cairns (Cairns, 2020). However, it must be stated that in none of the abovementioned works silica nanoparticles were used as specific surrogates of the harmful microbiological agents (microbiological markers), which is particularly important while taking into consideration the different methodology of preparing and spraying the samples, the concentrations of the nanomaterials and different types of surfaces on which the marker was being identified. Within the framework of this study, an attempt was made to assess the possibility of applying Scanning Electron Microscopy (SEM/EDS) to identify a silica marker of a size corresponding to the sizes of single coronavirus virions (200 nm) sedimented on different types of carriers. The research will enable to identify silica markers of the coronavirus virion size on sponge filters, membrane filters and graphite discs.

2. Methods and materials

The research process was designed in such a way which would facilitate to assess the possibility of applying the SEM/EDS technique to qualitatively identify the silica marker as well as to assess the applicability of this method in the case of different types of abiotic surfaces of various structure, porosity and shape. The possibility of applying the silica marker as a potential marker of virus pathogens, along with the option of its further identification on different types of carriers, constitutes a significant issue concerning simulation tests under laboratory and real conditions in terms of the pathogen spread as well as its presence on different types of surfaces. Considering the above, the idea of this research study was based on the assumption that the examined solutions would be sprayed by means of an atomizer on different types of carriers in a manner simulating the direct transmission route of the coronavirus (i.e. cough and sneezing) and next the carriers with the sedimented material would be subject to microscopic analyses using the SEM/EDS technique.

Two types of solutions were used in this study as research material; namely, the control solution (physiological saline solution constituting the equivalent of human saliva) and the silica marker solution (constituting the surrogate of the SARS-CoV-2 virus). The following three types of abiotic carriers were employed in the research: a membrane filter SKC, a sponge filter CIP and a graphite disc. The solutions were sprayed onto the carriers under laboratory conditions in the form of aerosols produced by means of a Turn'n'Spray atomizer (Bürkle, GmbH) (<https://www.burkle-inc.com...>, 2022). The experiment was conducted within the

framework of two research cycles for each type of the carrier. Each cycle consisted of three series during which the two solutions were applied on each of the carriers; the control solution (cycle 1) and the silica marker (cycle 2). In the next step, the carriers were subject to the SEM/EDS microscopic analysis.

2.1. The examined solutions

2.1.1. Control solution

The 0.9% solution of sodium chloride commonly referred to as a physiological saline solution (NaCl, molecular weight 58.44) was used as the control solution. The physiological saline solution was selected for the purpose of the research due to the fact that its chemical composition approximates the chemical composition of the secretion generated in the mouth during talking or sneezing. The solution is available on the market in the form of a chemical reagent (CHEMPUR, WE: 231-598-3; CAS: 7647-14-5). It is an odorless and colorless liquid with a relative density of 1.01 g/cm³ (20°C). According to the Regulation (EC) no 1272/2008 of the European Parliament and of the Council of 16 December 2008 on the classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006, the solution used in the research is not classified as a dangerous substance.

2.1.2. The solution of silica marker

The silica marker solution used in the study was a mixture of distilled water and nanoparticles of silica (SiO₂) which performed the role of coronavirus surrogates. The silica marker has the form of solid spherical silica nanoparticles of 200 nm diameter (General Engineering & Research, USA) suspended in water (basic SiO₂ solution). According to the product characteristic, the silica nanoparticles were synthesized using the Stöber method (www.geandr.com, 2022) which enables to obtain the final product of a very high purity (+99.999%) with a narrow size distribution. The characteristic of the nanoparticles used in the tests was drawn up on the basis of the manufacturer data and presented in Table 1. In the course of the research, the working solution was prepared by means of transferring 4 ml of the basic silica marker solution into a 100 ml volumetric flask and filling it up with distilled water to reach the total volume of 100 ml. In the initial phase of the research works, an attempt was made to prepare the silica solution based on physiological saline solution. However, due to the process of agglomeration of the NaCl particles and silica nanoparticles (SiO₂) which impedes the identification of the material sedimented on the carriers, it was decided that the marker solution would be prepared using distilled water. The adopted approach allowed for the imaging of the nanoparticles sedimented on the carriers.

Table 1.*Characteristic of the silica (SiO₂) marker solution used in the study*

Composition/ formula		SiO ₂ suspended in H ₂ O	
Components of the basic solution (SiO ₂ suspended in H ₂ O)		Water	> 80.0%
		Colloidal silica	< 15.0%
The aspect and the form of the basic solution	Form	Liquid	
	Colour	Transparent to white	
pH [-]		7.0-8.0	
Relative density of the solution [g/cm ³]		1.00-1.20	
Density of SiO ₂ [g/cm ³]		2.65	

2.2. The carriers of the examined solutions

Three types of abiotic carriers were employed in the research, i.e. membrane filters (cellulose), sponge filters and graphite discs. The picture below (Fig. 1) illustrates the carriers used in the study while the comprehensive characteristics are presented in Tables 2 and 3.

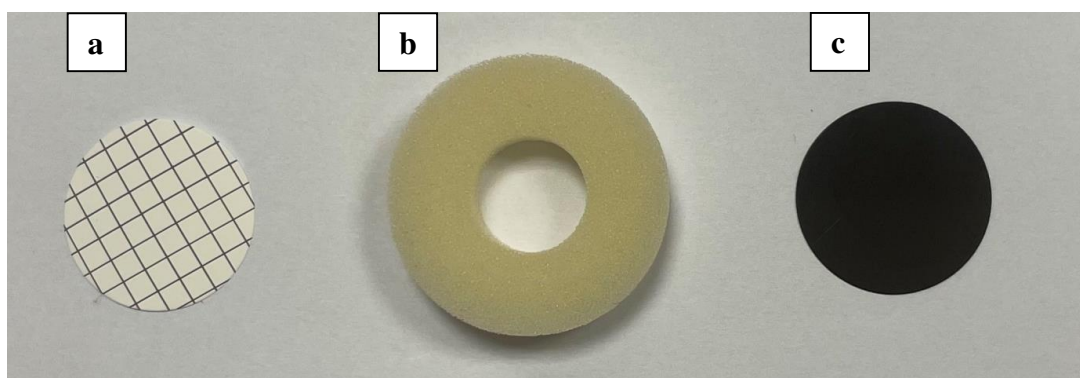


Figure 1. The carriers of the SARS-CoV-2: (a) membrane SKC; (b) sponge filter CIP; (c) graphite disc.

2.2.1. Membrane filter SKC

The first carrier used in this research was a cellulose nitrate membrane filter (SKC) with a 25 mm diameter, black grids and a 0.8 μm pore size produced by Sartorius Stedim Biotech GmbH, Göttingen, Germany. The characteristic of the cellulose nitrate filter based on the manufacturer specification is presented below in Table 2. The membrane filters used for the purpose of this research are commonly applied as pads for vacuum filtration, or as filtration membranes for the assessment of water, sewage and air quality. The filters used in this study were exposed to the aerosols using clean tweezers taken from an airtight box.

Table 2.*Technical data – cellulose nitrate membrane filters*

Material	Cellulose nitrate
Sterilization	Gamma irradiation or ethylene oxide
Pore size	0.8 μm
Thickness	Approx. 6 mil (150 μm) ± 10 μm
Size	25 mm
BSA protein bond	Approx. 160 μg/cm ²
Extractable substances	< 4%
Maximum operating temperature	356°F (180°C)
Color	White
Sealing compatibility	Ultrasonic, heat, radio frequency and insert moulding

2.2.2. *Sponge filter CIP*

The second carrier was a sponge filter CIP developed on the basis of polyurethane foam (TCR TECORA, France). This kind of material finds application as absorbent filters, *inter alia* in devices measuring air dustiness (e.g. dust meter CIP 10). Such devices are typically equipped with a small size rotating cup containing sponge filters (absorbent material) for the air sampling.

The measurement of air dustiness by means of this device may be performed on the basis of the so-called dosimetric method or the stationary method (Courbon, Wrobel, Fabriest, 1988). The device facilitates the sampling of a broad aerosol spectrum starting from the respirable, through the thoracic to the inhalable fractions by means of the gravimetric method and a dedicated head (selector). Widely used to determine the exposure to particles that are health risk, the gravimetric method of air sampling with a dedicated selector finds application in mining, wood and textile industries (Gero, Tomb, 1988). In standard laboratory research, this material ensures very effective and thorough filtration of biological water contaminants. Sponge filters successfully separate solids from liquids and gases stopping them mechanically and operating like a sieve. Thanks to their spongy structure (based on open and closed tubules/pores constituting 97% of the volume of the material), the filters are most effective for capturing contaminants and impurities present in water solutions. Sponge filters are characterized by high moisture and thermal resistance, recovery capabilities, high flow of air and/or liquid, high elasticity as well as tensile strength. The technical parameters of the filter used in this study are compiled below in Table 3 (Raimbault et al., 2021).

Table 3.

Technical data – Polyurethane foam sponge filters CIP

Material	Polyurethane foam PU
Density	0.029 [g/cm ³] (according to PN-EN-ISO 845)
Tensile strength	5-60 [kPA] (according to PN-EN-ISO 1798)
Elongation at break	Min. 50 [%] (according to PN-EN-ISO 1798)
Air flow	Very high
Thermal resistance	245 [°C]
Color	Nude
External diameter	36 [mm]
Internal diameter	15 [mm]
Thickness	10 [mm]
Weight of the rotating element with the filter	Approx. 3 [g]
Weight of the filter	Approx. 0.3 [g]
Sponge filter grade (number of pores per centimeter)	25

2.2.3. *Graphite disc*

Micro to Nano high purity vitreous carbon discs (planchets) of 25 mm diameter produced by Agar (Fig. 1c) were used in the research (www.microtonano.com/Vitreous..., 2022). The double sided adhesive discs are dedicated to examining samples by means of Scanning Electron Microscopy (SEM). Used in electron microscopy to mount the samples on the SEM stub, graphite discs are characterized by mechanical and chemical stability and durability under different operating conditions. Their use facilitates the observations of objects in high vacuum conditions as well as at various temperatures. However, their most important feature is the

electrical conductivity as the carbon content ensures removing the electric charges from the sample. Therefore, the effect of electron accumulation on the surface of the sample placed in vacuum is nullified. In addition, the specimens subject to SEM observation should be accordingly prepared. Namely, they should be of the smallest possible volume in addition to being durable, resistant and eclectically conductive. The biological specimens require fixation, dehydration and drying prior to being mounted on the stub. In the case of non-conductive specimens, they are coated with a thin layer of a conductive material (e.g. gold, platinum or carbon) by means of a vacuum sprayer.

2.3. Spraying of the solutions

The application of the solutions onto the three types of the carriers was performed under laboratory conditions. The examined solutions were applied in the form of aerosols generated by means of a Turn'n'Spray atomizer (Bürkle, GmbH). The device consists of a multiple use 250 ml bottle and a spraying nozzle with a 0.6 mm (0.02 in.) diameter. The amount of the liquid sprayed per stroke (measurement series) was $1.2 \text{ ml} \pm 0.1 \text{ ml}$ ($0.04 \text{ oz.} \pm 0.003$). Within the course of the experiment, the nozzle generating the aerosol stream was vertically directed downwards, at a distance of 30cm from the carriers on which the drop-lets of the examined solutions were collected (Lee et al., 2010).

2.4. SEM/EDS analysis

Scanning Electron Microscopy (SEM) with the system of Energy Dispersive Spectroscopy (EDS) constitutes a technique applied in material science research whose aim is to draw up a characteristic of the surface or the surface layer of the examined objects and materials. This technique enables to recognize the morphology of the examined structures including the elemental composition. In the course of the analysis, a given surface area is subject to a high energy focused beam of electrons. In the first stage of the investigation, the beam of electrons hits the surface layer of the material and induces signals coming from the examined layer. As a consequence of the reactions taking place, the induced and analyzed signal of the secondary electrons (SE) enables the imaging of the examined surface. The analysis of the X-ray radiation carried out during the measurement makes it possible to determine the elemental composition of the layer of the examined material (object). Thereby, the SEM technique facilitates the analysis of the sample surface, the assessment of the morphology as well as the shape of the biological material microstructures in huge magnification. The basic requirement concerning the samples subject to the SEM analysis is the ability to conduct electricity; therefore, in the case of organic samples, whose ability to conduct electricity is very low, special preparation of the samples is required. In addition, highly hydrated biological objects (e.g. microbiological specimen, plant or animal tissue) due to the possible vapor emission during the analyses require the conditions of controlled vacuum (from 6 to 650 Pa). In the SEM/EDS technique, the electron beam is generated from a tungsten

filament cathode. The controlled electron beam is focused on the sample surface by means of condenser lenses. The magnification may be altered within the range of X 5 to X 300 000, which makes it possible to observe the surface in the scale of macro and micro areas. The achievable resolution depends on the following factors: the type of the sample, the accelerating voltage of the electron beam, the current of the electron beam, the working distance between the sample and the objective lens, the adjustment and the correction of astigmatism. The microscope has a very good resolution with the possible voltage of 3-30 kV. The achievable resolution of the imaging equals 4nm at the acceleration voltage of 30kV. Thanks to the large sample chamber, there is a possibility to analyze samples of relatively big sizes at different distances and different tilts.

2.4.1. The scope of the microscopic analysis

The study involved the following two research cycles: (i) a qualitative identification of salt crystals (NaCl) sedimented on various carriers after spraying the control solution (cycle I), and (ii) a qualitative identification of silica markers sedimented on the carriers after spraying the silica marker solution (cycle II). The investigation was conducted based on a SEM analysis supported with an X-ray EDS microanalysis. The SEM/EDS analysis was performed using a variable vacuum SEM SU3500 Hitachi electron microscope (Hitachi High-Tech Corporation, Japan) which was coordinated with an EDS UltraDry (Thermo Scientific) X-ray spectrometer with energy dispersion. The microscope is equipped with two detectors, which allows conducting the observations of the sample surfaces in two operating modes; namely, SE (secondary electrons) image recording and BSE (backscattered electrons) image recording.

Dedicated software enables to perform the measurements of the observed objects directly on the screen of the microscope and to digitally record the photographic documentation. The study of the salt crystals and the silica markers involved determining the morphology, the grain size and the elemental composition on the basis of the observations of the grain surfaces and the X-ray microanalysis. The parameters of the X-ray microanalysis were as follows: (i) acceleration voltage – 15 keV, (ii) working distance (WD) – 10 mm, (iii) pressure – 30 Pa, and (iv) vacuum – variable. In each of the research cycles, within the particular measurement series for each specimen, a sequence of microanalyses were performed. The scope of the microanalyses involved several dozens of chemical composition measurements of the characteristic particles in order to determine the dominant chemical forms of the occurrence of particular elements.

3. Results

3.1. The SEM/EDS technique – the imaging of physiological saline solution

Fig. 2 presents the morphology of the physiological saline solution on the examined carriers (a membrane filter SKC, a sponge filter CIP, a graphite disc). The tests concerning the presence of the physiological saline on all the types of the carriers using Scanning Electron Microscopy (SEM) demonstrated regular, polyhedral shapes occurring individually or in the form of agglomerated particles with the size range of 50-500 μm . The shape of the particles was determined using the descriptive method. The chemical composition in the micro-areas of the examined samples of the physiological saline showed that sodium chloride (NaCl) is the dominant component (Fig. 3).

The NaCl crystals (monocrystals) identified on all the carriers used in the research are characterized by a regular crystalline structure. Exemplary crystallized forms of NaCl occur on all of the applied carriers (Fig. 2a, 2b, 2c). A detailed analysis of microscope data showed that the grains of the sodium chloride (NaCl) sedimented on the carriers reach the size of a few to several dozen micrometers. The spectrum of the chemical composition in the micro-area confirms the presence of NaCl in the sample of the physiological saline (Fig. 3).

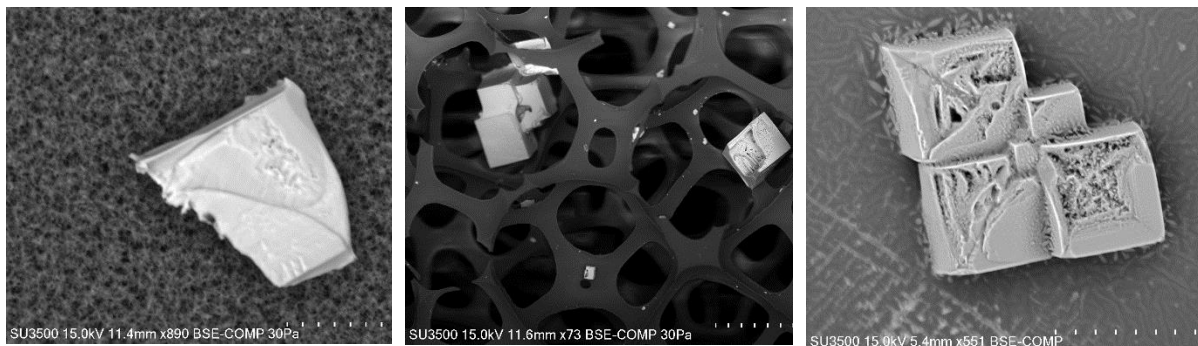


Figure 2. Illustrative SEM images of physiological saline grains on the carriers: (a) membrane filter SKC; (b) sponge filter CIP; (c) graphite disc.

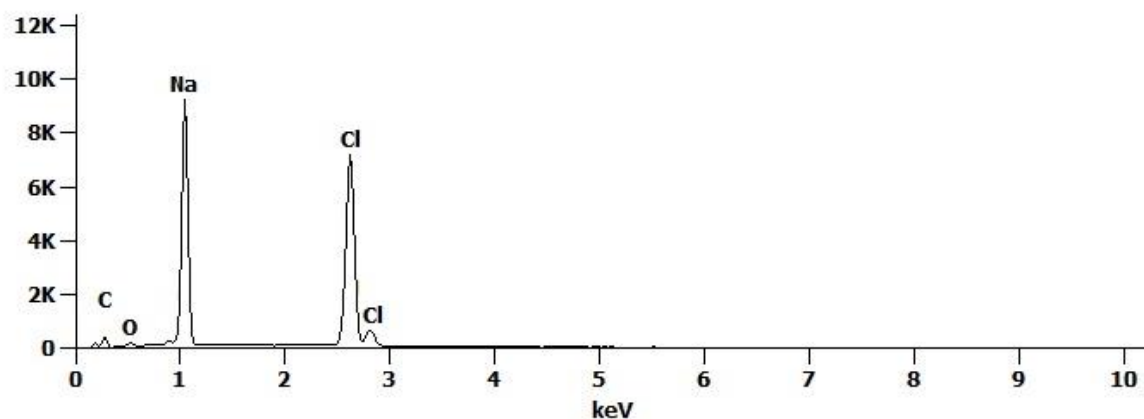


Figure 3. Illustrative chemical composition spectrum in the micro-area of physiological saline sample.

3.2. The SEM/EDS technique – the imaging of the silica solution

The morphology of the silica marker grains sedimented on all of the carriers used in this study is presented in Fig. 4, Fig. 5 and Fig. 6). As discussed in a previous section (2.1.2 Silica Marker), the grains of the marker are characterized by a spherical shape with the size of approximately 200 nm, which corresponds with the sizes of single SARS-CoV-2 virions. As can be seen in Fig. 4, Fig. 5 and Fig. 6, regardless of the carrier type, the grains of the marker occur in agglomerated forms, whereas the shape of the examined particles is decidedly rounded. The shape of the particles was determined by means of the descriptive method. Based on the performed analysis of the chemical composition spectrum, it was found that in the micro-areas of the marker samples, Si (silica) constitutes the dominant element (Fig. 7), which confirms the presence of the sprayed silica marker on all of the carriers used in the study.

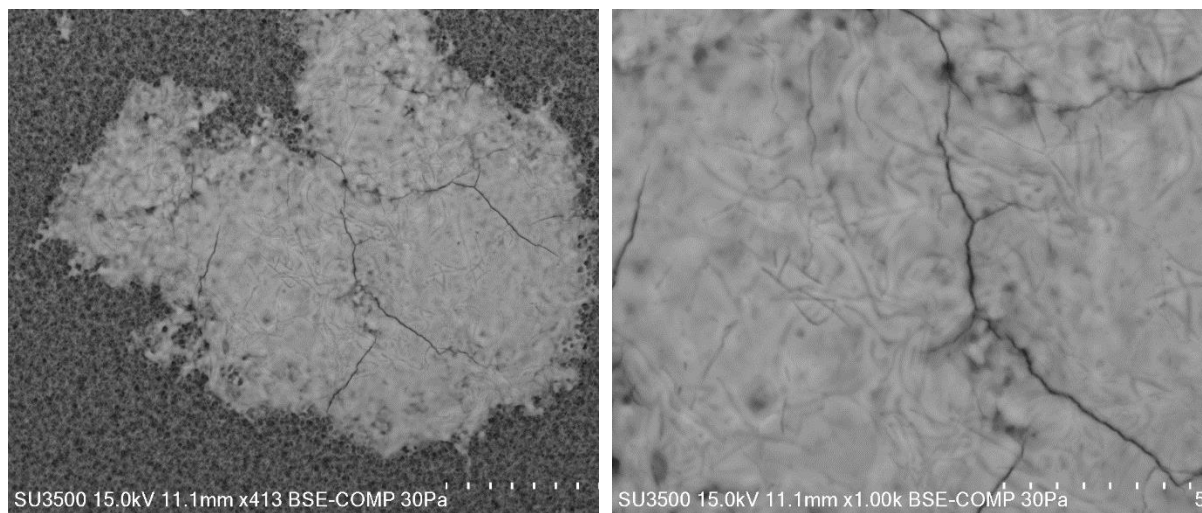


Figure 4. Scanning Electron Microscopy (SEM) imaging: (a) and (b) silica marker with the particle size of 200 nm sprayed on the membrane filter SKC.

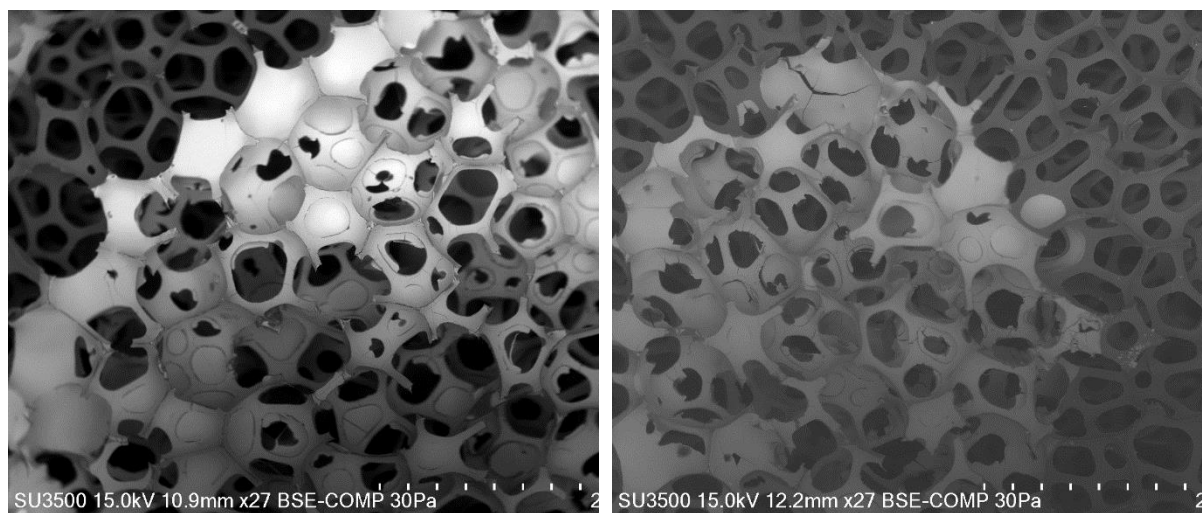


Figure 5. Scanning Electron Microscopy (SEM) imaging: (a) and (b) silica marker with the particle size of 200 nm sprayed on the sponge filter.

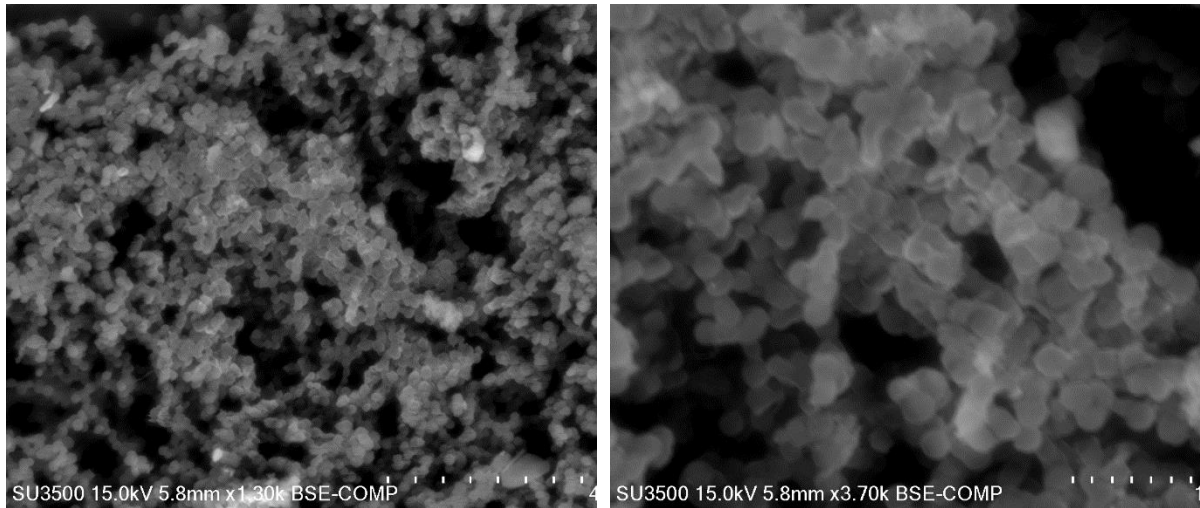


Figure 6. Scanning Electron Microscopy (SEM) imaging: (a) and (b) silica marker with the particle size of 200 nm sprayed on the graphite disc.

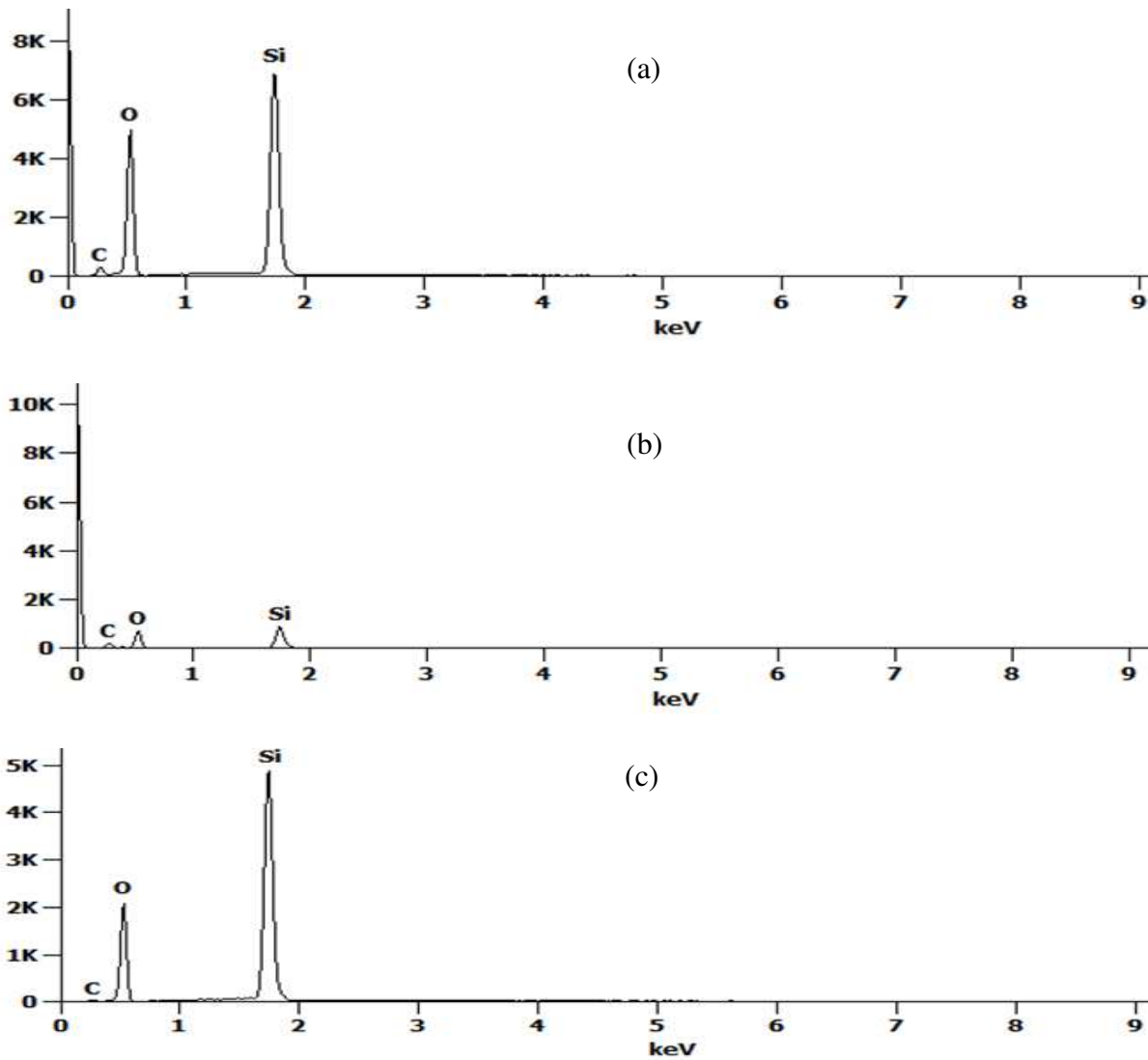


Figure 7. Illustrative chemical composition spectrum in the micro-area of the silica marker sprayed on: (a) membrane filter SKC, (b) sponge filter, (c) graphite disc.

As regards the membrane carrier, the grains of the silica marker occur in the form of solid agglomerates (Fig. 4a, 4b). In the case of the sponge filter, the silica markers cling to the polyurethane foam wall forming shell agglomerations, and thus reflecting the surface of the filter which is characterized by a larger specific surface area in comparison to the other two carriers (Fig. 5a, 5b). Concerning the graphite disc, the silica marker is present in the form of visible silica agglomerate grains of a spherical structure (Fig. 6a, 6b). In the chemical composition spectrum induced in the micro-area using the EDS technique, the maxima of silica and oxygen which differ in terms of intensity are distinctly visible and confirm the presence of the silica markers (Fig. 7). The induced EDS signal of the elemental composition analyzed in the micro-area coming from the silica marker applied to the membrane filter (Fig. 7a) as well as on the graphite disc (Fig. 7c) is stronger than the induced signal of the elemental composition obtained from the silica marker sedimented on the sponge filter (Fig. 7b). The bigger strength of the EDS elemental signal coming from the silica marker is most probably connected with the bigger accumulation of the silica marker sprayed on the membrane filter in the form of solid structures and the agglomerates of the silica marker on the graphite disc. The lower intensity of the EDS elemental signal coming from the spherical shell structures clinging to the sponge filter is most likely associated with the smaller amount and the smaller thickness of the silica marker on the sponge filter.

4. Discussion

The objective of this research study was to assess the possibility of using Scanning Electron Microscopy (SEM/EDS) to identify the silica marker (silica nanoparticles of SiO₂) which may be applied as a potential surrogate of the pathogens in laboratory and field simulation tests, especially in the case of SARS-CoV-2. The selection of the marker used in this research study was based on two key features of the silica particles; namely, their neutral character in terms of the microbiological and physico-chemical properties (the silica particles are neutral both for the environment and the research staff performing the experiment) and the fact that a single silica nanoparticle (≤ 200 nm) corresponds to the size of a single coronavirus virion. The concurrence regarding the size of silica particles (SiO₂) and the size of the pathogen (SARS-CoV-2 virion) were the foundation to assume that after spraying, the silica nanoparticles will behave in a similar manner to the coronavirus particles present in the body fluids (consisting of 99% of water) which are exhaled by COVID-19 infected people while coughing or sneezing. According to literature data, viruses of the particle size in the range of 25-400 nm, including SARS-CoV-2 (\square 40-200 nm), may exist in the air as single virions or in the forms of agglomerates due to the process of aerosolisation. Clinical tests proved that the size distributions of virus aerosol particles generated in the breathing and coughing of people with

upper respiratory tract infections demonstrated big similarity and range from several dozen nanometers to several dozen micrometers with a simultaneous domination of the particle size $< 5\mu\text{m}$ (Lee et al., 2011; Verpaele, Jouret, 2013). The hazards resulting from the aerosol transmission of pathogens are confirmed in research on the spread of the seasonal flu virus conducted with the application of a slot sampler with condensation or the quantitative measurements of virus concentrations by means of RT-qPCR. The research demonstrated that the particles of the size $\leq 5\mu\text{m}$ contain 8.8 times more virion copies than the ones of the size $> 5\mu\text{m}$ (Milton et al., 2013). Among the participants of the study who had respiratory symptoms (coughing and sneezing), the flu virus RNA of particle size ranges $0.65\text{-}4.7\mu\text{m}$ and $> 4.7\mu\text{m}$ was detected in 80% of children and 58% of adults (Issa et al., 2023). In addition, the measurements of viruses responsible for respiratory tract infections performed at hospital wards showed that a significant number of infection particles had the aerodynamic diameter $\text{Ø} \leq 4.8\mu\text{m}$ (Milton, 2013; Fennelly, 2020). In their research studies, Gralton (Gralton et al., 2011; Duan et al., 2021; Fennelly et al., 2020) point out that with the increase in the number and size of the generated aerosol particles, it is possible that accumulated structures (agglomerates) are created in which the number of the microorganisms increases due to the effect of accumulation. The authors also emphasize that the soluble components present in the bio-aerosol may provide specific protection against the surrounding environment, thus maintaining the contagiousness of the pathogen. The effects of nano-silica accumulation indicating the phenomenon of the agglomeration of the nanoparticles present in the bio-aerosol were also observed during the conducted experiment. The markers applied on the surfaces of the carriers form agglomerates, accumulated structures, in a similar way as the viruses present in the aerosol in the air. The occurrence of the agglomerates of the silica marker sprayed by means of an atomizer, was observed on the carriers subject to microscope analysis; see the results of the SEM imaging presented in (Fig. 5) and (Fig. 6). The photographs show agglomerations clinging to the structure of the CIP sponge filter (Fig. 5) as well as accumulated structures/particle clouds sedimented on the graphite disc (Fig. 6). Despite numerous attempts, it was impossible to image single particles of the SiO_2 marker on the selected carriers because during the falling of the sprayed solution mist, the particles clustered and formed agglomerates. Nevertheless, the chemical composition analysis confirms the presence of silica in the analyzed micro-area indicating the presence of the marker on each of the three carrier types. Therefore, the obtained results prove that even if it is impossible or difficult to identify single nano-silica particles based on the results of the imaging, the presence of the particles may be confirmed by means of the elemental composition analysis using induced X-ray radiation. The results of the physico-chemical analysis based on the examination of the spectra chemical composition (Fig. 7) demonstrate that such analyses bring positive outcomes and enable to identify the marker on each type of the surfaces used in this research. On the basis of the SEM observations, it was found that the quantitative SEM/EDS analysis of single silica marker grains on the cellulose and sponge carriers is hampered or impossible. These limitations are caused by the

occurrence of the silica nanoparticles in the form of solid agglomerations on the membrane carrier and in the form of shell agglomerations on the sponge filter. During the analysis of the results of the imaging (photographs), it was impossible to identify single grains of the silica marker. Most probably, it results from the process of agglomeration of the silica nanoparticles and the adsorption of the agglomerates on the surfaces of the filters (Fig. 4, Fig. 5). The agglomeration of the silica nanoparticles constitutes a phenomenon also observed by other researchers. For example, Rovani et al. demonstrated the agglomeration of silica nanoparticles obtained from sugar cane ash by means of the SEM and TEM techniques. The observed agglomerates of the particles were in the range of 20 to 50 nm (Rovani et al., 2018). A stronger spectrum signal of the chemical composition in the micro-area on the membrane filter (Fig. 7a) and a weaker signal of the induced X-ray radiation on the sponge filter, resulting from the smaller amount of the silica marker clinging to the walls of the filter (Fig. 7b), constitute the consequence of the silica marker agglomerations. On the other hand, the silica marker grains sedimented on the graphite carrier produce a stronger spectrum signal of the chemical composition in the micro-area (Fig. 7c). Due to the occurrence of silica markers in the agglomerates sprayed on the graphite carrier, there would be a possibility of identifying the markers not only based on the qualitative but also the quantitative analysis (Fig. 6a, Fig. 6b), which would indicate better prospects for the research concerning silica markers on graphite carriers. The photographs in Fig. 4-6 demonstrate a better resolution of the SEM imaging and the possibility of counting single grains of the silica markers in the agglomeration clusters on the graphite carrier.

To date, the detection of pathogens of such fine sizes has been carried out mainly in water solutions, for example by means of flow virometry which enables to identify even single particles of the virus. According to the literature reports, the flow virometry makes it possible to detect micro-particles of the size ranging from 100 nm to 1000 nm which may constitute both the cell components (e.g. exosomes) and the unwanted intruders (viruses and bacteria) (Binder et al., 2020).

Laboratory research demonstrated that flow virometry is a far more sensitive technique of virus detection compared to ELISA tests and it is characterized by virus detectability similar to the RT-PCR tests (Hill, Pan, Williamson, Santarpia, Hill, 2013). However, the flow virometry is dedicated to liquid samples; therefore, in the case of air aerosols it may be applied only after saturating the water solutions with the air sample (Kulkarni et al., 2016). Also, there exist studies confirming the application of fluorescent markers in the research on bio-aerosols. The overwhelming majority of the cases involve works conducted in structures of small cubature or in closed containers (tubes, pipes); the aim of the research is the quantitative identification of the objects, the assessment of the particle transmission routes and the degree of their dispersion. Yet, due to the requirements concerning research with the use of fluorescent markers, they rarely find application in experimental studies conducted in real scale.

Microscope techniques constitute an alternative form of research which enables the imaging of the pathogen occurring in the analyzed samples (Yoon, Lee, Kim, Yoo, Min, Kim, 2019). Even though the microscope techniques have been used for centuries, only the advancements in electron microscopy in recent decades made virus imaging possible. Viruses with the sizes smaller than the wavelength of visible light could not be investigated until the invention of electron microscopy in the 1930s. Since that time, electron microscopy has become the method used to identify this group of pathogens on the basis of their sizes, shapes, ultrastructural features and the distribution in tissues. Electron microscopy is a powerful tool in the field of microbiology due to its resolution capability in comparison to an optical microscope. Electron microscopy significantly contributed to the development of research concerning pathogen identification (Brown et al., 2015) functions and structures; it also played the key role in rapid diagnostics of different groups of viruses in environmental samples (Van M. Hoang et al., 2016).

The results of the conducted research prove that the SEM/EDS electron microscopy enables to identify silica markers of sizes corresponding with coronavirus virions on membrane filters, sponge filters and graphite discs. Consequently, the technique constitutes a sensitive tool for identifying such tiny structures as the silica nanoparticles. Due to the simplicity of handling, the low operating costs as well as the environmental neutrality, the silica nanoparticles may perform the function of pathogen markers in dedicated experimental studies. Scanning Electron Microscopy (SEM) appears to be a reliable and potent instrument both in the diagnostics of contagious diseases and microbiological research (Golding, Lamboo, Beniac, Booth, 2016). According to (Nolte-^t, Cremer, Gallow, 2017). Scanning Electron Microscopy (SEM) was applied in ultra-rapid microscope imaging of SARS-CoV-2. Using the high-definition scanning microscopy, the research team examined the interactions of the new coronavirus with Vero cells (Esperanto: *verda reno*) which represent a continuous and aneuploid cell lineage similar to fibroblasts applied in the production of vaccines against viral diseases; the lineage allows for cell passaging for extended periods of time under laboratory conditions. The authors justify the use of the SEM technique due to its capability to rapidly screen the Vero cells infected with SARS-CoV-2 and to perform a thorough ultra-structural analysis of SARS-CoV-2 in the entire infection cycle. In the course of that research study, the SEM technique allowed for the imaging of cell surface morphology and the intracellular surfaces in order to assess the degree of the virus distribution within a time period of 2-48 h which elapsed from the onset of the infection (Bonar, Tilton, 2017). Another research study with the use of Scanning Electron Microscopy was the one by Mondei; applying the SEM technique, the author demonstrated the typical shape of the crown of the new coronavirus cultivated in cell cultures (Corina et al., 1999). Scanning Electron Microscopy was also used in the research on coronavirus severe acute respiratory syndrome invading the human placenta (Chen et al., 2020; Algaet alroba, Rekawek, Sevan, 2020; Mondeja, Valdes, 2021).

5. Conclusions

The results of the performed research works confirmed that Scanning Electron Microscopy SEM/EDS may be successfully applied as a research tool for identifying silica markers. As proven, based on the results of the SEM/EDS investigations, it is possible to qualitatively identify the silica markers on different types of carriers such as sponge filters, membrane filters or graphite discs. Therefore, it was demonstrated that the SEM/EDS technique constitutes a sensitive tool which enables the qualitative identification of structures as fine as the silica nanoparticles which thanks to their handling simplicity, low operating cost and environmental neutrality may be used as pathogen markers in dedicated experimental studies. The obtained results demonstrate that the silica marker (SiO₂) can be effectively used as a surrogate of pathogenic organisms in simulation tests. The neutral character of the marker ensuring the safety of research staff as well as the fact that the single nanoparticle of silica (Ø 200 nm) corresponds to the size of a single virion of SARS-CoV-2 (Ø 40-200 nm) grant the possibility of its application in the simulation studies of the coronavirus transmission routes conducted both under laboratory and real conditions. In addition, the study confirms the interdisciplinary character of material engineering science as a research area involving the design, production and optimization of materials for their future applications, mostly in engineering. Material engineering is based on exploring the relationships among the chemical composition, the structure and the properties of the materials as well as the parameters of the production processes. The understanding of the above issues leads to the development of new solutions as well as the refinement of the already existing ones. The investigation confirms the importance of this research area in micro-biological studies, with a special emphasis on the optimization of the materials used in personal protective equipment used during pandemics.

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METRICS BASED PROJECT TIME MANAGEMENT – APPLICATION OF LINEAR PROGRAMMING

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Purpose: The purpose of the article is to develop an algorithm updating the estimated duration based on metrics and linear programming in the execution phase of the project. A secondary objective is to prove that the acceptance of the metrics-based approach by practitioners is highly probable.

Design/methodology/approach: We combine linear programming with metrics based project management and propose an algorithm updating the initial project duration estimation during project execution. Survey has been used to verify the knowledge and acceptance degree of metrics based management among project management practitioners. An computational example is used to illustrate the application and potential benefits of the proposed algorithm.

Findings: It has been shown that metrics based updating of initial project duration estimation can be extremely important for project time management, and thus project success, and that this approach is technically not difficult to implement in practice. It has been also proven that such an approach has high chances of being accepted in practice.

Research limitations/implications: In our research a theoretical example has been used with a limited selection of metrics. Real world cases and close cooperation with project managers and other stakeholders is needed in order to improve and adapt the approach to actual needs of practical project management.

Practical implications: The proposed approach may substantially improve the prediction quality of project duration and, consequently, increase project success probability.

Originality/value: An original algorithm for project duration updating during project execution has been proposed. This algorithm is based on metrics that should measure all the important phenomena that decrease the quality of the prediction of project duration, also human related ones, and on linear programming. No similar approach has been identified in the literature.

Keywords: project time management, metrics, linear programming, project duration estimation.

Category of the paper: research paper.

1. Introduction

The analysis of project duration and the differences between planned and actual duration of projects have received much attention in the project management literature. It is a problem that is of utmost importance in practice: underestimated project duration leads to delays, reaching several hundred percent of the originally planned duration in not few cases (The Standish Group, 2015), and delaying other endeavours in turn, overestimated one (a much more rare phenomenon) – to unnecessary blocked time and often to a certain relaxation and reduced efficiency at work. The differences between planned and actual project duration have many causes, which include optimism/pessimism bias, strategic misrepresentation or neglecting uncertainty.

By understanding the factors and consequences of project delays, project managers can develop strategies to mitigate problems and improve project performance. One way to do this is to improve the time estimation process in the planning phase of the project, and another way, to be applied in addition to the first solution, is to update the initial time estimation systematically, during project execution, on the basis of the information about the current project situation and the so far indices about the estimation quality. The updated information about the current situation in the project can be efficiently obtained thanks to metrics. Metrics in project management are indicators that objectively present selected information about the project as early as possible (Kerzner, 2017), which allows for some kind of forecast of the final results when changes in the project are still possible or low-cost. Taking the above into account, the use of metrics for project time management could prevent at least some of the negative consequences resulting from optimism/pessimism bias, strategic misrepresentation or neglecting uncertainty and erroneous estimation altogether, because the metrics might indicate to the project manager early enough during the project that some of those phenomena have taken place and remained unnoticed. The purpose of the article is thus to develop an algorithm updating the estimated duration based on metrics in the execution phase of the project. The algorithm will use a linear programming approach used in the planning phase of the project and modify it accordingly, using metrics. The secondary objective of the paper is to justify, on the basis of a survey, that the metrics-based approach has high chances to be implemented in practice.

The structure of the paper is as follows: in the 1. section we discuss the main reasons of the differences between the planned and actual duration of projects, in order to indicate the information that should be captured by the metrics during project execution. In section 2 we underline the importance of updating during the initial estimations during project execution, and in section 3 we present the state of art regarding project metrics that refer to time and the results of a survey that prove the importance of metrics to project managers and high chances of using this approach in practice. In section 4 we present the linear programming model that

is the basis of our solution. Our proposal, the algorithm of updating the initial estimation of project duration during project execution, is described in section 5, and section 6 contains an example illustrating the proposed approach. The paper terminates with some conclusions.

2. Differences between projects planned and actual duration – their reasons and consequences

In the literature on project management, much attention is devoted to the analysis of project duration and the differences between the planned and actual duration of projects. These differences have their causes, including: optimism bias, strategic misrepresentation, or neglecting uncertainty, and, obviously, their often serious consequences.

Even if the planning process is performed professionally and with care (which is not always the case (Hullet, 2016)), projects frequently encounter unexpected hurdles that result in delays, causing frustration among stakeholders and potentially leading to budget overruns. The delays in projects, in all project domains and types, are often considerable. For example, the (The Standish Group, 2015) shows that almost 50% of IT projects are delayed by more than 100%; in (Espinoza, Presbitero, 2022) we can read that 60% of investment projects are delayed by at least one year, similar statistics are available for other industries. By understanding project delay factors and consequences, project managers can develop strategies to mitigate problems and improve project outcomes.

Optimism bias proved to be widely accepted as a major cause of unrealistic scheduling for projects (Prater et al., 2017). Optimism bias refers to the tendency of people to believe that they are less likely to experience (in their projects) negative events, and more likely to experience positive events than other people (in other projects). Flyvbjerg (2006) describes optimism bias as “a cognitive predisposition found with most people to judge future events in a more positive light than is warranted by actual experience”. Numerous authors (Flyvbjerg, 2006; Macdonald, 2002; Morris, Hough, 1987) underline in their works that the main reason of poor project performance was often not project execution but optimistic under-estimation of baselines.

Moreover, it is common knowledge that strategic project planners and managers not only underestimate cost, but also overestimate benefits to achieve approval for their projects intentionally, due to political reasons. This is called strategic misinterpretation. Optimistic planners and managers also do this, although unintentionally. Optimism bias and strategic misrepresentation reinforce each other, when both present in a project (Flyvbjerg, 2021).

While optimism bias tends to dominate project planning, pessimism bias can also impact project delays. Pessimism bias refers to an excessive tendency to expect negative outcomes and overestimate risks, which may result in overly conservative timelines and excessive caution. While optimism bias leads to underestimation that is obviously harmful to organisations,

pessimism bias may be a problem too: it can lead to overestimation that unnecessarily blocks time that might be used for other endeavours undertaken by the organisation and weakens the motivation for efficient work.

Another common reason for substantial differences between the planned and the actual duration of projects is neglecting uncertainty, which may be understood as lack of full knowledge (Kuchta et al., 2023). Uncertainty may be a consequence of human- or project team related issues (Hulett, 2016), like the lack of competency of the experts or their unwillingness to admit their lack of knowledge. Also, issues like possible need for rework in a task, that would obviously delay it, are not always noticed, or admitted in the planning stage of projects, because of the lack of uncertainty management (Hulett, 2016). Uncertainty usually diminishes with project progress, but it is usually nonnegligible in the project planning phase. Constructing schedules based on one-point, crisp estimates, instead of probability or fuzzy distributions leads to unrealistic schedules that are then reported to be late, although in fact they may remain within the limits of certain confidence intervals that could be identified at the beginning if uncertainty management was applied (Hulett, Nobsch, 2012). Metrics can be very helpful in detecting and updating uncertainty during project execution.

3. Updating initial project estimations

Project estimations serve as the roadmap for project managers, providing a baseline against which progress is measured. However, relying solely on initial estimations can be risky, as projects rarely unfold exactly as planned (Vytlačil, 2020). Because of the reasons listed in the previous section, project estimations are often far from reality. However, as the project proceeds, many of the factors causing inaccurate estimations either become visible or lose some of their significance, and the uncertainty is diminishing. For this reason, it is not advisable to stick to initial estimates without continuously performing adequate, up to date analyses. It is only by updating initial estimates each time it is justified or required that we may continue to have a fairly realistic vision of the final outcome of the project at any moment of project implementation. And the information of the necessity to update project estimates should be acquired by means of adequate project metrics, as indicated by the approach called metrics-based project management (Kerzner, 2013).

The importance of updating project estimations has been noticed by the authors of the Earned Value Method (Fleming, Koppelman, 1997) that is considered a valuable technique for monitoring and controlling project progress. If EVM is applied, several metrics are calculated systematically during the project course. They provide information on the current relationship between the actual and planned cost and time, and, what is still more important, on this relationship as forecasted for the future, when the project is finished. Although EVM is

efficient above all for cost-related issues, it also provides indications concerning the current status of other project aspects (e.g. expected project duration (Vanhoucke, 2010), that is our main subject in this paper), especially in its extended versions (there exists, e.g. Green Earned Value Method (Koke, Moehler, 2019) that uses metrics related to sustainable management and helps remaining up to date as far as expected project sustainability parameter values are concerned, or Customer Earned Value (Kim, Ballard, 2002) that, on the basis of current customer-related values, assesses future satisfaction of the customer).

The present paper focuses on project time management. As mentioned above, EVM offers several metrics serving to predict project duration during project execution, especially several generalizations of the method (Batselier, Vanhoucke, 2017; Vanhoucke, 2010) do so. However, they are fundamentally based on the relationship between the planned and the actual duration of project tasks that have been already (up to the control moment) executed. As mentioned above, reasons for project delays are varied and not limited to simple mistakes in the estimation value. They comprise more profound phenomena, like optimism and pessimism biases and possibly many more human-related issues. Therefore, other metrics related to time management than those included in the EVM should be considered. This topic is discussed in the next section.

4. Project metrics based management with respect to project duration

In project management based on metrics (Kerzner, 2022), of which the Earned Value is a special case (rather old and limited), at systematic intervals during project execution, the values of several metrics are calculated. These metrics should inform project managers and other stakeholders about the current status of the project and, above all, give them some insight about the final results of the project (that are still to come in future) in the context of its objectives and success criteria. The proper choice of the metrics is essential for project control efficiency.

In this paper we concentrate on one of the main project success criteria, that of keeping the planned deadline. Thus, we are interested in metrics that would grasp, during project execution, possibly all issues that might, in the future, have an influence on the difference between the planned and the actual project duration.

On the basis of literature review, we identified 34 potential metrics supporting project management, which are presented in Table 1. Metrics 13 and 14 are part of the Earned Value Method, other metrics are not used in the scope of this method.

Table 1.
Potential project metrics identified through literature review

No of the metric	Description of the metric
1	Number of resources allocated versus planned
2	Quality of resources allocated versus quality planned
3	Project complexity index
4	Level of customer satisfaction with the project result
5	Level of customer satisfaction with project progress
6	Level of customer satisfaction with project communication
7	Number of commitments kept to the customer in relation to the number of total commitments
8	Number of critical constraints
9	Number of cost adjustments made
10	Number of critical assumptions
11	Number of hours without allocated human resources
12	Percentage of total overtime hours worked
13	Deviation of costs
14	Schedule deviation
15	Cost performance index
16	Schedule performance indicator
17	Compliance with accepted quality indicators
18	Quality of implementation of the risk management plan
19	Quality of project management
20	Quality of management of customer expectations
21	Quality of management of customer interactions
22	Number of changes to the project scope
23	Degree to which the opinions of individual project team members are taken into account
24	Quality of defining and communicating roles to individual project team members
25	Opportunity for personal and professional development of team members
26	Level of understanding of the client and its industry by the project team
27	Degree to which the project contributed to establishing or strengthening the company's position in the industry (additional opportunity generation)
28	Degree to which it succeeded in timely invoicing and obtaining payments
29	Amount of wasted/unproductive time
30	Level of knowledge and competences of the project team in project management
31	Quality of supplier monitoring
32	Degree to which the project team looked after the client's interests
33	Degree of implementation of occupational health and safety rules
34	Number of tasks (work packages) completed according to plan

Source: own work.

The challenge consists in selecting the right metrics, and assuring both their measurability and adequate communication of their values to the relevant stakeholders. Another challenge is to implement the approach in practice, which means convincing project managers and stakeholders that it may be useful in every day project management. For this reason we conducted a research examining the potential of using also non-standard (those not belonging to the Earned Value Method) time related metrics in project control in practice.

In the research was conducted in April 2023 on a sample of 100 project managers from 100 organizations in the form of a telephone interview, the question of the present and potential usability of the above metrics was studied. The first part of the questions in the questionnaire concerned the frequency of the current use of individual metrics in projects in the surveyed organizations. Figure 1 shows the distribution of responses.

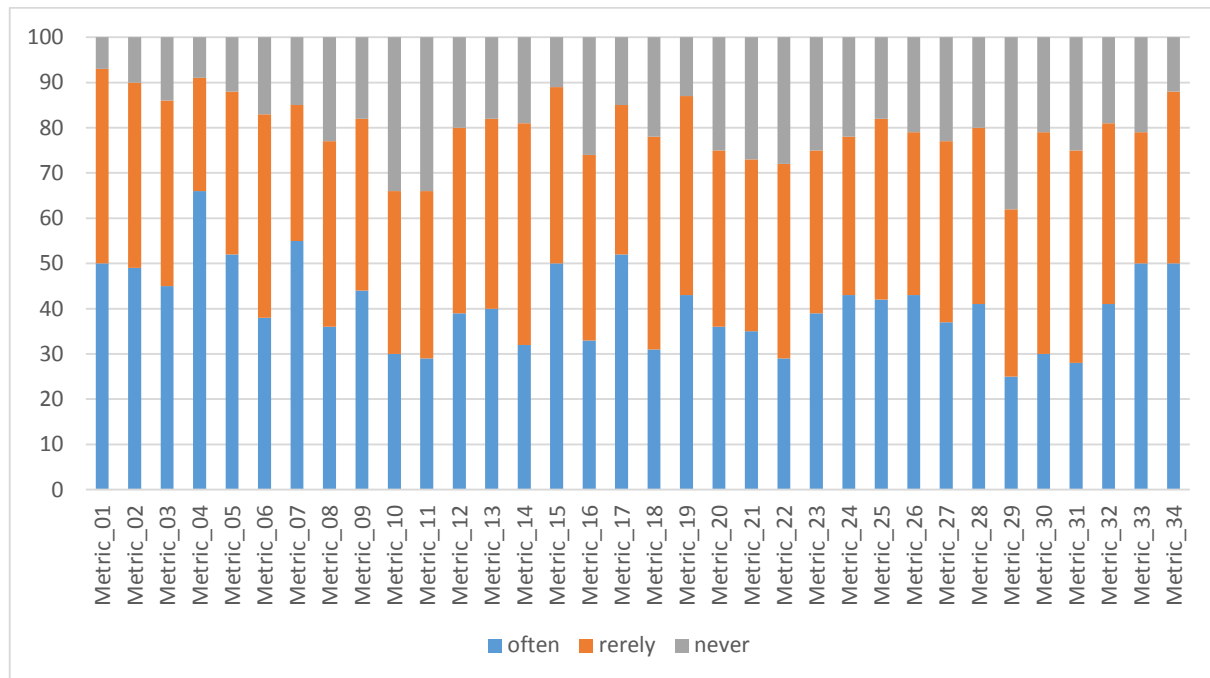


Figure 1. Frequency of use of the metrics in projects in the surveyed organizations – distribution of responses.

Source: own work.

According to over 50 respondents, metrics that were often used in projects in their organization were metrics (ordered by the frequency of use): 4,7,5,17,1,15,33 and 34. The remaining metrics were identified as often used in projects in the organization by less than 50 respondents (range from 25 to 49 respondents).

According to only less than 30 respondents, metrics that were rarely used in projects in their organization were metrics 33 and 4. The remaining metrics were identified as rarely used in projects in the organization by less than 30 respondents (range from 30 to 49 respondents).

According fewer than 40 respondents, metrics that were never used in projects in their organization were metrics 29,10 and 11. The remaining metrics were identified as never used in projects in the organization by fewer than 30 respondents (range from 7 to 28 respondents).

The next question concerned the opinion of the respondents whether it would be beneficial to use the respective metrics for project management.

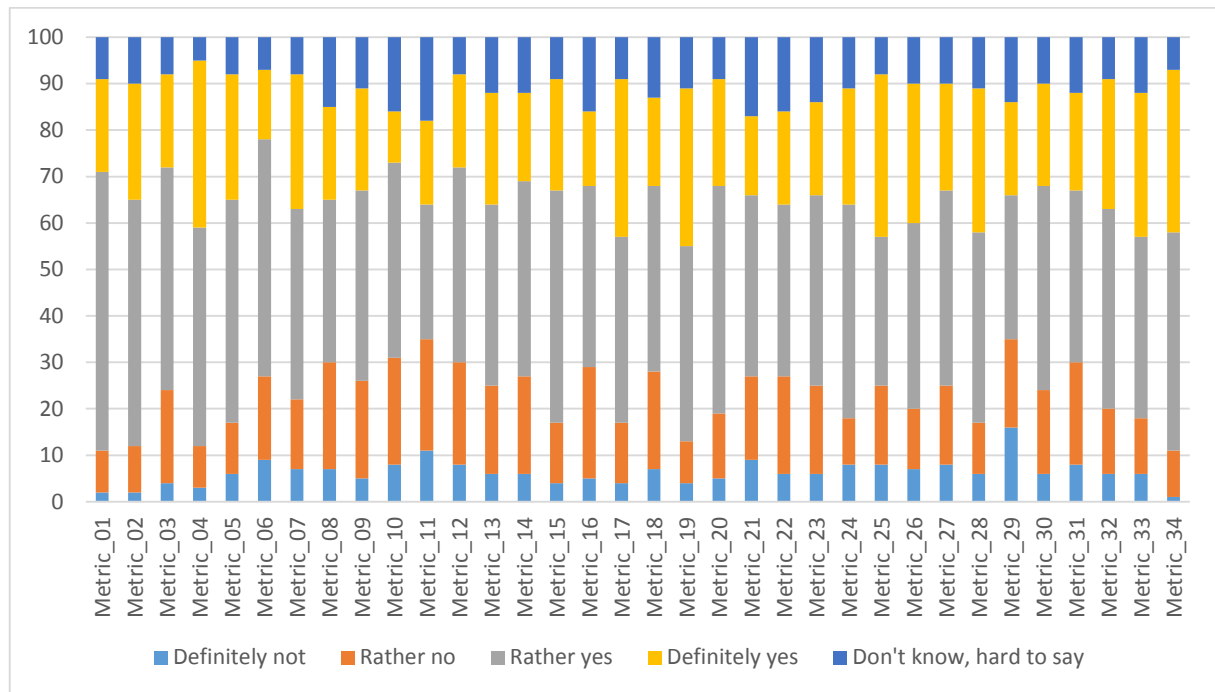


Figure 2. It would be beneficial and justified to use this metric? – distribution of responses.

Source: own work.

To the question: “Would it be beneficial and justified to use this metric?” for 33 metrics, over 50 respondents indicated the answer: “Rather yes” or “Definitely yes” (range from 51 to 83 respondents). For all metrics, only less than 35 respondents indicated the answer: “Rather no”, “Definitely no” (range from 11 to 35 respondents).

It seems thus that the usage of metrics in practice has already been accepted and it has a clear growing potential. Numerous metrics from Table 1 should be taken into account in project time management. Their unfavourable values may indicate the fact that some tasks have been or, which is much more important, will be delayed. E.g., metrics 1, 2, 11, 12 may indicate shortage of resources or of qualified resources, which obviously may delay some project activities. Metrics 4, 5, 6, 7, 17, 20, 32 may imply the need to redo certain tasks, to prolong some of them or to add additional tasks, in order to have the additional time necessary for increasing the stakeholder or customer satisfaction or the compliance degree with previous arrangements. Metrics 14, 16, 22, 34 may point to general mistakes in project initial estimation and the need to update them. Other metrics might also be considered, e.g., the features or credibility of the experts who performed the estimation of project task duration: if an expert has turned out to be an optimist while estimating the tasks already completed, the estimated duration of the tasks still to be performed should probably be updated.

In the following, we will propose the inclusion of metrics into the linear programming model that determines the expected project duration. First, we will discuss the original model that does make use of metrics. Secondly, in Section 6, we will apply the model to project metrics-based control.

5. Linear programming model determining the expected project duration in the planning and execution phase of the project

Let us assume that we have a project network with a total of n nodes, where n represents the number of events in the project network. An event is the moment when one or more activities (called also tasks) with the same predecessors are started and all their predecessors are finished, or the moment when the project starts, or finally the moment when the project terminates. Project start moment is assumed equal to 0 and is represented by the 1st node in the network. Its moment of occurrence is denoted as x_1 , where $x_1 = 0$. The n^{th} event, represented by the last node, stands for the project end. Its occurrence time $x_n = Z$ represents the moment when all the project tasks are ended. This moment is crucial in our linear programming model and constitutes the objective function that should be minimized. The value of this objective function represents the shortest possible project duration under the given information on project activities estimated duration, and activities predecessors of the Finish-to-Start type (other predecessor types are not considered in the model, but their inclusion would be straightforward in a generalised model).

The expected project duration will be estimated systematically, in different moments t , $0 \leq t \leq AT$, where AT stands for the actual project duration, and $t=0$ for project start and all the planning period preceding it. The magnitude t will be a parameter of the model and will correspond to the moment when the model will be applied. In fact, t will be selected among systematic control moments $t_k, k = 1, \dots, K, 0 \leq t_k < AT$, in which the values of selected metrics will be collected and certain decisions on the project should be taken, with $t_1 = 0$ representing the planning stage of the project and $t_k < t_{k+1}, k = 1, \dots, K - 1$.

We have thus the following objective function:

$$Z(t) = X_n(t) \rightarrow \min \quad (1)$$

Let $A_{(i,j)} \in A$, where A is the set of all project tasks, represent a single project task. $A_{(i,j)}$ starts in the i^{th} node and finishes in the j^{th} node, $i, j = 1, \dots, n$. $D_{(i,j)}(t), i, j = 1, \dots, n$ represents the duration of activity $A_{(i,j)}$ as known in moment t , where $0 \leq t \leq AT$. Duration $D_{(i,j)}(t)$ may be the estimated one or the actual one, depending on whether in moment t the respective activity has already been completed or not. Durations $D_{(i,j)}(0)$ are the durations estimated in the planning phase of the project. For reasons discussed above, they should be subject to possible adjustment during project execution, on the basis of selected metrics.

The constraints of the model will be as follows:

$$x_j \geq x_i + D_{(i,j)}(t), A_{(i,j)} \in A \quad (2)$$

$$x_i \geq 0, i = 1 \dots n, \quad (3)$$

$Model(t)$ for a selected t , $0 \leq t \leq AT$ will denote model (1)(2)(3) with the parameter t . The optimal value of the objective function (1) of $Model(t)$ will be denoted as $PD(t)$ – the duration of the projects as seen in the moment t .

6. Algorithm updating project estimated duration, based on metrics and linear programming

As mentioned above, facing the lack of credibility and stability of initial time estimations in projects, it is generally accepted that the initial estimates should be updated during the project course, and this should be done in regular time intervals, in selected control moments $t_k, k = 1, \dots, K, 0 \leq t_k < AT$, on the basis of carefully chosen metrics. We assume that project stakeholders have decided to use L metrics, $M_l, l = 1, \dots, L$, the value of each of them acquired in moment t will be denoted as $M_l(t), l=1, \dots, L$. The metrics can be chosen from Table 1 or be original proposals of project managers or organisations execution the projects. The following algorithm will allow us to know $PD(t_k), k = 1, \dots, K$, an updated information on the expected duration of the whole project as seen in the control moment $t_k, k = 2, \dots, K$. The quality of this information will be higher, the better metrics will be chosen.

The following algorithm should be applied:

1st step. Before the project start ($t_1 = 0$), determine the project network, composed of nodes $i = 1, \dots, n$ and arcs representing project activities $A_{(i,j)}, i, j = 1, \dots, n, A_{(i,j)} \in A$.

2nd step. During the planning phase, collect from experts estimations of project activities durations $D_{(i,j)}(0), i, j = 1, \dots, n, A_{(i,j)} \in A$. Keep track of the experts responsible for the estimation of each activity and their features (e.g. history of past estimations and their accuracy). Obviously, this step has to be executed with the highest care and expertise possible, consulting the most knowledgeable experts.

3rd step. Apply $Model(0)$ to determine the estimated project duration $PD(0)$.

4th step. Adopt the metrics $M_l, l = 1, \dots, L$ that might be helpful to control the estimation quality of activity durations, chosen previously.

5th step. Set $k := 1$.

6th step. Set $k := k + 1$. Either choose control moment t_k or STOP.

7th step. Analyse values $M_l(t_k), t = 1, \dots, L$.

8th step. Calculate the possible influence of the information implied by $M_l(t_k) t = 1, \dots, L$ on the estimation of the duration for those $A_{(i,j)} \in A$ that have not been finished in moment t_k .

9th step. Calculate $D_{(i,j)}(t_k)$ for those $A_{(i,j)} \in A$ that have not been finished in moment t_k , either taking $D_{(i,j)}(t_k - 1)$ or values updated on the basis of values $M_l(t_k) t = 1, \dots, L$.

10th step. Apply model $Model(t_k)$ and calculate $PD(t_k)$. Analyse the obtained data.

11th step. Go to step 6.

The STOP in the 6th step will occur when the project will be so close to its termination that no new control point t_k will be need.

The algorithm will be illustrated by means of an example.

7. Computational example

Let us consider the following project. Estimations of individual activity durations were performed by 3 experts: X, Y, Z.

Table 2.

Example project – information retrieved in the planning stage ($t_1 = 0$)

Estimator	Activity	Duration $D_{(i,j)}$
Expert X	A(1,2)	5
Expert Y	A(2,3)	8
Expert Z	A(2,4)	7
Expert X	A(3,5)	10
Expert Z	A(4,5)	11
Expert Y	A(5,6)	6

Source: own work.

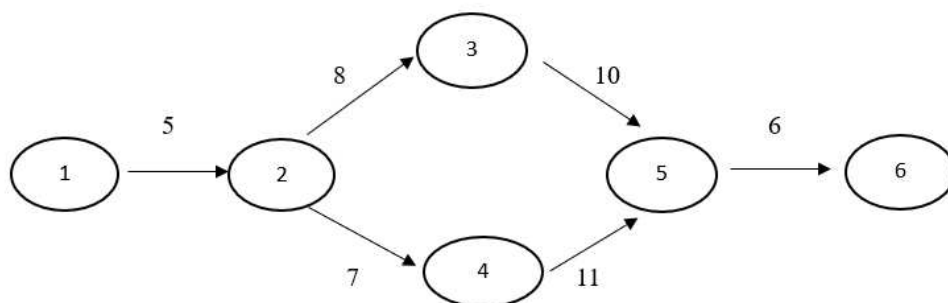


Figure 3. The network of the project example.

Source: own work.

We have thus $PD_{(0)} = 29$. This is the information we communicate to the customer and other stakeholders before the project start. It is an important commitment that may influence the “be or not to be” of the project, the decision on its acceptance or withdrawal.

Let us now assume that the project has been accepted for realisation and actually started. The record of project control during its execution is presented in Table 3 and explained afterwards.

Table 3.

Example project – information retrieved in the planning stage and in consecutive control moments

Estimator	Activity	$D_{(i,j)}(t_1)$ $t_1=0$	$D_{(i,j)}(t_2)$ $t_2=8$	$D_{(i,j)}(t_3)$ $t_3=14$	$D_{(i,j)}(t_4)$ $t_4=15$
Expert X	A(1,2)	5	8 (completed)	8 (completed)	8 (completed)
Expert Y	A(2,3)	8	8	6 (completed)	6 (completed)
Expert Z	A(2,4)	7	7	7	10 (completed)
Expert X	A(3,5)	10	16	16	16
Expert Z	A(4,5)	11	11	11	14,5
Expert Y	A(5,6)	6	6	4,5	4,5

Source: own work.

Let us suppose the first control moment t_2 falls after 8 days. It turns out that the estimated duration of task A = 5 days was wrong, the task took in fact 8 days. This wrong estimation came from Expert X. It seems that this expert was too optimistic and possibly is characterised by the optimism bias. We can use the metric “optimism degree of expert X”, calculated as the ratio of the actual and the planned duration of activity A(1,2), and apply this metric to the estimated duration of the yet unfinished activity A(3,5) that was estimated by the same expert. We might also apply the metric to the durations of all unfinished activities, but we assume that there is no reason yet to believe experts Y and Z are characterised by the same optimism degree as expert X.

In the control moment $t_3=14$ we find out that activity A(2,3) took 6 days instead of 8. Thus, expert Y turned out to be pessimistic. Performing an analogous step as below, we update the duration of activity A(5,6) estimated by the same expert. The same is repeated in $t_4=15$ for expert Z.

In Table 4 we can see how drastically the estimation of project duration was changing during project execution.

Table 4.

Example project – estimation of project duration from the planning stage, updated during project execution on the basis metrics representing experts features

Control moment	PD(t_k)	Critical path
$t_1=0$	29	1-2-3-5-6
$t_2=8$	38	1-2-3-5-6
$t_3=14$	34,5	1-2-3-5-6
$t_4=15$	37	1-2-4-5-6

Source: own work.

Taking into account the presented data, we can see how in real time the information about the expected project duration could be changed. The changes with respect to the initial estimation were close to 13%. It is important to underline that already on the 8. time unit of project duration the substantial misestimation committed in the planning stage was discovered, thanks to the application of adequate metrics and the proposed model. There was still time for negotiations or other steps before the project was finished and actually delayed.

The reason of such misestimations in the planning stage may be, as mentioned above, different; in the example we are modelling the personal features of each expert (optimism bias, pessimism bias), but many more phenomena have to be taken into account. The metrics have to be chosen to measure all phenomena that may influence the estimation quality.

8. Conclusions

Project estimations are often far from reality. Due to the lack of reliability and stability of initial time estimations in projects, it is generally accepted that initial estimates should be updated during the project course at regular intervals based on carefully selected metrics. The quality of this information will be higher, the better metrics will be chosen. It is therefore worth defining metrics that can be helpful in controlling the estimation quality of activity durations. Therefore, the article proposes an approach involving the inclusion of metrics determining the expected project duration into a linear programming model having project duration as the objective function and develops an algorithm updating project estimated duration in the planning and execution phase of the project.

With the increasing complexity and level of uncertainty in projects that we are currently seeing, the importance of metrics continues to grow. However, their definition and application in projects is extremely difficult, because in projects a significant role is played by phenomena that are difficult to measure and to a small extent predictable, in particular those related to optimism/pessimism bias, strategic misrepresentation or neglecting uncertainty. In the theory of project management based on metrics, great emphasis is placed on the thesis that even seemingly unmeasurable phenomena can be measured if metrics are properly defined. In this case, metrics could be used, for example, regarding the degree of optimism/pessimism or other features of experts involved in the project. Thanks to this, underestimation or overestimation of project duration or delays in project implementation can be minimised during project execution.

The model proposed here can comprise various metrics, related to various phenomena influencing project duration. Future research should concentrate on the identification of adequate metrics and on case studies, verifying the proposed approach in practice. It has to be underlined that linear programming model can be implemented in such widely accessible tools as Excel. The only constraints limiting its potential application are thus the acceptance of the metrics-based approach in practice (that, on the basis of the survey presented here, can be judged as having a high potential) and the selection of the appropriate metrics, preceded by a careful analysis of the reasons of delays and misestimations of project duration. Such an analysis should be both general (covering all projects) and branch- or organisation specific.

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TO BE OR NOT TO BE... AN ENTREPRENEUR: WHAT MOTIVATES AND WHAT LIMITS STUDENTS' ENTREPRENEURIAL INITIATIVES?

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Purpose: The study aimed to present the entrepreneurial intentions of students and to identify factors that motivate and limit these initiatives.

Design/methodology/approach: The research used literature studies and quantitative surveys. This study used a set of primary data obtained by a direct survey using a structured survey questionnaire. The survey was conducted in 2019. The respondents were students of economic studies from the Koszalin University of Technology.

Findings: Many students are willing to start a business in the future. They are motivated, in particular, by the desire for greater professional independence and the opportunity to implement their business ideas. Students see self-employment as an opportunity to earn a higher income. The challenge in starting a business is the lack of sufficient financial resources and the lack of sufficient knowledge and skills in running a business. Increasing students' motivation to start a business is possible by improving existing policies to support entrepreneurship, especially among young people. In addition, an important element that can stimulate the entrepreneurial spirit among students is adapting teaching programs to students' needs in terms of acquiring practical skills in starting and running their enterprise, including deepening knowledge in the field of financial knowledge and skills.

Research limitations/implications: The research adopted a purposive sampling method, which has its limitations.

Practical implications: The research results may serve as an inspiration for further analyzes of factors determining the initiatives of entrepreneurial students, and may also be used in practice by various types of organizations supporting entrepreneurial initiatives among young people at the local, regional and national level.

Originality/value: The article extends research on student entrepreneurship by presenting an international comparison of student entrepreneurship motives and challenges in developed and developing countries and enriches existing research on the identification of entrepreneurial initiatives among Polish students.

Keywords: entrepreneurship, entrepreneurial initiatives, motives, challenges, students.

Category of the paper: Research paper.

1. Introduction

Entrepreneurship plays a key role in the economy of every country (Ferreira et al., 2023). Entrepreneurs create new jobs, stimulate innovation, intensify competition, and adapt to changing market conditions and social trends (Gujrati et al., 2019). They are the “engine of economic growth” making a huge positive contribution to the country's economic and social growth (Koe et al., 2012).

Entrepreneurship is identified with running a business. According to Shane and Venkataraman (2000), entrepreneurship is a set of activities that involve identifying, evaluating, and exploiting opportunities to introduce new products and services, markets, organizing methods, raw materials, and processes by creating efforts in ways that have never existed before. Entrepreneurship is also the process of creating new things. According to Sudół (2011), entrepreneurship is a feature of an enterprise and an entrepreneur that includes the readiness and ability to undertake and solve new problems innovatively and creatively, with full awareness of the associated risks, as well as the ability to take advantage of emerging opportunities and respond quickly and flexibly to changing conditions. Entrepreneurs are perceived as people who create new combinations (solutions) in various forms (new goods or goods of better quality, new production methods, new markets, or innovative organizational processes). Entrepreneurship is becoming the domain of Renaissance people—people with versatile interests and specializations focused on constantly expanding their horizons and self-development (www.citibank.pl). Entrepreneurship should also be associated with the personality traits of an enterprising person, which are highlighted, among others, by Herron and Robinson (1993). They defined entrepreneurship as a set of behaviors aimed at initiating and managing the reallocation of economic resources (i.e., shifting the distribution of production factors) and creating new values using these means. Entrepreneurial people identify and use opportunities emerging in different contexts and markets and choose different paths to achieve their goals. Certo, Moss, and Short (2009) describe entrepreneurs as people who can do something different and see opportunities where others cannot. These entrepreneurial intentions and actions provide people with opportunities to achieve financial freedom, power, and decision-making ability (Basu, Virick, 2008). Research conducted in 2021 by the Citi Handlowy Foundation and the Foundation for the Development of the Knowledge Society shows that young Polish men and women have a very favorable attitude towards entrepreneurship, treating running their businesses as a desirable career path. The percentage of people under 30 who run their own business or have this type of experience is relatively low, but over 60% of them are considering starting a business in the future (www.citibank.pl). It is impossible to deny that young people have an extraordinary ability to adapt to ongoing changes. This feature allows them to take on challenges and respond to changes taking place in the country more flexibly than people of any other age category (Domalewski, 2007).

Gubik and Farkas (2015) emphasize that the changing nature of the young generation of students leads to new expectations related to lifestyle, working conditions, and career development, which has a significant impact on intentions to start their businesses.

Students represent the entrepreneurs of tomorrow, and their entrepreneurial actions will shape future societies (Sieger et al., 2014). Therefore, there is a constant need to study the growing interest of students in starting businesses (Alves et al., 2019). As shown by previous research, the motives and limitations of starting their own business among students have been widely analyzed by scientists from developed and developing countries. Understanding the factors that promote or limit new business creation is critical to regional economic development efforts because high levels of new business creation, particularly by young people, contribute significantly to a region's economic vitality and are a key signal of a dynamic economy (Florida et al., 2004).

The study aimed to present the entrepreneurial intentions of students and to identify factors that motivate and limit these initiatives. This study is an attempt to fill the gap in research that relates to the identification and assessment of factors determining entrepreneurial attitudes and behaviors among students. Understanding what prompts students to start a business and what limits their entrepreneurial initiatives is an important element in assessing their readiness to run their own business. These findings may constitute an important voice in the discussion on the creation of effective programs to support the development of self-employment among young people in Poland. The research results can be an inspiration for further in-depth analyzes of the determinants of entrepreneurial attitudes and behaviors among students; they can also be used in practice by various types of organizations supporting entrepreneurial initiatives at the local, regional, and national levels.

2. Determinants of students' entrepreneurial initiatives - research review

Many empirical studies conducted among students at universities in Poland indicate that students' entrepreneurial initiative is determined by various factors. Bieńkowska-Gołasa and Krzyżanowska (2023), analyzing the socio-economic determinants of student entrepreneurship among students of the SGGW in Warsaw and students of the Pedagogical University of Krakow, showed that the most important motives for starting a business, according to students, are the ability to pursue their own passions as well as independence and self-reliance. However, students indicated a lack of knowledge about setting up and running a business and the high costs of running it as the main barriers. Gano and Łuczka (2020), analyzing the determinants of entrepreneurial intentions of students of universities in the Greater Poland Voivodeship, proved that the desire to have their own business is motivated by the desire for greater social recognition. The example of entrepreneurial activities in students' immediate environment plays

an important role in stimulating entrepreneurial intentions. Students thought that running your own business involved greater risk than working full-time. The dominant factor motivating students to start a business was the desire to obtain a high income. An important motivator for entrepreneurial activities was also the opportunity to develop in fields interesting to the student. The ability to decide independently about working hours was also important. Risk and the willingness to take it were not perceived as motivating factors. The key barrier to entrepreneurial initiatives among students is financial resources. Students pointed to the high costs of running their own business as well as the lack of financial resources needed to start a business. High rental prices for commercial premises and the risk associated with running your own business are also significant problems. Żuchowski and Wyszomirska (2015), analyzing the entrepreneurial initiatives of students of universities in Ostrołęka, showed that the factors limiting entrepreneurial initiatives are primarily: a high level of risk, the responsibility of running one's own business, dedication, the scope of time required to run one's own business, as well as excessive bureaucracy. The following factors were identified as activating students to engage in entrepreneurial behavior: the desire to be professionally independent, higher earnings, the opportunity to test one's knowledge and skills in practice, self-fulfillment, the flexibility of working hours, and, to a small extent, the desire to continue family traditions. Myjak (2014), analyzing the entrepreneurial initiatives of students of management, economics, and production engineering at the State Higher Vocational School in Nowy Sącz, proved that the factors encouraging students to start their own business are higher education (in particular, acquired practical skills), as well as specific personality traits such as creativity, willingness to take risks, and new challenges. The factors limiting the willingness to become self-employed include financial barriers (lack of sufficient financial resources to start a business, difficult access to foreign capital), high operating costs, unclear legal regulations, a lack of professional experience, a lack of motivation, and a lack of a business idea. Wronowska (2016), based on research conducted among students of economic analytics at the University of Economics in Krakow, proves that the most frequently indicated factors inhibiting entrepreneurial initiatives include: lack of a business idea, insufficient financial resources, fear of failure, lack of knowledge about starting and running activities, and too much risk and responsibility related to the operation of the enterprise. However, the main incentives for students to take up self-employment are flexible working hours, independence and self-fulfillment, and the possibility of getting rich quickly. Poteralski (2005) indicates that the entrepreneurial initiatives of university graduates in the West Pomeranian Voivodeship were positively influenced by the ability to influence the amount of their earnings, independence, a chance to achieve success and self-fulfillment, as well as a sense of power and the ability to decide about their fate. In turn, the challenges of entrepreneurial intentions include a limited level of equity capital, tax burdens, a high level of risk, an unfavorable economic situation in the country, and a high susceptibility of national law to changes. Kulig-Moskwa and Strzelczyk (2014), analyzing the entrepreneurial intentions of students of the WSB University in Wrocław,

prove that students feel aversion to self-employment due to the high level of risk and responsibility, as well as due to existing competence and administrative barriers. Students who plan to start their own business indicated that they see self-employment as a prospect of higher earnings, professional independence, and a chance to pursue their interests. Kilar and Rachwał (2014) analyzed students of the Faculty of Geography and Biology at the Pedagogical University of Krakow. They proved that the external factors stimulating entrepreneurial initiatives are: market demand for the type of business activity, the prospect of organizing new jobs, favorable economic conditions, and the possibility of achieving high profits. Among the favorable internal factors, in particular, the opportunity for self-fulfillment, independent decision-making, and independent time and work management were mentioned. The main limitations of entrepreneurial initiatives resulting from the external environment include legal conditions, excessive bureaucracy, state fiscal policy, high costs of employment, and employee maintenance. The most frequently indicated internal challenges were: negative self-assessment showing a lack of entrepreneurial traits, high risk of failure, lack of appropriate funds, time-consuming nature of running one's own business, too much responsibility, and lack of a business idea.

The level and nature of entrepreneurship significantly between EU Member States. The reasons for low enthusiasm for an entrepreneurial career are, therefore, varied (European Commission, 2013). Fantová (2016), examining the factors determining the entrepreneurial activities of students from fourteen different universities in the Czech Republic, showed that the motivation for starting one's own business is the prospect of professional independence, self-fulfillment, relatively higher earnings, but also acquiring knowledge and practice throughout the enterprise's life cycle. Another stimulus for increasing self-employment among students was the lack of interesting job offers, the high quality of entrepreneurship education offered by Czech universities, or the possibility of part-time work. It may also be interesting that future entrepreneurs did not take into account risk resistance as a desirable personality trait defining an entrepreneurial attitude. The Czech Republic does not make it easier for new entrepreneurs to start a business. The negative impact on student entrepreneurship can be identified with a complicated and often variable legislative process, poor law enforcement, or administrative complexity. Additionally, respondents often reported a lack of funds needed to start a business, a growing fear of failure, and the time that should be devoted to business development. According to research conducted by Belús et al. (2017) in a group of Slovak students, these people can count on financial support from the state, but there is still a lot of bureaucracy and legal barriers. According to the surveyed students, the motive for starting their own business was the opportunity to fully use their skills, career development, and having an experienced entrepreneur in the family. In turn, Čapienė and Ragauskait (2017) proved that for students studying at the Faculty of Economics and Management at Aleksandras Stulginskis University in Lithuania, the most important reason to start a business is the desire to achieve a higher income. The majority of respondents indicated that working full-time is not associated

with ensuring a decent standard of living. Moreover, in the opinion of students, being "your boss" allows you to fully use the acquired knowledge, develop your interests, and, above all, make your dreams come true. However, according to students, creating your own business may be associated with several problems, such as the lack of a good business idea that would enable you to "stand out" and survive on the market, a high workload that involves enormous sacrifice, and a lack of time free from running a business. related to activities. Kvedaraite (2014) also conducted research to determine the determinants of entrepreneurial attitudes among Lithuanian students at other universities. The author showed that, apart from the reasons mentioned earlier, the desire to create jobs also largely motivates people to start their businesses. In the opinion of the surveyed undergraduate students who took part in the study, it can be concluded that the lack of information about creating a business, the low chances and high costs of obtaining a loan, and the lack of entrepreneurship skills are the most important obstacles to starting one's own business. The motive of being one's boss is a significant determinant of Albanian students' pursuit of a professional career. According to the analysis of Kume et al. (2013), final-year students at the University of Tirana in Albania who aspire to be self-employed are more motivated to build a business that their children can inherit. Future entrepreneurs are also highly motivated to challenge themselves and then grow and learn, build great wealth, and generate a high income. Research by Roman et al. (2015) led to several conclusions that indicated, among others, factors stimulating entrepreneurial initiatives among students in Romania. In the opinion of students, the most important arguments in favor of setting up your own company are related to the elements of self-development (implementing ideas, achieving dreams, having an interesting job, accepting challenges), as well as work independence (having autonomy, being your boss, having career prospects). The authors showed that success is always perceived as individual, while limitations are always the fault of the system. The ideal job for students is not necessarily one that brings a steady income but one that adapts to their lifestyle and expectations in terms of professional achievement. Elements that are important for students include a flexible schedule, development opportunities, and confirmation of one's personality. Overall, improving technical infrastructure, linking government programs more effectively, continuing the process of de-bureaucratization, and promoting entrepreneurial achievements in the media can bring long-term, significant improvements in entrepreneurial activity in Romania.

Research to determine the factors determining entrepreneurial initiatives among students was also undertaken by researchers in developing countries outside the European continent. Understanding entrepreneurial intentions among university students is particularly critical in Africa, where unemployment levels are very high. The oversupply of labor, the rise in unemployment, and the lack of positive feedback on past efforts to find solutions to these problems among Kenyan graduate youth have created an important basis for greater attention to entrepreneurship. A study conducted by Rukundo Setuza (2017) showed that the entrepreneurial attitudes of university students in Kenya and Rwanda are influenced by their

closest friends and other people in their close environment. It has also been proven that most students start their businesses because they have good ideas and want to implement them. As an entrepreneur, the student believes that he would have sufficient control over his business and be fully independent. In Eastern Africa, a significant factor hindering the growth of the number of entrepreneurs is cultural barriers, i.e., discrimination against women. The level of development in a developing country is of great importance in the development of entrepreneurship. Most Rwandans work in agriculture, which is the sector with the lowest wages and lowest labor productivity. Moving large numbers of citizens from agriculture to the non-agricultural sector is crucial to reducing poverty and achieving economic transformation. Entrepreneurs have a positive image in Ethiopian society, and the creative atmosphere at Ambo University inspires people to develop ideas to start new companies. Seyoum Alemu and Tefera Ashagre (2015), examining the factors determining entrepreneurial attitudes among students of Ambo universities, showed that for students, the most important factor influencing entrepreneurial initiatives is the tendency to make decisions, society's attitude towards entrepreneurship, having an entrepreneur in the family, the existence of demand for a given product or service, the availability of qualified consultants and service support for new businesses, and government support by providing land and required resources. In turn, students identified a lack of knowledge and initial capital, as well as elements related to government support, as barriers that make it difficult to start their businesses. Although banks are willing to provide loans to startup companies, registering and starting a business is difficult for the government bureaucracy. According to respondents, a business idea and human resources are not a problem when starting your own company. Lunavath (2015) proved that education is a key factor in the development of modern entrepreneurship. Students believe that an entrepreneur must have a good technical and professional background. This is also one of the reasons why many entrepreneurs fail in India. Efforts by academic institutes to promote entrepreneurship are largely unsatisfactory. Additionally, the results suggest that most respondents will not decide on an entrepreneurial career due to a lack of support or a feeling of discrimination against a given gender. In turn, Uddin and Bose (2012), examining the attitudes of students at universities located in Bangladesh, proved that the factors determining entrepreneurial activities are: the tendency to take risks, the need for achievement, education, and the environment in which a business is started. The biggest barrier for future entrepreneurs is the lack of job security and stability. Also, the study by Kabir et al. (2017) showed that entrepreneurship education will provide skills and knowledge that can help students change the typical mindset from job search to job creation. Hence, focusing on developing the entrepreneurial mind through education will be important for the development of an entrepreneurial culture as well as for sustainable socio-economic development. Peng et al. (2012) confirm that entrepreneurial intentions are positively influenced by self-control, risk-taking, experience, and entrepreneurial competencies. According to students from nine different universities in Xi'an, China, some of the constraints on entrepreneurial behavior are caused by

a lack of self-confidence, insufficient funds, a lack of time, family support, business skills, and entrepreneurship education. Therefore, as the results of the research show, both state policy and the entrepreneurial environment have a significant impact on the entrepreneurial attitude of students.

To sum up, the students came from varied motives and restrictions in starting their businesses. However, some similarities can be noticed in students' motives for self-employment. Professional independence was indicated as an important motivator of entrepreneurship by students from European countries (Poland, the Czech Republic, Romania) and also from outside Europe (Kenya). Similarly with the motive of self-fulfillment and development opportunities (Poland, Slovakia, Lithuania, Albania, Romania, Estonia, Bangladesh), the use of acquired knowledge and skills (Poland, the Czech Republic, Bangladesh), a good business idea (Poland, Kenya) and having an entrepreneur in the family (Slovakia, Ethiopia). In turn, higher earnings (Poland, the Czech Republic, Lithuania, Albania) and the possibility of flexible working hours and forms (Poland, Czech Republic, Romania), creating new jobs (Lithuania) and building businesses for future generations (Albania) were indicated by students as motivators of entrepreneurial initiatives from European countries. While students from non-European countries pointed to market demand, support from the environment, and society's attitude towards entrepreneurship (Ethiopia). The limitations for students in starting their own business are excessive bureaucracy (Poland, Czech Republic, Slovakia, Romania, Ethiopia) and financial barriers (Poland, the Czech Republic, Lithuania, Ethiopia, China). In Poland, students additionally pointed out excessive fiscalism. The lack of a business idea limited the entrepreneurial initiatives of students from Poland, Lithuania and China, as did the lack of knowledge, experience, and skills. This limitation was pointed out by students not only from Poland, Lithuania, and China, but also from Ethiopia and India. Too much dedication and time-consuming, as well as a high level of risk and responsibility and a fear of failure, are the limitations of entrepreneurship indicated by students from European countries (Poland, the Czech Republic, Lithuania). Students from European countries also pointed to legal barriers as important limitations to entrepreneurial initiatives. Students from non-European countries indicated cultural barriers (Rwanda, India), the country's economic situation (Rwanda) and lack of family support (China).

Differences in the motives and constraints of entrepreneurial initiatives by students from different countries emphasize the importance of the need for a regional approach to creating appropriate support and development programs for entrepreneurship. Countries differ in socio-economic and environmental resources, which together constitute their development potential (Wieliczko, Kurdyś-Kujawska, 2018). Each country is unique, so the effects of entrepreneurship support policy in one area will not be the same, both in terms of direction and magnitude of impact. The practice of shaping entrepreneurship support programs among students should therefore be based on identifying and taking into account country-specific needs and their local conditions, as well as expressing the expectations of young people, including students.

3. Research material

The research material consisted of data obtained through survey research using a structured survey questionnaire. The study was conducted in 2019 on a group of economics students studying at the Faculty of Economic Sciences of the Koszalin University of Technology. The respondents were students who expressed their willingness to participate in the study. 330 people took part in the study. Ultimately, 245 correctly completed questionnaires were qualified for the study. The survey questionnaire used in the study consisted of questions that allowed for the inclusion of the necessary elements to assess the entrepreneurial intentions of students. The first part of the questionnaire included questions about entrepreneurial attitudes, intentions to start their own business, sources of business financing, motives, and barriers limiting entrepreneurial initiatives. The second part of the survey consists of personal detail questions. The survey questionnaire included open questions, closed questions, filtering questions, and ranking questions using a 5-point Likert scale. The study used literature studies and quantitative research. To determine the factors determining the entrepreneurial intentions of students, the Pearson correlation coefficient was used, and to determine the strength of the relationship between the variables, the V-Cramer coefficient was used, which has values in the range $<0.1>$, and the closer the value of the coefficient is to one, the stronger the strength of the relationship. between the examined features. χ^2 statistics were determined based on two-way tables (Sobiech, Kurdyś-Kujawska, 2014). The analysis was performed at a significance level of p-value 0.05.

The analyzed group of students was dominated by women. Most students studied finance and accounting. The average age of the students was 23 years. Every third surveyed student indicated a village as his place of residence. Every fifth of them lived in a city with over 100,000 inhabitants and a city with a population of less than 20 thousand inhabitants. The vast majority of students assessed their financial situation as good. Few (3.67%) students indicated that their financial situation was bad or very bad. Over 70% of students have an entrepreneur in their family and/or among their friends. Most often, these were people from extended family (38.77%), parents (24.08%), and friends from outside the university (20.81%).

Table 1.
Characteristics of the study sample

Specification	Category	%
Gender	Woman	79.00
	Man	21.00
Field of study	Economy	28.57
	Management	22.85
	Finance and Accounting	48.58
Year of study	I	14.29
	II	66.53
	III	19.18

Cont. table 1.

Place of residence	City with over 100,000 inhabitants	21.63
	City 50,000-100,000 inhabitants	11.43
	City 20,000-50,000 inhabitants	11.02
	City under 20,000 inhabitants	20.41
	The countryside	35.51
Financial situation	Very good	11.43
	Good	48.98
	Average	35.92
	Bad	2.04
	Very bad	1.63
Having an entrepreneur in family and/or friends	Yes	71.43
	No	28.57

Source: own study.

4. Results and discussion

More than half of the surveyed students (51.84%) expressed their desire to run their own business. The student's willingness to start their own business was determined by their field of study. The analysis of the relationships showed that there is a significant positive relationship between studying management and the desire to start one's own business. The strength of the relationship between the field of study - management, and the desire to start one's own business was average (Cramer's V 0.15). If a student studied management, the chance of starting their own business increased by 118%. It was also shown that there is a significant positive relationship between the desire to start one's own business and having an entrepreneur among family and/or friends, and the strength of the relationship between these variables is average (Cramer's V 0.17). Having an entrepreneur among family and/or friends increased the chance of entrepreneurial initiatives among the surveyed students by 125%. As Boldureanu et al. (2020) point out, the existence of a role model is an important factor influencing an individual's future decisions to start a business. Lafuente et al. (2007) emphasize that contact with an entrepreneurial role model makes people more likely to develop the willingness and self-confidence to create their own businesses. Research by Venkataraman (2004) shows that many entrepreneurs declare that their decision to start a business and the way they developed their business were influenced by the examples of other people who served as entrepreneurial models. Factors such as gender, year of study, place of residence, or subjective assessment of the student's financial situation had no statistically significant impact on their willingness to start a business.

A significant number of students indicated that they had previously worked in the industry in which they would like to start their own business (38.35%) or had completed an internship there (24%). One-fourth of respondents confirmed that the industry in which they wanted to start their own business was consistent with their chosen field of study. 18% of respondents indicated a lack of experience.

2.45% of students indicated that they were already running their own business as of the date of the survey. These were mainly students in their final year of studies. The relationship analysis showed that there is a significant positive relationship between the year of study and running a business. The strength of the relationship between the variables is average (Cramer's V 0.18). If a student studied in their last year of studies, the chance of running their own business increased by 8.06 times.

Among students who plan to start their own business, in 47.24% of cases, the perspective of taking appropriate steps to initiate entrepreneurial ventures is transferred to the period after gaining the necessary experience. Students feel confident and ready to tackle running their own business when they believe they have acquired sufficient knowledge and practical skills. Every third student (34.65%) was unable to predict the time of implementation of their plans to start a business, defining this moment as the distant future. 14.17% of students indicated the time immediately after graduation as the time to start their own business. A small group of surveyed students (3.94%) decided to become self-employed while still studying.

From the point of view of the surveyed students, the most important feature of entrepreneurship is activity that results in the multiplication of capital (average grade of 4.17). Creating enterprise growth and economic growth turned out to be equally important features of entrepreneurship as capital multiplication (average grade of 4.02). Students rated the introduction of innovations and the use of market opportunities relatively highly (average grade 3.63 and 3.62, respectively). The surveyed students were least likely to combine entrepreneurship with personality traits (average grade of 3.47).

Entrepreneurial motivation is the main factor stimulating the start of entrepreneurship. It is the internal driving force for young entrepreneurs to engage in entrepreneurial activities and achieve entrepreneurial goals (Barba-Sanchez, Atienza-Sahuquillo, 2017). The most important motivator for students to start their own business was the prospect of gaining greater professional independence and the opportunity to implement their own ideas. Our results are consistent with the results of e.g. Bieńkowska-Goła & Krzyżanowska (2023), Gono & Łuczka (2020), Kilar & Rachwał (2014), Wronowska (2016), Kulig-Moskwa & Strzelczyk (2014), Zbierowski (2014), Safin (2014), Pilarczyk (2017), Moczydłowska & Pycz (2017), Gajda (2016), Eider et al. (2012), Bieńkowska-Golasa (2018) and Katana (2016). Professional independence is related to an individual's ability to make decisions independently and is the basis for professional development. As Kukła and Nowacka (2019) note, self-employment is related to the pursuit of one's own goals and needs at work and the reluctance to adapt to the requirements and expectations of anyone. Larsson and Thulina (2019) suggest that the ability to be one's own boss and a strong internal locus of control are of fundamental importance for an individual, contributing to their well-being. As Shir (2015) notes, well-being correlates with the experience of pride, joy, and other pleasant effects. According to Neneh (2014), students' motivation to start their businesses is the desire to be own bosses, to have more control over their destiny, and to be ultimately responsible for the success of their business.

A high percentage of students also indicated that the prospect of obtaining a higher income than from hired work is an important motivator for starting their own business. Bernat (2016) reached similar conclusions when analyzing a group of students from economic and non-economic faculties at the University of Szczecin, showing that students consider entrepreneurship as a path to financial success. Higher income as a motive for students' entrepreneurial intentions has been shown in studies, among others: Żukowski & Wyszomirska (2015), Wronowska (2016), Poteralski (2005), Kulig-Moskwa & Strzelczyk (2014), Gono & Łuczka (2020), Pilarczyk (2017), Gajda (2016), Eider et al. (2012), Brajer-Marczak & Maciszewska (2012), and Katana (2016).

Students are interested in starting businesses to improve their knowledge and skills, so they equate the possibility of self-employment with self-development. They are motivated to start their own business by the desire to achieve success and achieve their professional goals. They understand self-employment as an opportunity to work on new challenges and implement their initiatives that are related to improving the market, products, and/or services. Similar research results present e.g. Poteralski (2005), Zbierowski (2014), Safin (2014), Wronowska (2016), Moczydłowska & Pycz (2017), Gajda (2016), Eider et al. (2012), Brajer-Marczak & Maciszewska (2017), and Katana (2016). As suggested by Venesaar et al. (2006), freedom of action encourages students to be entrepreneurs. This freedom manifests itself in implementing your ideas and developing your hobbies in business. This shows that students have ambitions for freedom and do not want to submit to the visions, goals, and schedules of others.

Table 2.

Motives of students' entrepreneurial intentions

Specification	Degree of validity					Average score
	1	2	3	4	5	
greater level of professional independence	0.00	1.39	6.94	40.97	50.69	4.41
the opportunity to implement your own ideas	0.69	0.00	15.28	36.81	47.22	4.30
the prospect of obtaining a higher income	3.47	1.39	6.94	39.58	48.61	4.28
possibility of self-development	0.69	2.08	13.89	36.11	47.22	4.27
the need to achieve success	0.69	7.64	20.14	31.25	40.28	4.03
the opportunity to take on new challenges	0.69	6.25	15.97	45.14	31.94	4.01
improving the market, products or services	4.86	13.89	30.56	31.94	18.75	3.46
lack of job offers corresponding to education	6.94	15.28	30.56	27.78	19.44	3.38
lack of competition	9.72	13.89	27.78	31.25	17.36	3.33
the need for recognition and respect from the environment	12.50	13.19	23.61	29.86	20.83	3.33
acquired knowledge and skills	18.06	18.06	32.64	20.14	11.11	2.88
environmental influence	19.44	25.69	25.69	13.19	15.97	2.81

Note. 1: strongly disagree; 3: yes or no; 5: definitely agree

Source: own study.

A factor such as the lack of offers on the labor market corresponding to the student's education did not significantly influence their willingness to start their own business. As Earle and Sakova (2020) have shown, barriers to access to desired paid work may push individuals towards self-employment as a last resort. Students do not consider their knowledge

and skills to be of much importance when deciding whether to start a business or not. This may be due to inadequate, rigid, and inflexible entrepreneurial curricula. Similarly, the influence of the student's environment was not a motivating factor for self-employment. Students are unlikely to base their decisions about starting their own business on the opinions of family, relatives, close friends, teachers, and other people. They rely on their own beliefs and capabilities in running a business rather than on the opinions of others.

Starting a business for students can be difficult. According to Sugiarto (2014), the challenges faced by students are similar to those faced by entrepreneurs in general and can be classified as financial, managerial, marketing, production and technological. The most important limitation related to starting a business, according to students, was the lack of sufficient financial resources. A high percentage of students also indicated limitations resulting from a lack of sufficient knowledge. This has also been proven in studies, e.g. Bienkowska-Gołasa & Krzyżanowska (2023), Gono & Łuczka (2020), Myjak (2014), Wronowska (2016), Poteralski (2005), Kilar & Rachwał (2014), Kunasz (2008), Brajer-Marczak & Maciszewska (2012), Zbierowski (2014), Safin (2014), Wronowska (2016), Pilarczyk (2017), Moczydłowska & Prycz (2017) and Gajda (2016). To open their own business, students should have a certain amount of knowledge in the field of entrepreneurship. Information about how an enterprise should function, where and how to acquire customers and suppliers, what type of business taxation to choose, and where to obtain sources of financing are just the basic issues that constitute the foundation for starting an entrepreneurial initiative. Li et al. (2020) indicate that potential entrepreneurs must have appropriate financial education to make better investment and planning decisions and take advantage of business opportunities available on the market. Qader et al. (2022) argue that people with high levels of financial literacy can easily develop the necessary risk management skills, identify available business opportunities, gain greater market knowledge, manage their money more effectively, and make better financial decisions, all of which are crucial to the development of ventures and entrepreneurship. According to Li and Qian (2020), adequate financial knowledge is essential, especially in light of evidence pointing to financial constraints as a barrier to new business creation.

Table 3.

Barriers of students' entrepreneurial intentions

Specification	Degree of validity					Average score
	1	2	3	4	5	
lack of sufficient financial resources	0.41	3.67	9.80	24.49	61.63	4.43
lack of sufficient knowledge	3.67	7.35	22.45	31.02	35.51	3.87
no business idea	7.76	7.35	18.78	23.27	42.86	3.86
complicated and often incomprehensible legal provisions	5.31	5.31	23.67	32.24	33.47	3.83
excessive bureaucracy	3.67	10.61	21.63	29.80	34.29	3.81
excessive fiscalization	2.04	11.43	23.67	32.24	30.61	3.78
lack of experience	2.04	10.20	29.39	32.65	25.71	3.70
high risk associated with running a business	3.67	10.20	28.57	31.43	26.12	3.66

Cont. table 3.

lack of knowledge about institutions supporting entrepreneurship	5.31	13.47	24.49	30.20	26.53	3.59
stress and workload associated with running your own business	7.35	12.65	24.49	29.80	25.71	3.54
lack of a network of business contacts	6.12	11.84	28.98	29.39	23.67	3.53
fear of failure	10.61	14.29	21.63	24.90	28.57	3.47

Note. 1: strongly disagree; 3: yes or no; 5: definitely agree.

Source: own study.

Students often pointed out the lack of an idea for their own business as a barrier limiting entrepreneurial initiatives. Students indicating that they lack an idea for their own business may be the result of insufficient knowledge of where to look for inspiration. How to use your own experiences or interests to create business ideas. Complicated and often incomprehensible legal regulations are also a key challenge for students planning to start a business. The reason for the aversion to starting one's own business is also the increased number of documents and administrative obligations that a future entrepreneur must fulfill. Another factor limiting entrepreneurial initiatives among students is excessive fiscalization, i.e., the index of taxes that an entrepreneur must pay while running a business. Such conclusions also result from research Żukowski & Wyszomirska (2015), Kilar & Rachwał (2014), Myjak (2014), Poteralski (2005), Kulig-Moskwa & Strzelczyk (2014), Pilarczyk (2017), Moczydłowska & Prycz (2017), Bieńkowska-Golasa (2018), and Katana (2016).

Another challenge for the initiative of entrepreneurial students is risk. Risk is inherent in running a business. The reason for its occurrence is the fact that the phenomena that affect a given entity are independent of it. For some students, the high level of risk may be an incentive to start their own business, but for most of them, the risk of running a business limits the decision to become self-employed. Similar conclusions have been presented in studies, e.g. Żukowski & Wyszomirska (2015), Gono & Łuczak (2020), Wronowska (2016), Poteralski (2005), Zbierowski (2014), Pilarczyk (2017), Gajda (2016), Kunasz (2008) and Katana (2016).

In turn, the stress and workload associated with running a business and the fear of failure ultimately lead to students not taking entrepreneurial initiatives. However, this factor was slightly less indicated by students.

5. Conclusion

Most students demonstrate entrepreneurial initiatives, but a still high percentage of students do not intend to undertake any entrepreneurial initiatives in the future. Students who decide to start their own business mostly base their further activities on gaining the necessary experience after graduation. However, they were unable to predict when this would happen.

Hence, it is unsurprising that only a few students run businesses while studying. This tendency was characteristic mainly of students in their final year of studies.

An important element that significantly increases the chance of students having entrepreneurial intentions is the existence of an entrepreneur in the environment of family, acquaintances, or friends. This allows future entrepreneurs to learn how to run a business and how to deal with problems that may arise in various decision-making areas of the company.

There was no statistically significant impact on students' entrepreneurial intentions of factors such as gender, year of study, place of residence, or subjective assessment of the student's financial situation.

Entrepreneurial initiatives among students were motivated mainly by the possibility of greater professional independence and the possibility of implementing their business ideas. Another impetus for self-employment is the prospect of obtaining a higher income than in employed work. Students did not attribute a significant role to the acquired knowledge and skills and the influence of the environment on their future entrepreneurial intentions.

The main challenge for student self-employment is the lack of sufficient financial resources to start a business. This barrier may be the result of limited opportunities to generate savings during studies; not all students can count on informal loans from family or friends. Moreover, students may not have sufficient knowledge regarding financial support for entrepreneurial initiatives for young people or those starting their businesses for the first time.

What is disturbing is the fact that more than half of the surveyed students indicated that a lack of appropriate knowledge and skills and no business idea limits their entrepreneurial initiatives. This may indicate insufficient entrepreneurship education, which does not stimulate students' self-efficacy, does not develop their entrepreneurial awareness, and does not help them prepare to take up entrepreneurial initiatives after graduation. Limitations related to the lack of understanding of legal provisions, excessive bureaucracy, and high fiscal burdens also turn out to be a major challenge for students' entrepreneurial initiatives. People with knowledge of entrepreneurship, including finance, are better prepared to make rational decisions regarding the selection of optimal sources of financing and search for alternative ways of obtaining capital. Knowledge, including skills, contributes to a better understanding of the rules that prevail on the market, including the legal aspects of running a business. With knowledge and skills, students make informed decisions regarding future entrepreneurial initiatives that will result in improved overall well-being. A source of knowledge for students can be practitioners - entrepreneurs who are already active in business and have achieved success in it.

Increasing students' motivation to start a business is possible by improving existing policies to support entrepreneurship, especially among young people. These changes should take place in the areas of financial support, simplification of procedures for setting up and running a business, and reducing fiscal burdens. In addition, an important element that can stimulate the entrepreneurial spirit among students is adapting teaching programs to students' needs in terms of acquiring practical skills in starting and running their enterprise, including deepening

knowledge in the field of financial knowledge and skills. Students' contacts with people who run businesses and are successful in them should be increased.

This study is exploratory and constitutes a contribution to further research on students' entrepreneurial initiatives and the factors that motivate and limit these initiatives. Future research should focus on finding new factors that have not been analyzed so far so that they relate to current trends emerging in society and the economy.

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NEW TECHNOLOGIES AS TOOLS SUPPORTING INNOVATION MANAGEMENT

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Purpose: The objective of this article is to examine the application of emerging technologies as tools for enhancing innovation management in organizational settings. The article seeks to provide insights into how these technologies contribute to the generation of ideas, collaboration, scalability, and accessibility in the context of innovation management. Furthermore, the authors analyse the current state of open innovation and the mutually beneficial relationship between artificial intelligence and open innovation platforms. The article concludes by discussing strategies for effectively utilizing new technologies, with a particular emphasis on cross-functional collaboration and making data-driven decisions to achieve successful innovation.

Design/methodology/approach: The research utilizes rigorous methodologies, including a review of existing literature and the use of visual representation techniques.

Findings: This research investigates the influence of emerging technologies, such as artificial intelligence, big data analytics, and blockchain, on the management of innovation. The results suggest that these technologies facilitate the use of data to inform decision-making, streamline the processes involved in managing ideas, and foster collaboration across different functions within an organization. Analysis of the current state of open innovation in the European Union indicates favourable developments as well as certain obstacles in research and development expenditures.

Originality/value: The originality of the paper lies in its comprehensive exploration of the synergies between emerging technologies and innovation management strategies. The study contributes novel insights by examining the state of open innovation in the European Union. The paper's value lies in its applicability to organizations seeking to leverage technology for innovation, offering insights to navigate the evolving landscape of innovation in a digital era.

Keywords: emerging technologies, innovation management, collaboration, artificial intelligence, data-driven decision-making.

Category of the paper: Literature review.

1. Introduction

In the context of the dynamic and competitive modern business environment, the effective management of innovation plays a crucial role in enabling organizations to maintain their competitive edge. To successfully navigate the complexities of innovation, companies are increasingly adopting novel technologies that facilitate the optimization of processes, stimulation of creativity, and facilitation of growth. This article aims to examine the significance of these emerging technologies as instrumental resources in supporting innovation management. Furthermore, it will delve into the essential technologies and strategies that empower organizations to effectively harness innovation, supplemented by the inclusion of tables and charts to visually illustrate crucial concepts.

In the modern business landscape, innovation plays a crucial role in maintaining relevance and competitiveness. It is driven by rapid advancements in technology, globalization, and evolving consumer demands (Chesbrough, 2003; UNCTAD, 2021). The ability to innovate, effectively manage creative processes, and translate ideas into marketable products or services is not just a desirable trait for organizations, but rather a necessity for their survival and prosperity (Tidd, Bessant, 2013; Janjic, Radenovic, 2019; Lyeonov et al., 2022). Successful innovation management involves systematic planning, organization, and monitoring, all within a dynamic and iterative framework. It goes beyond idea generation and focuses on fostering a culture of innovation, efficiently allocating resources, and mitigating risks in the ever-changing technological and market landscape (World Intellectual Property Organization et al., 2022; Radziwon et al., 2023).

Organizations are faced with the daunting task of effectively utilizing innovation, fostering creativity, and successfully navigating the intricate innovation landscape. However, there is optimism as advancements in technology have emerged as crucial instruments that enable organizations to directly confront these challenges (Eggers, Turley, Kishnan, 2019; Am et al., 2020).

This article explores the significant impact of emerging technologies on the facilitation of innovation management. These technologies include idea management software, which encourages the sharing and selection of ideas, as well as open innovation platforms that foster collaboration with external partners. Additionally, the article discusses the role of artificial intelligence (AI) in enabling data-driven decision-making, along with other advanced technologies. As a result, the field of innovation is transforming.

The integration of new technologies, along with efficient innovation tactics, can bring about a paradigm shift in the way organizations engage in innovation. This transformation is not a choice but rather an essential requirement. As enterprises become more interconnected and face heightened competition, effective innovation management is not merely a means of survival but also a means of thriving and assuming a leadership position in the market (Brem,

Voigt, 2009; Urbancova, 2013; Celukanovs, Wattle Björk, 2019; Nadikattu, 2020; Kuzior, 2021).

The paper thoroughly examines the precise technologies and strategies that are transforming the field of innovation management. Moreover, it investigates the obstacles and future trajectories that organizations must carefully contemplate as they embark on their innovation endeavours. Remaining at the vanguard of innovation management necessitates an ongoing commitment, requiring organizations to constantly adapt and embrace the latest technological advancements.

2. Methods

In this study, the authors employed various methodologies to investigate the research questions at hand.

This research utilized a rigorous methodology to examine and evaluate the use of emerging technologies as instruments for facilitating innovation management in organizational settings. The methodology involved a diverse range of methods, such as an extensive review of relevant literature and visual representation methods.

The section on literature review aims to provide a comprehensive overview and analysis of the existing scholarly works and research studies relevant to the topic at hand.

The study commenced with a comprehensive analysis of relevant academic literature to establish a robust theoretical framework. Scholarly publications from various disciplines including innovation studies, management, and technology adoption were thoroughly scrutinized. The primary objective of this literature review was to identify fundamental ideas, patterns, and areas of insufficient understanding of the dynamic interplay between technology and innovation management.

To improve the comprehensibility and ease of use of the research results, the study utilized visual representation methods. Graphs and tables were strategically utilized to visually display important data, patterns, and comparisons that were discovered.

3. Key Technologies Supporting Innovation Management

In the contemporary business environment characterized by rapid change and intense competition, innovation is a crucial factor determining the success of organizations. To maintain a competitive edge, companies must constantly strive to cultivate innovation in their processes, offerings, and service delivery. Fortunately, the advent of novel technologies

has played a pivotal role in facilitating and reinforcing the management of innovation. Consequently, it is substantial to explore the fundamental technologies that empower businesses to augment their strategies for managing innovation, thereby nurturing creativity and propelling growth.

Innovation management encompasses multiple interconnected activities, including generating ideas, allocating resources, evaluating risks, and executing plans. Given the contemporary digital era, organizations are increasingly relying on advanced technologies to enhance these processes and propel their innovation strategies. Presented below are several significant technologies such as artificial intelligence and machine learning, big data and analytics, cloud computing and blockchain technology that are instrumental in facilitating innovation management.

Table 1.

Emerging technologies that enable the assistance of innovation management

Criteria	AI and Machine Learning	Big Data and Analytics	Cloud Computing	Blockchain Technology
Description	Artificial intelligence and machine learning technologies are employed to analyse data and streamline processes to facilitate innovation management.	Big data enables the examination of customer behaviour and patterns.	Cloud technology provides the ability to scale resources and enables remote access, fostering innovation.	The utilization of blockchain technology enhances the protection and monitoring of intellectual property, consequently promoting a conducive environment for collaboration.
Data Analysis	Offers predictive analytics and insights based on data analysis.	Examines extensive datasets to identify patterns and potential areas for improvement.	Facilitates the process of making decisions based on data.	A protected ledger system for safeguarding intellectual property.
Collaboration	Enables collaboration and the exchange of ideas through the utilization of artificial intelligence-powered tools.	Collaboration is facilitated through the exchange and dissemination of insights and trends.	Enables the facilitation of remote collaboration and the availability of resources.	Promotes the establishment of trust among stakeholders to facilitate collaboration.
Scalability	Expands the capacity for data analysis and automation to align with the expansion of a business.	Capable of efficiently managing larger amounts of data and conducting extensive analysis.	Provides scalable resources and infrastructure.	The concept of scalability in relation to blockchain networks.
Accessibility	Enables the remote utilization of data and resources to facilitate international cooperation.	This facilitates the ability of teams to collaborate on data and analytics regardless of their geographical locations.	Enables individuals to remotely access and collaborate with others.	This platform offers a secure means of accessing and retrieving blockchain records.

Cont. table 1.

Use Cases	Analysis of customer behaviour, automation of processes, implementation of chatbots, and other related topics.	The examination of market trends, the division of customers into distinct groups, and the creation of models to forecast future outcomes.	The practice of remotely overseeing project management, developing applications, and collaborating with virtual teams.	The safeguarding of intellectual property, the promotion of transparency in supply chains, and the effective management of contracts.
Challenges	Issues related to the protection of personal data, biases in algorithms, and the challenges associated with integrating systems.	Issues related to the quality of data, threats to cybersecurity, and challenges in integration.	Issues related to security, challenges associated with data transfer, and complexities involved in migrating to the cloud are some of the key concerns in this context.	The issues related to scalability, adherence to regulations, and the establishment of trust.
Source	(Brynjolfsson, McAfee, 2017; Haefner et al., 2021)	(McAfee, Brynjolfsson, 2012; Zhou, 2020; Capurro et al., 2021; Dehbi et al., 2022)	(Khanagha et al., 2013; Golightly et al., 2022)	(Alkhudary et al., 2020; Baudier et al., 2022; Kuzior, Sira, 2022)

Source: developed by authors.

3.1. Idea Management Software

Idea management software stands at the forefront of modern innovation strategies, offering organizations a dynamic platform to harness the collective intelligence of their workforce and external stakeholders. This sophisticated software solution facilitates the ideation process by providing a structured framework for the generation, evaluation, and selection of ideas (Chesbrough, 2003). Therefore, it makes sense to undertake an analysis of idea management software on the base of such features as idea submission portal, idea evaluation, collaboration tools and analytics and reporting.

One of the core features of idea management software is its user-friendly idea submission portal. This portal serves as a digital suggestion box, encouraging employees and external contributors to share their innovative ideas effortlessly. By creating an accessible avenue for idea submission, organizations nurture a culture of innovation where every member feels empowered to contribute (Gassmann, Enkel, Chesbrough, 2010; Tomczak, 2022).

Idea management software incorporates advanced evaluation algorithms that help organizations sift through the influx of ideas (Mikelson et al., 2022). By employing criteria such as feasibility, market relevance, and alignment with strategic goals, this software assists in identifying high-potential concepts. It streamlines the evaluation process, ensuring that valuable ideas are not lost amidst the volume of submissions (Chesbrough, 2003).

Collaboration is the heartbeat of innovation, and idea management software provides a collaborative ecosystem for refining and developing ideas. Cross-functional teams can engage in discussions, offer feedback, and collectively enhance the concepts. These collaborative tools

break down organizational silos, fostering interdisciplinary cooperation crucial for innovative breakthroughs (Tidd, Bessant, Pavitt, 2005; Castañer, Oliveira, 2020).

Data-driven decision-making is a hallmark of successful innovation management. Idea management software comes equipped with robust analytics and reporting tools. These tools offer real-time insights into innovation metrics, idea progression, and the effectiveness of innovation campaigns. By analysing these data points, organizations can fine-tune their strategies, optimize resource allocation, and elevate the overall innovation process (Visvizi et al., 2021).

Idea management software not only promotes internal innovation but also extends its reach to external partners and customers. Open innovation principles emphasize the value of external collaboration in innovation processes (Chesbrough, 2003). Idea management software serves as a bridge, connecting organizations with external innovators, thereby enriching the pool of ideas with diverse perspectives and expertise.

The implementation of idea management software aligns with the evolving landscape of innovation, where collaboration, transparency, and data-driven insights are paramount. By incorporating this technology into their innovation strategies, organizations position themselves to navigate the complexities of the modern market, transforming innovative ideas into tangible, market-ready solutions (Endres, Huesig, Pesch, 2021).

The following table delineates the characteristics and both advantages of idea management software.

Table 2.
Strengths and weaknesses of the features for the idea management software

Feature	Advantages	Disadvantages
Idea Submission Portal	Encourages idea sharing. Allows for a centralized platform for idea collection.	Risk of idea overload without effective curation. Requires continuous engagement to maintain participation.
Idea Evaluation	Streamlines the idea selection process.	Potential for bias in the evaluation process. Can be time-consuming if not automated.
Collaboration Tools	Fosters cross-functional innovation.	Collaboration can sometimes slow down the process.
Analytics & Reporting	Monitors innovation performance. Provides data-driven insights for decision-making.	Requires time and effort to set up and interpret data. Data overload can be overwhelming without clear objectives.

Source: developed by authors.

In the subsequent sections, the authors explore complementary technologies such as open innovation platforms and artificial intelligence, shedding light on their synergistic roles in shaping a comprehensive and effective innovation management framework.

3.2. State of Open Innovation and Open Innovation Platforms

Data regarding research and development (R&D) investment provides somewhat indirect indications of open innovation. Researchers particularly keep investigating different external and internal factors that influence the business-education R&D collaboration (Samoilikova et al., 2023a; 2023b). Detailed data on the allocation of funds for R&D, both from public and private sources, offers some insights into the extent of interaction and collaboration between the government and the business sector (Backer et al., 2008).

Over time, from 2019 to 2022, there was a positive tendency for R&D expenditures in both public and business sectors as well as direct and indirect support of business R&D in the European Union (Figure 1). The authors suggest that a decrease in R&D expenditures in both public and business sectors could be observed due to such factors as economic conditions, policy changes, private sector dynamics or global factors.

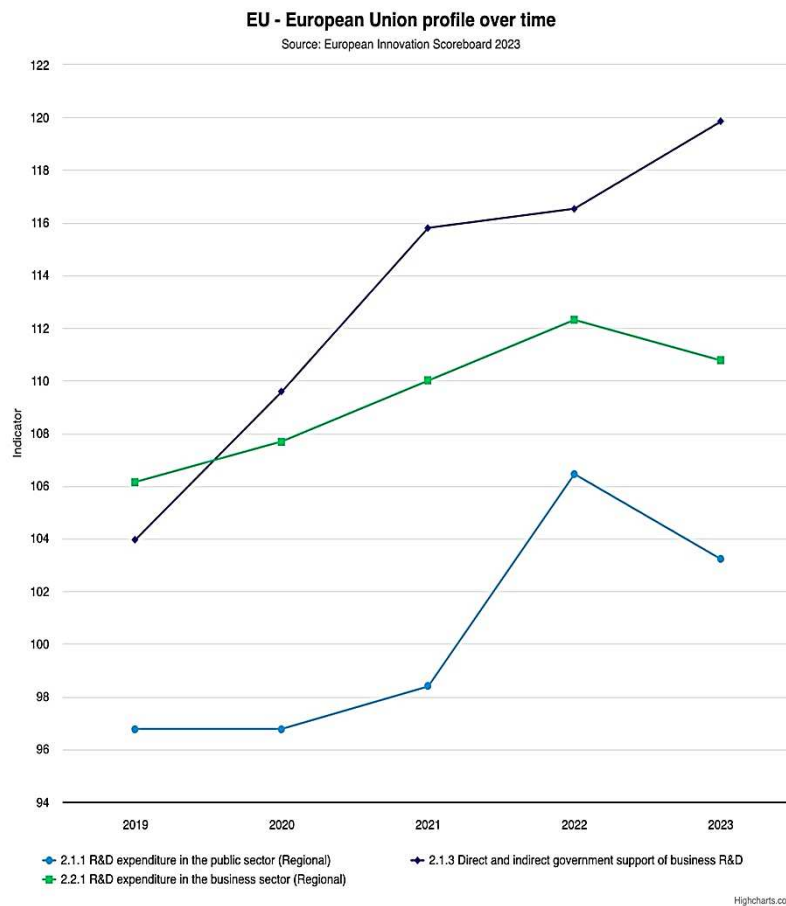


Figure 1. European Union profile over time for finance, support, and firm investments.

Source: European Innovation Scoreboard 2023 (retrieved November 10, 2023).

Furthermore, collaboration is another evidence of open innovation. The innovative small and medium-sized enterprises SMEs collaborating with other public-private co-publications and job-to-job mobility of human resources in science & technology (HRST) are among the factors that provide an understanding of the linkages, therefore collaboration (Figure 2). As for the score for innovative small and medium-sized enterprises SMEs, there was

considerable growth from 2020 to 2021. From 2021 to 2022 the score remained stable whereas from 2022 to 2023 it shows a downward trend. From 2019 to 2022 the score for private co-publications showed an upward trend and afterwards is going to remain stable. After 2022, the score of job-to-job mobility of HRST declines sharply and it is lower than in 2020.

The authors imply that the decrease in the rating of innovative SMEs between 2022 and 2023 could be indicative of obstacles or modifications in the innovation environment for these types of businesses. The consistent presence of joint publications by private entities implies an ongoing and consistent level of collaboration in the domain of open innovation. The significant decrease in job-to-job mobility among highly skilled HRST field after 2022 is a matter of concern, as it has the potential to affect the movement of personnel in this sector.

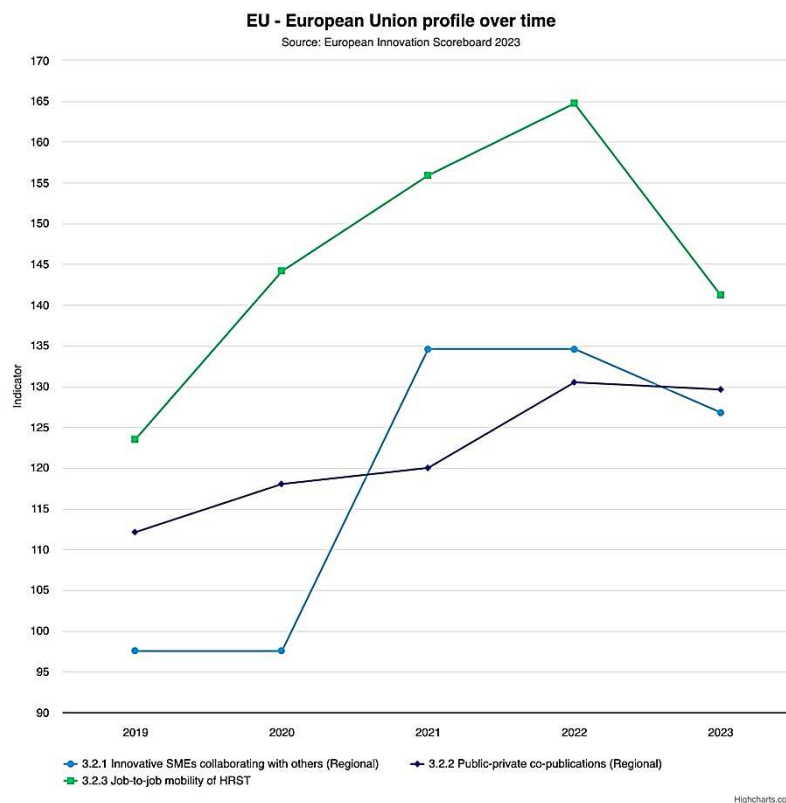


Figure 2. European Union profile over time for linkages.

Source: European Innovation Scoreboard 2023 (retrieved November 10, 2023).

In the dynamic realm of business and technology, the notion of open innovation has surfaced as a potent tactic for enterprises aiming to access external pools of knowledge and skill. Open innovation platforms, a crucial facilitator of this approach, assume a significant role in fostering collaboration with a diverse array of external stakeholders, encompassing clientele, suppliers, and emerging ventures. Such collaboration not only expands the prospects for innovation but also yields substantial and profound outcomes.

3.3. The Role of AI for Open Innovation Platforms

Over the past few years, there has been a significant shift in the field of innovation management, marked by the emergence of new technologies that greatly influence the methods through which organizations encourage creativity and facilitate progress. Aligned with a worldwide tendency towards the integration of artificial intelligence across various spheres of human existence, there has been a noticeable surge in interest and the emergence of distinct research clusters focusing on the utilization of this technology to address organizational challenges in recent years (Bilan et al., 2022). In this rapidly evolving environment, AI has emerged as a crucial factor, bringing about substantial changes in Open Innovation Platforms.

Open Innovation Platforms signify a fundamental change from conventional closed innovation approaches, emphasizing cooperation, knowledge sharing, and inclusiveness (Andrzej, Skulimowski, Köhler, 2023). Artificial intelligence plays a pivotal role in this environment, providing unmatched abilities to enhance and optimize different aspects of the innovation process (Kuzior, Sira, Brożek, 2023).

AI's main benefit to Open Innovation Platforms is its capability to rapidly analyse large datasets. This allows organizations to efficiently navigate through extensive information, uncovering patterns, market trends, and potential advancements that could have been overlooked otherwise. Using machine learning algorithms, AI improves the evaluation of innovative ideas, guaranteeing that the most promising concepts are promptly recognized and given priority.

In addition, AI promotes improved communication and collaboration among heterogeneous teams, surpassing geographical limitations (Skulimowski, Köhler, 2023). Natural Language Processing (NLP) systems enable effective engagement and sharing of ideas, nurturing a worldwide community of creative individuals who can effortlessly contribute their knowledge and skills. This not only speeds up innovation but also guarantees the inclusion of a broader and more diverse array of viewpoints.

In the domain of idea generation, AI-powered tools have a significant role to play in producing innovative ideas and solutions. Through the utilization of predictive analytics and recommendation engines, these tools aid innovators in refining their concepts and aligning them with market requirements. This proactive guidance not only improves the calibre of proposals but also mitigates the potential risks associated with pursuing unfeasible ideas.

In addition, artificial intelligence contributes to the ongoing development of Open Innovation Platforms through the automation of repetitive tasks and decision-making procedures. By streamlining activities such as project management and resource allocation, AI-powered systems improve operational effectiveness, enabling organizations to devote increased time and resources to the imaginative facets of innovation.

As the importance of AI in Open Innovation Platforms becomes more widely acknowledged by organizations, the symbiotic relationship between human creativity and machine intelligence is set to redefine the limits of what can be accomplished (Wang et al., 2022). The incorporation of AI as a fundamental element in innovation management signifies a strategic commitment, propelling organizations towards a future where the combined capabilities of technology and human inventiveness merge to propel remarkable progress.

4. Strategies for Leveraging New Technologies

4.1. Cross-functional Collaboration

Implementing technology to support cross-functional collaboration is crucial for innovation. In the modern context of constantly changing areas of knowledge, there is a pressing need to promote innovation, which has become exceptionally significant. A key driver of innovation lies in the collaboration between individuals with different areas of expertise and perspectives, working together to tackle complex challenges. This collaboration, which goes beyond the confines of specific departments or fields, becomes even more effective when supported by advanced collaboration tools. Extensive research strongly emphasizes the crucial role that cross-functional collaboration and collaboration tools play in achieving successful innovation (Ungureanu et al., 2020; Raivio, 2022; Deng et al., 2023).

In the field of innovation within the public sector, the development of strong ecosystems is of utmost importance, as highlighted by McKinsey & Company in their analysis of how to accelerate the growth of technology hubs (Davis et al., 2023). The article emphasizes the fundamental role of collaboration across different functions in the establishment of innovation ecosystems. In this context, collaboration across functions goes beyond the boundaries of individual organizations, integrating diverse areas of expertise and creating synergies across sectors. The article emphasizes that the success of technology hubs relies on the harmonious collaboration between government entities, private companies, educational institutions, and start-ups, serving as evidence of the transformative impact of cross-functional collaboration in driving innovation within complex and ever-changing public-sector environments.

Within the ever-evolving realm of business education, Harvard Business School demonstrates its commitment to innovation through initiatives like the IT Hackathon (Simkin, 2023). This event serves as a prime example of the vital role played by collaborative efforts in generating inventive solutions to modern-day obstacles. The hackathon's inherent structure fosters cooperation among heterogeneous teams comprising students possessing diverse proficiencies in technology, business, and design. By uniting these interdisciplinary talents, the event serves as a miniature representation of the wider significance of cross-functional

collaboration, highlighting how the amalgamation of distinct perspectives and expertise can yield innovative results.

In addition, collaboration tools function as strongholds of information exchange and the generation of ideas. They enable virtual sessions for brainstorming, an essential element of the innovation process. Collaborators can effortlessly participate in idea-generation sessions by utilizing shared workspaces and document management systems based on cloud technology, which accelerates the advancement of projects and the immediate improvement of ideas.

In summary, the convergence of cross-functional collaboration and collaboration tools is a prime example of how modern innovation is facilitated. Organizations that recognize the importance of bringing together diverse skills, using specialized tools to leverage these skills, and fostering a culture of knowledge sharing are well-positioned to achieve significant breakthroughs. Their efforts contribute to the ongoing pursuit of intellectual advancement, a pursuit that has long been emphasized in both academic research and corporate agility.

4.2. Driven Decision Making

AI and data analytics are instrumental in making data-driven decisions. There are numerous advantages to utilizing data-driven decision-making in the realm of innovation, which can greatly influence the prosperity of businesses and organizations. The following table presents the benefits of data-driven decision-making in innovation.

Table 3.

Advantages of leveraging data in the decision-making process

Benefit	Description
Faster Identification of Opportunities	Real-time data analysis accelerates decision-making by providing instant insights into market trends, customer preferences, and emerging opportunities. This agility allows organizations to swiftly capitalize on new prospects and stay ahead of the competition.
Reduced Risk	Utilizing data-driven decision-making in innovation projects reduces risks by obtaining a thorough comprehension of potential obstacles. By examining historical data and present patterns, possible pitfalls can be identified and resolved, empowering organizations to make well-informed decisions that minimize the probability of failure.
Improved Resource Allocation	Organizations have the potential to enhance resource allocation by making data-informed decisions. By examining historical performance data, market demand trends, and resource utilization patterns, businesses can pinpoint areas of inefficiency, enhance resource allocation strategies, and guarantee that valuable resources are allocated towards initiatives that hold the greatest promise for success.

Source: developed by authors.

AI and data analytics have become increasingly influential instruments in the realm of decision-making, fundamentally transforming the way businesses and organizations leverage the inherent value of data. Some research emphasized the pivotal significance of AI and data analytics in facilitating decision-making processes driven by data (Duan, Edwards, Dwivedi, 2019; Shrestha, Ben-Menahem, von Krogh, 2019; Akter et al., 2020; Stone et al., 2020). It elucidated the profound impact of these technological advancements on multiple sectors, including the domain of innovation.

The utilization of data analytics and AI enables organizations to accurately predict future trends, market demands, and customer preferences, thereby allowing them to proactively adjust their innovation strategies to meet changing consumer needs (Bharadiya, 2023). This predictive capability enhances the effectiveness of innovation efforts. Additionally, data-driven decision-making aids in identifying inefficiencies within innovation processes, leading to more efficient resource allocation and cost reduction without compromising the quality of innovations.

The application of artificial intelligence and data analytics can enhance risk management practices within organizations (Rodríguez-Espíndola et al., 2022). This technology enables businesses to evaluate and address potential risks linked to innovation initiatives by identifying areas of vulnerability and potential threats. Consequently, informed decisions can be made to minimize risks and optimize the likelihood of achieving desired outcomes.

The utilization of data-driven decision-making enables businesses to customize their innovative solutions according to the unique preferences of individual customers, thereby fostering increased levels of customer satisfaction and loyalty (Czvetkó et al., 2022). This ability to personalize offerings can confer a substantial competitive edge.

One benefit of utilizing data-driven insights is the optimization of resource allocation within organizations. By employing these insights, organizations can effectively distribute resources to ensure that the appropriate projects receive the necessary attention and investment (Pratama, Dachyar, Pratama, 2023). This strategy helps prevent wasted efforts on initiatives that have limited potential.

The acceleration of time-to-market can be achieved through the streamlining of the innovation process, facilitated by data-driven decision-making. This ability to swiftly bring new products and services to market is of utmost importance in industries characterized by rapid changes, as being the first to introduce a product can yield significant advantages (Troisi et al., 2019).

In the present data-centric economy, organizations can gain a substantial competitive edge by utilizing data for innovation (Brynjolfsson, McAfee, 2017). Those who adeptly leverage data are frequently in a stronger position to outperform their rivals.

The combined advantages mentioned above highlight the significant impact that employing data-driven decision-making can have on innovation. As companies increasingly adopt AI and data analytics, they equip themselves to navigate the intricate and constantly evolving realm of innovation more effectively, swiftly, and prosperously.

5. Discussion

The discussion section of this article provides an analysis and integration of current knowledge and discoveries, clarifying the consequences of novel technologies as instruments that facilitate the management of innovation. The examination of new technologies, including AI) big data analytics, cloud computing, and blockchain, within the framework of innovation management has uncovered a landscape of significant change that necessitates strategic navigation by organizations.

Observing the process of reconfiguring the innovation landscape, the authors conclude that the incorporation of these technologies represents a fundamental change in the way innovation is approached (Chesbrough, 2003; UNCTAD, 2021). In response to a rapidly changing and highly competitive global business environment, organizations are not only compelled to adopt technological advancements for survival but also to excel and establish themselves as market leaders. This emphasizes the significance of remaining at the forefront of innovation management, which necessitates organizations to continuously adapt and adopt the most current technological resources (Eggers et al., 2019; Am et al., 2020).

Technological advancements have greatly contributed to the process of innovation. The paper provides a comprehensive analysis of the various technologies that have a significant impact on innovation management, highlighting their unique contributions. These technologies include AI and machine learning, which play a vital role in data analysis and decision-making (Brynjolfsson, McAfee, 2017), as well as big data analytics, which examine customer behaviour and patterns (Zhou, 2020; Capurro et al., 2021). Additionally, cloud computing offers scalability and remote accessibility (Khanagha et al., 2013; Golightly et al., 2022), while blockchain contributes to the protection of intellectual property and facilitates collaboration (Alkhudary et al., 2020; Baudier et al., 2022). Each of these technologies is crucial in the context of innovation management.

Idea management software serves as a catalyst. The importance of idea management software in promoting innovation within organizations is emphasized by Gassmann et al. (2010) and Tomczak (2022). This software plays a critical role in facilitating the generation, evaluation, and selection of ideas by providing a structured framework. Through promoting collaboration, streamlining evaluation processes, and facilitating data-driven decision-making, idea management software is a crucial element of innovation management strategies. The discussion thoroughly examines the advantages and disadvantages of various features offered by this software, including idea submission portals, evaluation algorithms, collaboration tools, and analytics and reporting.

Open innovation platforms and collaboration have become increasingly popular in recent years.

The conversation encompasses open innovation platforms and their role in promoting collaboration outside of organizational boundaries. Collaboration is seen as not only a strategic necessity but also backed by data that highlights the positive relationship between research and development investments, joint publications between private and public entities, and the movement of individuals between jobs in the fields of science and technology (European Innovation Scoreboard, 2023). The authors suggest that the decline in innovative small and medium-sized enterprises and job mobility after 2022 could suggest potential barriers or changes in the innovation landscape.

The subject of artificial intelligence's involvement in open innovation platforms is a subject of great importance (Skulimowski, Köhler, 2023). The transformative effects of AI, which include its capacity to efficiently analyse extensive data sets, enhance idea evaluation, facilitate communication, and assist in idea generation, are emphasized by the authors. Additionally, they highlight the interdependent bond between human creativity and machine intelligence, portraying AI as a strategic investment that drives organizations towards a future characterized by the convergence of technology and human ingenuity for significant advancements (Wang et al., 2022).

While investigating the influence of innovations on the organisation's maintenance there is always a need to examine strategies for taking advantage of new technologies.

The examination of the essential roles of cross-functional collaboration and data-driven decision-making in innovation management explores the strategies for harnessing new technologies. This discussion emphasizes how these strategies, aided by cutting-edge collaboration tools and AI-driven insights, aid in surmounting obstacles, minimizing risks, and optimizing the allocation of resources to enhance innovation effectiveness (Ungureanu et al., 2020; Raivio, 2022; Deng et al., 2023).

The authors of the article discuss the practical implications of their findings, focusing on how organizations can adapt and utilize these technologies to improve their innovation practices. They also highlight potential areas for future research, indicating the need for further exploration into the changing dynamics of technology and innovation management. Overall, the discussion section serves as a comprehensive summary of the article, bringing together the various aspects of technological contributions, strategic implications, and the evolving landscape of innovation. It provides a guide for organizations to navigate the complex relationship between emerging technologies and innovation management, offering timely and crucial insights for those aiming to stay ahead in the field of innovation.

6. Summary

In conclusion, the article effectively examines the complex connection between emerging technologies and the management of innovation. It offers a comprehensive examination of the technologies that are propelling innovation, evaluates their specific contributions, and presents practical approaches for capitalizing on these resources. The incorporation of tables and charts improves the visual depiction of important ideas, thereby improving the overall comprehensibility and availability of the article. By addressing the different aspects linked to the implementation of emerging technologies, the authors provide valuable perspectives for managers overseeing innovation and contribute to the ongoing academic discourse regarding the evolving interplay of technology and innovation.

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THE EVOLUTION OF LEADERSHIP STYLES DURING THE INDUSTRIAL DEVELOPMENT OF SOCIETY

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Purpose: The work aims to consider the evolution of leadership styles in the context of industrial development. The research aims to study changes in leadership approaches at different stages of industry development, such as industry 1.0, 2.0, 3.0, and 4.0, identify the characteristics of each stage, and discover how these changes have affected leadership approaches. Particular attention is paid to identifying factors that determine the evolution of leadership styles, mainly changes in the technological, economic, and socio-cultural environment, to understand how these factors influence the development of leadership approaches and how this is reflected in organizational strategies.

Design/methodology/approach: The article analyzes scientific literature and studies historical data and events devoted to the evolution of leadership styles in industrial development. The authors conducted a cross-sectional approach to a comparative analysis of leadership styles at different stages of industrial development in order to highlight the main differences and common elements. Scientists also used a systematic approach in the article to understand the interaction of factors of industrial development and the choice of leadership styles. The theoretical volume examines various approaches to leadership, and the practical aspect of the work is based on factual data and conclusions for the further use of the obtained results by modern leaders and managers.

Findings: The study found that technological change defines a new context for leaders, which requires adapting and developing new management skills such as flexibility, adaptability, and collaboration. The general conclusion of the article is that the evolution of leadership styles is closely related to industrial development and requires constant improvement and adaptation of managers to changes in the technological, economic, and socio-cultural environment.

Practical implications: Leadership is associated with technological and economic progress. The old approaches to leadership should be more relevant in today's world. Leaders must actively adapt their skills to new requirements, learn flexibility, and improve strategic thinking. Such changes in leadership practices have great potential to improve productivity and achieve success in the era of Industry 4.0.

Social implications: These articles can be used as a basis for developing modern strategies focused on the challenges of Industry 4.0 and will contribute to further developing leadership potential in conditions of constant change.

Originality/value: The study of the evolution of leadership in the context of industrial development consists of analyzing and comparing different leadership styles at different stages of industry. The study allows us to consider changes in leadership approaches and reveal their impact on organizational effectiveness and corporate culture. The work opens new perspectives for studying leadership based on the development of technologies and modern requirements for flexibility and sustainability in organizational management.

Keywords: leadership, leadership style, industry.

Category of the paper: Research paper.

Introduction

Throughout human history, especially in industrial development, leadership styles have played an essential role in shaping and transforming organizational management. From the beginning of the first industrial revolution, when the task was to ensure the efficient operation of mechanized factories, to today, when the integration of digital technologies defines new productivity standards, leadership has adapted to changes in the manufacturing environment (Yavari et al., 2020; Reisman, 1998; Kuzior et al., 2023).

The first stage of industrial development, defined by the massive introduction of mechanization and steam power, required effective control and coordination. Autocratic leadership styles were characteristic of this period, where management dominated processes, emphasizing standardization and production efficiency. With the development of the industry, the emergence of new technologies, and the increase in the complexity of the economic environment, the need for more flexible and creative approaches to management has emerged. This necessity led to a change in leadership styles, which caused the formation of transactional and transformational leadership, which are based on interaction and team development. In the Fourth Industrial Revolution period, characterized by digital transformation and the application of artificial intelligence, leadership in the conditions of Industry 4.0 becomes even more complex and requires managers' attention to innovation, strategic vision, and flexibility.

The study of different stages of the evolution of leadership styles in the conditions of industrial development is based on an understanding of the challenges and opportunities of management of each historical period. By examining the proposed evolution, one can better understand how leaders have adapted to change, contributing to the success of their organizations and the formation of new and innovative approaches to management in general.

1. Industry 1.0: labor mechanization and the First Industrial Revolution

Industry 1.0, often called the First Industrial Revolution, spans the period from roughly the mid-18th century to the mid-19th century. This period was decisive for transitioning from traditional manual production to the machine and mechanized labor system (Mohajan, 2019).

An essential feature of Industry 1.0 was the mechanization of industry and the introduction of steam power to replace manual labor (Broadberry et al., 2011; Clark, 2010). The factory system replaced artisanal production and shaped product mass production and standardization. This replacement led to the development of transportation infrastructure, including railroads and steamships, facilitating trade and transportation.

Industrial change created a new working class, especially in large cities and industrial centers. Working conditions were often poor, and standards needed to be tightly regulated (Apriliyanti et al., 2022). The period of the first industrial revolution was defined by centralized management and autocracy, where strategic decision-making was simplified and concentrated in the hands of rulers.

Industry 1.0 has made an enormous contribution to the social and economic landscape. The changes in the social structure and the increase in the urban population were irresistible. This period was characterized by rapid growth in industrial production. It marked the transition from a traditional rural economy to an industrial industry, laying the foundations for further technological innovation and social life and work changes (Vinitha et al., 2020).

The specific features of the Industry 1.0 era and the requirements of that period indicate the widespread use of *autocratic and analytical styles* of interaction with employees by managers (Homer, 1982; Steck, 2022).

The main emphasis in management using an *autocratic leadership style* consisted of the organization of the workforce, the mechanization of production, and the management of large factories. Leaders, often owners, had absolute power over decision-making. The task was to ensure the effective functioning of mass production. In this context, the autocratic management style proved effective and appropriate to the era's requirements (Harms et al., 2018). Leadership was aimed at ensuring standardization, efficient use of resources, and increased productivity through top-down control. The conditions of the time determined the need for order and organization, which made autocratic leadership the dominant style in the management of industrial production during the first industrial revolution.

Analytical leadership during the First Industrial Revolution was less pronounced than the autocratic leadership style. However, the management and organization of large factories were based mainly on mechanical solutions and optimization of production processes (Harris et al., 2011; Yammarino et al., 2005). Analytical leaders of the time focused on introducing mechanized technology and steam power to improve productivity and ensure production efficiency. The main principles of efficiency analysis considered the efficiency of mechanical

systems and ensured the stable operation of large-scale production. Leadership based on analysis during this period focused on optimizing processes through the introduction of new technologies and the intelligent use of resources. However, compared to later stages of industrial development, the analytical approach was a limited toolbox adapted to the specific requirements and opportunities of the period of the first industrial revolution.

2. Industry 2.0: electrification and mass production processes

Industry 2.0, or the period of the Second Industrial Revolution, spans the late 19th and early 20th centuries. One of the characteristics of this period was the widespread adoption of electrification and new energy sources, such as oil and gas, which revolutionized manufacturing processes and methods (Mohajan, 2020).

New forms of transportation appeared, including automobiles and airplanes, which expanded the possibilities of trade and movement of people. Industry became more mechanized and automated, and mass production became even more critical. This period was also characterized by the emergence of large monopolies and conglomerates, leading to the need to regulate markets and corporate activities (Bacon, 2007; Yin et al., 2017). Industry 2.0 was defined by intensive technological development and changes in production processes, which significantly improved production efficiency and economic growth.

The innovations of that time formed the need for effective management of large corporations, which led to the development of *transactional leadership* and strategic management. The primary attention of industry 2.0 leaders was directed to transactional relations between managers and subordinates, mainly to control the production process, standardization, and optimization of activities (Chan et al., 2005; Alharbi et al., 2021).

During this period of industrial development, emerging large corporations and factory enterprises highly valued the systematization and standardization of production processes. Transactional leadership reflected the need for clear hierarchical structures, control over the activities of subordinates, and setting standards to ensure efficiency and product quality. Transactional leaders focused on executing operations, ensuring planning and control through formalized procedures and standards. This approach was appropriate for effectively managing the large-scale production that characterized Industry 2.0.

Also, in the era of Industry 2.0, *performance-based leadership* has proven extremely important to adapt to the demands of mass production (Bradberry, 2012; Holton, 2000). Influential leaders were supposed to increase the organization's productivity, reduce production costs, develop and implement effective management methods to improve production processes, and optimize the use of resources. Performance-based leaders sought to develop standardized approaches to production, streamline work processes, and use new technologies to improve the

efficiency of production lines (Arvonen et al., 1999). This approach was particularly relevant in large factories, where the focus on mass production required the systematization and optimization of management approaches. Industry 2.0 leaders were innovative in developing and implementing methods that contributed to increased production efficiency and the development of new management standards.

3. Industry 3.0: automation of work processes and the Technological Revolution

Industry 3.0, or the Third Industrial Revolution, defined the second half of the 20th century. The main characteristics of this period were automation and the use of electronics, which led to increased automation of production and the development of new technologies such as computers and information systems (Mohajan, 2021; Connors et al., 2020). The growth of information technologies has opened up new opportunities for processing and sharing information, which has contributed to improving organizational performance and forming a networked society. Industry 3.0 has brought about significant changes in the production and management of organizations, causing the transition to the information society and new challenges in technology and the economy.

In this period, *transformational leadership* stimulated employees' creativity and personal development. Innovation and research in developing new products and technologies gained significant importance. The era of Industry 3.0 was defined by the globalization of the economy and the development of international corporations (Rifkin, 2011). The increase in the volume of international trade and the interdependence of economies became characteristic features of this period. Transformational leaders of this period began to emphasize the personal development of subordinates and the stimulation of the staff's creativity. Instead of focusing on control and standardization, transformational leaders prioritized developing their teams' potential, promoting personal growth, and creating conditions for expressing creative initiative. Leaders in Industry 3.0 also prioritized change and process improvement, as the rapid development of technology required adaptation and constant innovation (Ackoff, 1999; Bass, 1990). The ability to quickly respond to changes and effectively implement new technologies became a critical success factor. Transformational leadership in Industry 3.0 reflected a new approach to management with a focus on flexibility, creativity, and constant readiness for change to adapt to a rapidly changing economic environment (Shvindina et al., 2021).

Also, during this period, the need for *group leadership* or leadership based on group dynamics has become relevant due to changes in the structure of work groups and approaches to cooperation in organizations. Leaders in Industry 3.0 recognized the importance of group dynamics and teamwork. Instead of individualized leadership, they began to pay attention to

shared goals, communication, and interaction between team members (Barge, 1989; Jiang, 2021). Leaders tried to promote practical group work by stimulating interaction and exchanging ideas to achieve common goals. This approach met the requirements of the growing complexity and variety of tasks in Industry 3.0. Group leadership supports creating flexible, creative, and adaptable work groups to effectively solve tasks requiring diverse expertise and approaches.

Communicative leadership becomes essential to successful management due to the increasing complexity of organizational processes and the importance of effective communication in organizations. Communicative leaders of this period understood that effective communication within teams and between departments was essential for achieving common goals and solving problems (Hamrefors, 2010; Kuzior et al., 2021). The growing complexity of projects and the increase in the amount of information required managers not only to be able to communicate clearly but also to actively implement communication tools to ensure the clarity and efficiency of information exchange. Communicative leadership in Industry 3.0 focused on developing a culture of openness, mutual understanding, and interaction. Leaders have begun to use various communication tools, including remote work technologies and electronic platforms, to facilitate effective information sharing and collaboration in distributed and multi-level team structures.

4. Industry 4.0: digital transformation and unification of technologies

Industry 4.0, or the Fourth Industrial Revolution, represents the current technological and production innovation period. The main features of this stage are high-tech automation, increased interaction between digital technologies, artificial intelligence, and actual production (Xu, 2018; Ghobakhloo, 2020). Industry 4.0 includes using the Internet of Things (IoT), real-time data processing, large volumes of analytics, and enhanced interaction between humans and machines. This period aims to create "smart systems" and optimize production processes.

Industry 4.0 technologies expand the implementation of flexible and intelligent production systems, reducing production costs and increasing the organization's productivity. Artificial intelligence, machine learning, big data, and blockchain are used to optimize supply chains and improve product quality. Industry 4.0 is also marked by an emphasis on implementing digital technologies in all spheres of social life (Kuzior et al., 2023; Ingaldi, Ulewicz, 2019; Bilan et al., 2022) Industry 4.0 forms a new stage of technological development where production, information, and communications merge to create a more integrated and "smart" economy.

Intensive digital transformation and the introduction of advanced technologies require a *combination of transactional and transformational leadership*. Successful leaders must possess transactional leadership skills to ensure operational effectiveness in an environment of high technological change and unpredictability. Managing operational and resource efficiency are critical challenges in a rapidly changing economic environment. Transformational leadership is gaining importance in the era of Industry 4.0. Leaders must be able to create visions, motivate staff to innovate and be creative, and adapt the organization to the rapid changes in the technological landscape (Politis, 2002; Kalsoom et al., 2018). Combining transactional and transformational leadership becomes a critical success factor in Industry 4.0, where it is necessary to manage operations effectively, adapt to constant changes, and stimulate innovation.

Flexible and adaptive leadership are critical in today's realities, as the economic environment is subject to rapid and unpredictable changes due to the introduction of advanced technologies. Leaders focus on learning and adapting to constant changes in the development of technologies and markets, including the constant study of new products, mastering the latest digital solutions, and the ability to respond quickly to changes in the economic environment (Yuk et al., 2010). Flexible leadership considers the volatility and dynamics of Industry 4.0, where technological revolutions and new industrial paradigms can suddenly change the landscape of an organization's operations. Agile leaders understand that adaptability and flexibility become essential in the face of uncertainty and rapid technological change (Norton, 2010). In the era of Industry 4.0, leadership in conditions of uncertainty becomes an integral part of successful management due to constant changes in the technological landscape and organizational models. Leaders must possess decision-making skills under conditions of uncertainty and flexibility. Since Industry 4.0 is characterized by constant technological innovation, unpredictable changes in market conditions, and a high degree of complexity, leaders must be ready to adapt to new conditions and make decisions quickly. Such a modern trend requires leaders to develop strategic thinking skills, risk analysis, and the ability to adapt strategies in real-time (Kwilinski et al., 2020). Industry 4.0 leaders must be open to innovation, actively study new technologies, and look for ways to optimize processes in constant development and change. Flexibility and the ability to adapt to uncertainty are critical qualities of the modern leader.

Servant leadership is also necessary in rapid technological change and development. The support of employees determines servant leadership. Leaders of this type understand that ensuring the well-being and effectiveness of the team is essential to achieving shared goals in the face of change. Servant leaders work to create conditions for the development and success of each team member, promoting their personal and professional growth; that is, they support staff and provide resources for creative and innovative thinking, creating a favorable work environment for the development of employees' potential (Coetzer, 2017). Servant leadership in Industry 4.0 promotes the formation of flexible, high-performance teams ready to adapt to changes and implement innovations in work processes.

In today's environment, the importance of empathy and the ability to understand the needs and expectations of staff comes to the fore. Leaders in Industry 4.0 understand that human capital is a significant asset, and the ability to empathize plays a critical role in interacting with a team. *Empathetic leaders* actively listen to their employees, consider their needs, and consider the personal and professional aspects of their lives (Kock, 2018). They strive to create working conditions that promote self-expression and creativity, essential elements of successful work in Industry 4.0. Empathic leadership helps maintain and strengthen critical interpersonal relationships in the work environment by supporting and motivating the team in a rapidly changing economic environment and stimulating high levels of performance and job satisfaction of the staff.

5. Evolution of leadership styles in the context of social industrial development

Changes in the styles of the interaction of leaders with personnel occurred under the influence of developments in the social, economic, and technological environment, and each stage of industrial development was marked by its characteristics in leadership and management. Table 1 shows the evolution of leadership styles in the context of economic modernization of social life in the period of Industry 1.0, Industry 2.0, Industry 3.0, and Industry 4.0.

Table 1.

Leadership styles during Industry 1.0, Industry 2.0, Industry 3.0 and Industry 4.0

Period	Characteristics of the period	Leadership style	Characteristics of leadership style
Industry 1.0	Labor mechanization	Autocratic leadership	Centralized decision-making, strict hierarchy, minimal participation of subordinates, strict control, low level of employee satisfaction, dependence on the leader, and effectiveness in a crisis.
		Analytical leadership	Analytical thinking of the manager, factology, strategic planning, objectivity in solving problems and making decisions, the ability to consider alternatives, a systematic approach, and exactingness are less effective in a rapidly changing environment, where it is necessary to respond to new circumstances quickly.
Industry 2.0	Implementation of electrification and new energy sources	Transactional leadership	Through transactional relationships, motivation through incentives, and centralized decision-making, the leader evaluates and determines performance based on achieving specific goals and standards, focusing on performance and vertical structure.
		Performance-based leadership	Results orientation, performance rewards, and performance appraisal; the leader clearly articulates the expectations of each team member and defines performance standards, application of specific metrics, and key performance indicators to evaluate and measure success, individual recognition, and task orientation.

Cont. table 1.

Industry 3.0	Automation of work processes	Transformational leadership	The leader has a clear vision and defined goals, inspiration and motivation, stimulation of creativity, individual development of each team member, developed emotional intelligence in the leader, leadership ethics, and effective communication; the leader creates a favorable atmosphere for self-expression and self-realization of each team member, implementation of positive and transformational changes in the organization, collective identity.
		Group leadership	Involvement of employees by the leader for joint decision-making, development of group spirit, moderation of conflicts, group coordination, promotion of group determination, effective communication, facilitation of interaction between group members and creation of an atmosphere of mutual understanding, distribution of responsibility, creation of long-term group dynamics.
		Communicative leadership	Effective communication is the ability of the leader to actively listen to the thoughts and ideas of team members and provide constructive feedback, creating a clear vision; the leader can convincingly express his ideas and convince others of the importance and relevance of these ideas, adaptation to the audience, facilitating the acquisition of knowledge, conflict resolution, communication culture, the ability to empathize and understand the emotions and needs of other team members, change management.
Industry 4.0	Digital transformation and unification of technologies	Transformational + Transactional leadership	In the strategic vision, the leader uses the motivational elements of transformational leadership to stimulate self-development and team improvement, define expectations and rewards, develop leadership potential, apply effective communication that integrates the importance of mutual understanding and accomplishing tasks, leadership equity, the ability to implement change and drive innovation in the team, systematic approach, long-term cooperation.
		Flexible and adaptable leadership	Flexibility in decision-making, agility, fostering and encouraging creative thinking and innovative approaches, ability to learn, effective change management, collaboration, and communication, result-oriented, responsive to challenges, leadership empathy, willingness to change one's approach and style depending on the specific situations.
		Empathetic leadership	The leader shows the ability to feel and understand the emotions and experiences of his employees, active listening, the leader pays attention to the unique needs and expectations of each team member, encouraging the personal and professional development of employees, taking into account their goals and ambitions, openness to perspectives, involving the team in the decision-making process and taking into account their contribution, effective communication, responding to emotional context, creating and maintaining stable and trusting relationships in the team.

Source: Developed by the authors.

6. Conclusions

The history of the world's industrial development led to a constant transformation of leadership styles, reflecting the requirements and challenges of a certain period of time that arose before organizations and society (Khozhylo et al., 2022; Polyanska et al., 2022). In the period of Industry 1.0, when the industry underwent the first significant technological changes, autocratic leadership reflected the need for control and certainty in management. Industry 2.0 introduced the concept of transactional leadership, where management emphasized process optimization and production efficiency. Standardization and a systematic approach have become the main principles of management. The development of Industry 3.0 is associated with computerization and automation and has created the need for transformational and group leadership. Technological changes and increased complexity of tasks required leaders to focus on personal development and team cooperation. Modern Industry 4.0 creates the need for flexible leadership, which is focused on adapting to constant changes in the economic environment and introducing innovations into various organizational processes (Kuzior et al., 2022). Leaders must combine strategic vision, transactional and transformational elements, and servant and empathic leadership. The ability to make decisions in the face of uncertainty and maintain flexibility become attributes of a successful leader.

Thus, the history of the evolution of leadership styles indicates the need for constant adaptation and improvement of leadership by changes in the technological, economic, and socio-cultural environment. The challenges of industrial development have become essential prerequisites for the development of new approaches to leadership that promote cooperation, innovation, and flexibility for success in today's economic environment.

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INDICATION, SOLUTION, PREVENTION: A HOLISTIC APPROACH TO FINANCIAL, INDUSTRIAL ENGINEERING, AND BUSINESS PROBLEM ANALYSIS

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Purpose: The research aims to provide a guide for businesses, with the help of which the financial problems that the business usually encounters are diagnosed in time. This paper also contains recommendations for improving the solvency and financial situation of the company, which contribute to increasing the values of profitability indicators.

Design/methodology/approach: The approach to the topic includes an analysis of the current state of financial problems in companies using individual groups of financial indicators.

Findings: Profitability indicators are used to measure the company's ability to acquire new resources. In the financial analysis, ROA, ROE, and ROS indicators for 2021 had higher values than for 2022, but they are still within a safe range. Since every company tries to maximize its profit, it is necessary for the company to constantly try to increase the values of these indicators, maximize revenues, and minimize costs, which will also be reflected in the company's profit.

Practical implications: The practical benefit is in the detection of financial problems of a specific company, in the form of indication - solution - prevention, while the indication will be determined using the ratio indicators of the selected company. It will be a simple and quick financial analysis, with the help of which the company will be able to analyze its financial health. The years 2021 and 2022 will be compared.

Originality/value: The originality of the paper contains verification of the indication-solution-prevention model based on the data of a specific company.

Keywords: financial analysis, financial problems, financial ratios.

Category of the paper: research paper, general preview.

1. Introduction

Financial analysis does not only concern financial management itself, but has a significant impact on the development of enterprises (Chimucheka, Rungani, 2011, Mazur et al., 2021; Zada, Yukun, Zada, 2021) and even on society (Cisco, 2013). In the company it constitutes, among others, significant contribution of analyzing the company's strengths and weaknesses, opportunities and threats (SWOT analysis). When working with financial analysis and processing the results of financial analysis, deficiencies and weaknesses in the company's health are identified. These deficiencies can cause problems in the future. The strengths are related to the possible future appreciation of the company's capital and its growth (Furdygiel, 2020). These data must correspond not only to the quality but also to the complexity, therefore it is necessary to capture all data promptly that could in any way embellish the results of the assessment of the financial situation and health of the company (Kasajová, 2018).

According to Růčková (2011), it is generally true: the better methods are applied, the more reliable conclusions are obtained and thus the risks of wrong decisions are eliminated and thus there is a greater chance of success.

In addition to the choice of the analysis method, it is essential to know for whom the outputs from the given analysis are intended and to adapt the resulting presentation accordingly (Krajčovič, 2012; Trebuňa, 2019). The person who assigns the analysis does not pay attention to how the conclusions were reached, but to what these conclusions and results from the given method of analysis can mean for the given company. Visualization is also necessary, which will help to navigate the outputs of the given financial analysis more easily. It is recommended to process the information graphically, which will help people who do not know financial analysis to navigate the given issue (Buckova, 2020). Figure 1 shows the procedure for evaluating the financial analysis. It includes evaluating the company's past, and present and predicting the future financial situation of the company.

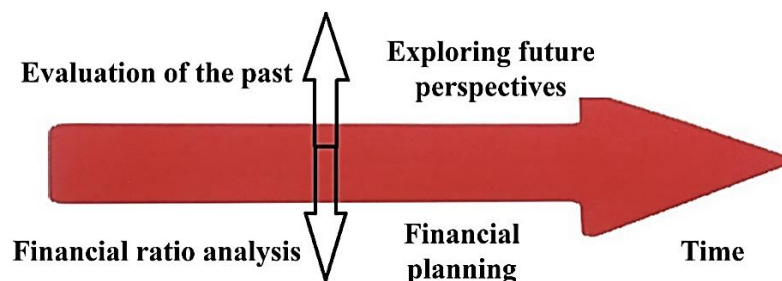


Figure 1. Scheme of the time point of view of the evaluation of financial analysis information

Source: Own study.

Financial indicators are the basis of financial analysis methods. They usually consist in presenting economic processes (Antoniuk, 2021) at a specific time, based on financial statements such as the income statement, balance sheet and statement of cash flows. The term

financial indicator can also be understood as a numerical characterization of the company's economic activity. Indicators taken directly from accounting statements are usually given in monetary units, but with the help of arithmetic operations, it is possible to define the obtained results in other units, e.g., in percentages or units of time. The choice of the type of indicator is defined by the purpose and goal of the given financial analysis. The purpose is mainly about who the given outputs from the analysis will serve, while the goal is given in advance by the business purpose and the conditions under which the given purpose is processed. Financial analysis is not only used for the financial management of the company but also evaluates the strengths and weaknesses of the company and the financial health of the company.

Profitability, also called return on invested capital, serves to measure how a company can create new resources and how it can make a profit using invested capital. Profitability indicators are most often based on the profit and loss account and the balance sheet, while more attention is paid to the profit and loss account because in some sources the term profitability is replaced by the term cost-effectiveness (Furmannova, 2021). In the case of profitability indicators, there is usually a flow quantity in the numerator and a state quantity in the denominator. What is important, profitability indicators are intended to evaluate the overall efficiency of the determined activity (Vavřík, 2022). Investors and shareholders are usually interested in these indicators, and they should have an increasing tendency in a certain period. In general, profitability is therefore expressed by the ratio of profit to the amount of invested capital.

In the global economy, the demand for a higher level of production and product quality is still growing, which has a direct impact on the optimal condition of production facilities. For this reason, the maintenance of every business must have adequate tools for planning, monitoring, and updating costs and deadlines, as well as for the performance of other important functions. In the past, the economic view of quality-focused primarily on the possibility of reducing costs associated with quality. However, the current approach compares costs associated with quality, maintenance, production itself, and economics. Benefits from these spheres are an essential part of summarizing individual information from the mentioned areas.

Therefore, for these reasons, in the following analysis, attention will be paid to profitability indicators and liquidity indicators. As part of this analysis for individual indicators, areas are selected from the point of view of economy, maintenance, quality, and production, for the reason that companies and individual employees of companies come into contact with these areas the most. Proposals in the form of indication-solution-prevention within these areas are analyzed in the tables of this article in the results section.

2. Methods

In the chapter, the financial problems of companies today will be discussed in more detail. Their identification and questions that the company most often deals with during its activity. Here, the company can find a quick guide to solving its problems, as well as answers to the questions it needs to solve.

2.1. Profitability indicators

According to Růčková (2011), when it comes to profitability indicators, the company most often looks for answers to questions such as:

- How effectively does the company use its assets?
The answer to the above question is provided by the ROA indicator, because the higher the ROA value, the more efficient the resulting use of assets.
- How can the company achieve an adequate margin?
The answer to the above question is provided by the ROS indicator, because the higher the ROS value, the stronger the company will be in terms of making a profit.
- What will be the return on individual investments for the company?
The answer to the above question is provided by the ROE indicator, because the higher the ROE value, the higher the efficiency of the company.

2.2. Liquidity indicators

According to Zuzik (2020), when it comes to liquidity indicators, the company is most often looking for answers to questions such as:

- How can the company deal with short-term liabilities? Is it a capable enterprise to pay off short-term liabilities?
The answer to the above question is provided by the liquidity indicator of the company, and the answer can also be found using cash flows.
- Does the business have sufficient capital to operate the company properly?
The answer to the above question comes from the total amount of working capital because the lower the value of working capital, the greater financial problems can arise in the company.
- How big will the risk be if the business is unable to pay interest to creditors?
The answer to the above question comes with interest coverage, because the higher the value of this coverage, the lower the risk.

3. Results

In the chapter selected financial problems that the company tends to encounter most often will be discussed, while these financial problems were selected based on the book by Klučka (1998). The design solution will be designed in the form of an indication of possible problems - solutions - and prevention. This procedure will be applied to selected financial problems associated with profitability indicators, cash flow indicators, activity indicators, and indebtedness indicators.

3.1. Financial problems associated with profitability indicators

Possible problems are in achieving liquidity, a decrease in profit, or a decrease in sales. Symptoms:

- profit reduction,
- growth of direct and overhead costs,
- deficit of resources (material, financial), which is related to the fact that production cannot be expanded,
- decrease in demand for manufactured products or provided services.

Possible causes of problems with profitability indicators are clearly shown in Table 1, from which it is possible to see the possible areas, as well as the causes from these areas that can lead to the emergence of the given problem.

Examining specific Table 1, Table 2 and Table 3 are crucial when considering individual indicators since monitoring these indicators can assist the company in identifying issues that are frequently concealed in the background. This effort aids the company in promptly diagnosing these problems by utilizing the distinct symptoms associated with each indicator. Moreover, this undertaking contributes to the company's ability to address the financial challenges it is currently facing.

Table 1.

Causes of problems with profitability indicators

Possible areas	Possible causes of problems		
	Economic area	Different structures in real and planned costs	Insufficient financial resources
Maintenance area	The maximum capacity of individual devices is not used	Individual technical devices are outdated	The devices do not have predictive maintenance in place
Quality area	Products and services are not of sufficient quality	Products and services are not in demand in the market due to the absence of quality improvement	High incidence of defective products
Production area	The company is insufficiently and poorly organized	Production planning and management are not organized	Absence of innovative changes in production

Source: Own study.

Table 2 shows solving problems with profitability indicators from different economic points of view.

Table 2.
Solving problems with profitability indicators

Possible area	Possible solutions to problems			
	Economic area	Removing products and services that are unprofitable	Finding new customers and subscribers	Regular control and adjustment of prices and modification of the marketing mix
Maintenance area	Using the maximum capacity of individual devices	Purchase of new powerful and technical equipment	Implementing predictive maintenance and avoiding post-failure maintenance	
Quality area	Producing a product of the required quality, which is determined by the customer	Launching a new product on the market or ensuring the modification of an existing product with sufficient quality	Focusing on eliminating the occurrence of defective products	
Production area	Creating a detailed production strategy	Making strict changes in the company in the area of production planning and management	Implementing tools to help with implementations and help increase productivity and profit	

Source: Own study.

Table 2 is followed by Table 3, where possible prevention against the occurrence of problems is displayed. Alternatively, it can help the company to completely avoid individual financial problems. Therefore, the objective of condensing the information from these tables is to furnish businesses with a straightforward, lucid, and all-encompassing guide that encapsulates all relevant knowledge cohesively. The most important output is these tables, which help entrepreneurs and companies to collect all the necessary information from different areas.

Table 3.
Prevention of problems with profitability indicators

Possible area	Possible prevention against the occurrence of problems			
	Economic area	Permanent analysis of the market and market situation	Adjusting the marketing mix to the market situation	Management and evaluation of costs regularly
Maintenance area	Paying attention to the overall efficiency of the equipment	Ensuring constant modernization of equipment	Avoiding production downtime	
Quality area	Management of investment policy following quality goals and company goals	Not introducing a product to the market that will not demonstrate the required quality	Increasing the company's competitiveness in the area of quality	
Production area	Regular optimization and management of production processes	Introduction of service-diverse processes in production	Ensuring the best possible deployment of employees and machines in production	

Source: Own study.

3.2. Financial problems associated with liquidity indicators and cash flow indicators

Possible problems that may arise are a deficit of financial flows and a deficit of cash.

Symptoms:

- lack of funds to cover obligations,
- lack of financial means to ensure one's needs (purchase of material, raw materials and payment of liabilities to suppliers, employees, and the state).

Causes of the problem:

- non-alignment (non-synchronization) of cash inflow and cash outflow,
- inequality between income and expenditure,
- the company is unable to dispose of cash at an acceptable level (incorrect cash management),
- the company invests money in activities whose return is either long-term or not,
- no effect.

Solution:

- obtaining additional resources (issuing bonds, issuing shares, obtaining a loan),
- reduction of unnecessary assets or their sale or lease (inventories, machines, buildings),
- ensuring and managing cash flow so that the due date is moved as far as possible,
- active communication with customers about their requirements.

Prevention:

- analyzing the company's internal processes,
- analyzing customers, maintaining contact with them, and evaluating their corresponding ratings,
- analyzing decision-making regarding individual investments,
- optimization of financial resources,
- reduction the scope of the order,
- reduction the number of items in stock,
- increasing demand for products using discounts,
- application of just-in-time (JIT) strategy.

4. Discussion

The chapter will discuss the financial problems of a specific company, in the form of indication-solution-prevention. The indication will be determined using the indicators of the selected company. It will be a simple and quick financial analysis through which the company will be able to assess its financial condition. The years 2021 and 2022 will be compared. The company's ratios will also be discussed. It will also be a simple financial analysis of the

company and an analysis of individual indicators that are important for the selected group of ratio indicators. Analysis of these metrics will represent symptoms or signs of the company's problem areas. At the end of Chapter 4, three indicators will be used to indicate of problem areas of the company, which provides a quick and accurate response for the company.

4.1. Characteristics of the company

The analyzed company is located in the Žilina region. The company's main activity is mail order and online sales, operating in the form of an online store. The company sells clothes. It currently has approximately three to four employees. The company was founded in December 2017, so the age of the company is approximately 6 years. The legal form of the company is a limited liability company.

The following figure 2 shows the company's net operating profit after tax and its development in €

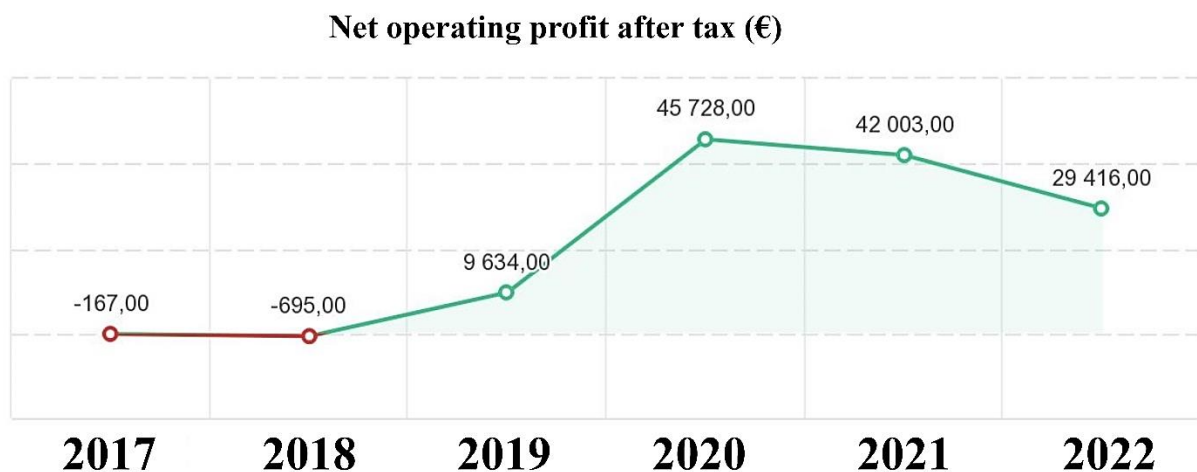


Figure 2. Net operating profit after tax of the company for a certain period.

Source: Company internal materials, 2023.

It can be seen from Figure 2 that in 2017 the company operated for 1 month and did not show a profit. Also, the company did not report a profit in 2018. The first profit was reported in 2019 for approximately €9,000. In 2020, the increase was approximately €45,000. In 2021 the profit was approximately €42,000 and for 2022 it was approximately €29,000.

In the following Figure 3, it is possible to see a graph of sales, including the sales of fixed assets and securities.

Sales, including the sale of sales of fixed assets and securities (€)



Figure 3. Sales, including the sale of sales of fixed assets and securities for a certain period.

Source: Company internal materials, 2023.

From Figure 3, it is possible to see the sales that were not there in 2017, because the company only operated for 1 month this year, as it was founded in December 2017. It also did not get any sales in 2018. The first sales can be seen in 2019, where reached the amount of approximately €39,000. In the following years, the sales had an upward trend, as in 2020 it was approximately €153,000, in 2021 it was approximately €170,000 and in 2022 it was approximately €211,000.

4.2. Indication of company problems using ratio indicators

Profitability indicators Return on Assets (ROA) indicator

Values of the ROA indicator for 2021 and 2022 are shown in Table 4.

Table 4.

Values of the ROA indicator for 2021 and 2022

	Year 2021	Year 2022
ROA indicator	32.90%	19.90%

Source: Company internal materials, 2023.

According to Table 4, it can be seen that the value of the ROA indicator for 2021 was 32.90% and for 2022 it was 19.90%. As explained in the theoretical part, the higher the value of the indicator, the better. This means that the company used its assets more efficiently in 2021 than in 2022. This indicator therefore serves to evaluate the efficiency of assets.

Profitability indicators Return on Sales (ROS) indicator

Values of the ROS indicator for 2021 and 2022 are shown in Table 5.

Table 5.

Values of the ROS indicator for 2021 and 2022

	Year 2021	Year 2022
ROS indicator	24.60%	13.90%

Source: Company internal materials, 2023.

According to Table 5, the ROS value for 2021 was 24.60% and for 2022 it was 13.90%. As explained in the theoretical part, the higher the value of the indicator, the better. Furthermore, the value of this indicator must be above 10%. This means that the company in 2021 was stronger in terms of making a profit per €1 of sales than in 2022. The value of the indicators in both cases is higher than 10%.

Profitability indicators Return on Equity (ROE) indicator

Values of the ROE indicator for 2021 and 2022 are shown in Table 5.

Table 6.

Values of the ROE indicator for 2021 and 2022

	Year 2021	Year 2022
ROE indicator	41.40%	22.50%

Source: Company internal materials, 2023.

According to Table 6, the ROE value for 2021 was 41.40% and for 2022 it was 22.50%. As explained in the theoretical part, the higher the value of the indicator, the better. This means that the company had a better rate of return on equity in 2021 than in 2022, and thus the return on capital is higher in 2021 than in 2022.

Liquidity indicators

The quick ratio is the liquidity of the first degree. The values of the quick ratio indicator for 2021 and 2022 can be seen in the following Table 7.

Table 7.

Values of the quick ratio for 2021 and 2022

	Year 2021	Year 2022
The value of the quick ratio (L1)	4.02	5.84

Source: Company internal materials, 2023.

The recommended value of ready liquidity should be in the interval $\langle 0.2-0.6 \rangle$.

The cash ratio is the liquidity of the second degree. The values of the cash ratio indicator for 2021 and 2022 can be seen in the following Table 8.

Table 8.

Values of the cash ratio for 2021 and 2022

	Year 2021	Year 2022
The value of the cash ratio (L2)	4.17	6.37

Source: Company internal materials, 2023.

The recommended value of current liquidity should be in the interval $\langle 1.0-1.5 \rangle$.

The current ratio is the liquidity of the third degree. This is total liquidity. The values of the current ratio indicator for 2021 and 2022 can be seen in the following Table 9.

Table 9.*Values of the current ratio for 2021 and 2022*

	Year 2021	Year 2022
The value of the current ratio (L3)	4.22	6.59

Source: Company internal materials, 2023.

The recommended value of total liquidity should be in the interval $\langle 2.0-2.5 \rangle$.

Liquidity indicators provide a reliable statement about whether the company can meet its obligations. All these indicators, which are listed above, have their recommended value. Since each indicator has an even higher value than recommended, it follows that the company could fulfill its obligations and is stable in covering its obligations.

However, it is necessary to note that the company would function optimally if the values of indicators L1, L2, and L3 were in the recommended ranges of values listed above. However, if these values were below the interval, it would mean that the company has cash problems, as these values are too low.

However, the high values of the indicators are also not good, because it indicates an inefficient distribution of funds in the company.

Therefore, when 2022 is taken into account in the order of values L1 - L2 - L3, it looks like this: 5.84 - 6.37 - 6.59. This means for L1 (5.84) that the firm can cover short-term liabilities only with money on account and in cash. For L2 (6.37), it means the firm's ability to cover short-term obligations, in addition to money on account and in cash, thanks to receivables.

And for L3 (6.59) it means the ability to cover short-term liabilities in addition to money on account and cash and receivables through the use of inventory. It is the same for the year 2021. However, at L1 it can be seen that the values are well above the recommended values and therefore it follows that the company has financial resources in the account. Therefore, if the company keeps its funds in this way, it is an inefficient management of financial resources.

5. Summary

This chapter will summarize the overall evaluation of the company's financial analysis for 2021 and 2022, which was carried out in this article. Recommendations that will serve to improve the financial situation and financial activities of the company is also mentioned here.

Profitability indicators are used to measure the company's ability to acquire new resources. In the financial analysis, ROA, ROE, and ROS indicators for 2021 had higher values than for 2022, but they are still within a safe range. Since every company tries to maximize its profit, it is necessary for the company to constantly try to increase the values of these indicators, maximize revenues, and minimize costs, which will also be reflected in the company's profit.

Liquidity indicators provide a relevant statement about the company's financial situation and its ability to cover its obligations. Prompt, regular liquidity showed a surplus value, which means that the company could meet its obligations and is stable in covering its obligations. However, unnecessarily high values of these indicators may mean that the company does not use its assets efficiently and there is an inefficient distribution of financial resources in the company.

The research carried out was carried out to help the company with its financial problems. This work can help the company diagnose these problems promptly using the individual symptoms that were mentioned in the individual ratio indicators. Furthermore, it can help the company to solve the financial problems it is dealing with at the given time. Alternatively, it can help the company to completely avoid individual financial problems. Therefore, the article aimed to provide readers with a simple, clear, and comprehensively written manual that includes all knowledge in a simple whole.

Individual tables for profitability and activity indicators are a basis for entrepreneurs. They help entrepreneurs and companies that do not have enough time to study economics, production, quality, and maintenance to gather all the necessary information from various areas. They are also of great importance in that they allow problems to be detected in time, to solve the problems that have arisen correctly, or to prevent them completely.

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THE EVOLUTION OF PROFIT MARGINS IN THE MINING AND EXTRACTION INDUSTRY

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Purpose: The aim of this paper is to test the hypothesis of the occurrence of increased margin values in the mining and extraction industry in an environment of increased CPI inflation rates in selected EU countries.

Design/methodology/approach: The study used selected quantitative methods, including: categorising companies by mean and standard deviation and the Kruskal-Wallis test for non-parametric independent variables.

Findings: The study showed that an increase in margins was observed in France and Italy in the 2021 and 2022 periods analysed. The largest increase was found in France, where the median gross profit margin increased from 3.5 per cent between 2015 and 2020 to 7.3 and 6.3 per cent, respectively, between 2021 and 2022.

Research limitations/implications: A significant limitation is the limited access to complete data. In addition, the analysis included countries that differ in terms of the availability of raw material deposits and also have varying levels of socio-economic development. As soon as more data becomes available, it would be worth expanding the area of analysis.

Practical implications: The occurrence of increased gross profit margins is a phenomenon limited to selected countries and not generally observable in the global market. These findings can be valuable for understanding economic trends in specific regions and can help isolate countries where companies experience higher margins compared to others. Our research provides basic information that can provide a starting point for decision-makers involved in the extractive sector at both EU and individual EU member state level. The conclusions drawn by the authors suggest the need for further exploration of the identified research area.

Originality/value: To our knowledge, this is one of the first articles on the verification of elevated margin values in the mining and extraction industry. The study contributes to the assessment of the adaptability of the European Union mining and quarrying industry and the phenomenon of increased margins.

Keywords: mining and extraction industry, profit margins, European Union.

Category of the paper: testing of data.

1. Introduction

Mineral resources remain one of the pillars of socio-economic development (Bustillo Revuelta, 2018; Karaś, 2020). Securing access to mineral resources is crucial for the global economy as it affects its innovation and competitiveness (Ferro, Bonollo, 2019; Hofmann et al., 2018). The demand for mineral resources, as well as the extraction of mineral resources, is constantly increasing (Balci, Kumral, 2022; Bustillo Revuelta, 2018). A particular focus is on critical raw materials¹, which have applications in many strategic sectors (Mancini et al., 2015). The dynamic growth in demand for critical raw materials is largely driven by their role in the energy transition and digitalisation (Johnston, 2022; Lewicka et al., 2021).

Geopolitical events have always had an impact on the economy, affecting the extractive sector as well (Laing, 2020; Umar et al., 2022). Over the last three years, two crises affecting the economy have overlapped: the COVID-19 pandemic and the war in Ukraine (Adekoya et al., 2021; Kuzemko et al., 2022). The outbreak and spread of the COVID-19 pandemic forced the introduction of restrictions. This resulted in disruptions of an economic, political and social nature (Gałaś et al., 2021). As a result of the global economic downturn, there was a decline in industrial production and an increase in commodity stocks, which led to a decline in mineral prices (Jowitt, 2020). In the case of metal prices, bauxite and copper saw the largest losses (Laing, 2020). However, it was oil prices that fell the most, due to a decline in demand, as well as Saudi Arabia and Russia's decision to not restrict oil production, causing an oversupply (Jowitt, 2020).

Before the start of the war in Ukraine, the two countries involved in the conflict - Russia and Ukraine - remained significant players for global commodity markets and leading energy suppliers on the European continent (Benton et al., 2022; Umar et al., 2022). The unprecedented economic sanctions imposed on Russia, which included imports and exports of service goods, political interventions, and informal pressure on private companies to leave the Russian market led to an increase in mineral and energy prices (Benton et al., 2022; Markus, 2022; Tosun, Eshraghi, 2022). Thus, the war in Ukraine has global implications, despite its direct interest in only two countries (Adekoya et al., 2021). The conflict has increased global geopolitical risks, caused commodity shocks and disrupted supply chains, and further contributed to inflation (Akcil et al., 2019; Markus, 2022). The war in Ukraine has also highlighted the nature of commodity security (Johnston, 2022).

¹ Critical raw materials - mineral resources of economic and strategic importance to the European economy, for whose continuity of supply there is a high degree of risk. Published in March 2023, the fifth list of Critical Raw Materials includes 34 materials: Antimony, Arsenic, Baryte, Bauxite, Beryllium, Bismuth, Boron/Borate, Cobalt, Coking Coal, Copper, Feldspar, Fluorspar, Gallium, Germanium, Hafnium, Heavy rare earth elements Helium, Lithium, Magnesium, Manganese, Natural Graphite, Nickel, Niobium, Platinum group metals, Phosphate Rock, Phosphorus, Scandium, Silicon metal, Strontium, Tantalum, Titanium metal, Light rare earth elements, Tungsten, Vanadium (European Commission, 2023).

The aim of this research paper is to verify the hypothesis of the existence of elevated margin values in the Mining & Extraction industry in an environment of elevated CPI inflation rates. The study was based on the selected quantitative methods, including: the categorisation of companies with respect to the mean and standard deviation, and the Kruskal-Wallis test for non-parametric independent variables.

The originality of the study conducted can be summarised as follows. The study contributes to the knowledge of the mining and extraction industry. Research on the mining sector still remains fragmented. In previous years, research on minerals and the mining sector in the European Union has focused on the low-carbon economy and climate neutrality (Guzik et al., 2021; Smol et al., 2017; Smol, Kulczycka, 2019), critical raw materials and their impact on sustainability (Blengini et al., 2017; Christmann, 2021; Hofmann et al., 2018; Hund et al., 2020; Mancini et al., 2015, 2018), as well as the potential for mineral recycling and substitution (Ferro, Bonollo, 2019; Hagelüken et al., 2016; Kulczycka et al., 2016; Løvik et al., 2018). Achieving the 2020 and 2030 climate and energy targets is important for the European Union in the transition towards a low-carbon economy (Ślusarczyk et al., 2023). Hence, the European Union is a leading actor in the pursuit of climate neutrality and the achievement of a sustainable development model (Janik et al., 2020; Smol et al., 2020). This study aims to link inflation rates and profit margins to the mining sector.

In addition, to our knowledge, this is one of the first articles on the verification of elevated margin values in the mining and extraction industry. Another important element of the study is that the analysis was related to the European Union countries, which allows for a more complete depiction of the issue of the phenomenon of elevated margins in the mining sector.

The research article is structured as follows: the next section provides a literature review. The following part presents the research methodology used to analyse the value of margins in the extractive sector. Subsequently, the results of the analysis carried out are presented together with the main conclusions of the analysis. The final section summarises the main conclusions and presents the limitations of the research.

2. Literature review

The spread of the COVID-19 pandemic had a huge impact on the global economy (Cai, Luo, 2020). A number of wide-ranging measures were taken globally to limit the spread of the pandemic. This has involved the introduction of numerous restrictions that have had an impact on the economic and social dimensions. It also led to a recession of the European economies (Jestl, Stehrer, 2021). The mining sector was not prepared and resilient to the effects of the COVID-19 pandemic (Laing, 2020). The pandemic affected metal and mineral production, as well as industries supplied by the mining and extraction sector (Jowitt, 2020). During the

COVID-19 pandemic, mining operations continued in most states; however, some facilities were operating at reduced capacity (Jowitt, 2020; Kumar et al., 2020). In this regard, there was also less demand as a result of the economic downturn and the decline in production, the risk of oversupply of minerals increased, which in turn caused prices to fall (Galaś et al., 2021; Jowitt, 2020; Kumar et al., 2020; Laing, 2020). Interestingly, gold and palladium prices increased during the COVID-19 pandemic. This was due to the temporary closure of the mining sector by South Africa. Additionally, both gold and palladium were in demand among investors. Platinum prices did not rise, driven by uncertainty about future demand, including a reduction in demand for the metal by the automotive sector (Jowitt, 2020).

Climate change is now seen as a major challenge for the global economy (Khurshid et al., 2023). The European Union has numerous actions and targets for a low-carbon and climate-neutral economy. However, this is feasible depending on the capacities of individual member states and unforeseen events (Ślusarczyk et al., 2023). The category of unforeseen events can include the war in Ukraine, which has highlighted the importance of raw material security, as well as the fragile raw material supply chain (Johnston, 2022; Nerlinger, Utz, 2022). Russia is an important producer of minerals such as gold, palladium and nickel. With the outbreak of war in Ukraine, the focus was primarily on precious metals and nickel, scandium and titanium that are categorised as critical raw materials (Johnston, 2022). There was concern about shortages and disruptions to the supply of these raw materials, on which an increasing number of economies are dependent (Akcil et al., 2019; Nakatani et al., 2018). Palladium, nickel, scandium and titanium play an important role in the energy transition, thereby affecting availability and prices (Khurshid et al., 2023). The war in Ukraine contributed to an increase in raw material prices, which translated into higher inflation (Korosteleva, 2022). There has also been a decline in production in the mining sector (Irtysheva et al., 2022). As a result of the outbreak of war in Ukraine, for example, nickel prices rose by more than 100% during the first two weeks of the conflict (Johnston, 2022). The metal has applications such as in battery storage systems or new energy vehicles, which include electric vehicles (EVs) and plug-in hybrid vehicles (PHEVs) (Wang et al., 2023; Yao et al., 2021). Russia, along with Indonesia and the Philippines, is one of the largest nickel producers. The nickel market was already in deficit before the war in Ukraine due to steadily increasing demand, and global nickel prices have been subject to a drastic fluctuation trend in recent years (Guohua et al., 2021; Wang et al., 2023). Hence, the war in Ukraine has exacerbated concerns about trade impediments and supply delays (Johnston, 2022).

Both the effects of the COVID-19 pandemic and the war in Ukraine contributed to a marked increase in inflation in 2021-2022, which impacted individual economies. Inflation levels in individual EU member states were clearly dispersed. Headline inflation in the Baltic States was 20-25%, which was three to four times higher than in the euro area countries with the lowest inflation rates (Topalova et al., 2023). Rising consumer prices represented a new economic, political and social challenge faced by the European Union (Menyhért, 2022). The inflation rate

was expected to reach lower levels despite the COVID-19 pandemic and the war in Ukraine (Topalova et al., 2023). However, inflation has reached levels that significantly affect household and business decisions (Visco, 2023).

In addition, with the lifting of restrictions introduced during the COVID-19 pandemic, there was an increase in demand for energy, the price of which began to rise. The energy crisis that affected the European Union intensified with the outbreak of war in Ukraine. The effects of the pandemic were still being felt, and there were additional concerns about the ongoing hostilities, including the impact on the global economy or the duration of the conflict (Adekoya et al., 2021; Bounou, Yatié, 2022). Russia is one of the largest producers and exporters of oil and natural gas (Umar et al., 2022). In contrast, Ukraine has the seventh largest proven coal deposits in the world (Johannesson, Clowes, 2022). Before the start of the war in Ukraine, 1/3 of the natural gas and oil consumed by the European Union had been from Russia. Conventional energy markets experienced sudden price increases that were caused by supply shocks (Umar et al., 2022). The increase in energy prices is indicated as the main reason for the increase in the cost of living. Energy prices in August 2022 were on average 40 per cent higher compared to August 2021. This posed a challenge not only for households, but also for other stakeholders (Menyhért, 2022).

It is highlighted that inflation related to the COVID-19 pandemic and the war in Ukraine coincided with sustained increases in corporate profits and margins (De Loecker et al., 2020). The sharp rise in inflation that occurred between 2021 and 2022 has been attempted to be explained in a number of ways. Some of the causes have been identified as: demand-supply mismatches, temporary disruptions in supply chains, and a price-wage spiral (Glover et al., 2023). However, it is increasingly suggested that the cause of the 2021-2022 inflation was the pricing strategy policies of firms. Hence, the concept of 'Greed inflation', which assumes that firms exploit their market position by raising prices faster than there is an increase in production costs, has gained prominence (De Loecker et al., 2020). 'Greed inflation' can contribute to the disruption of companies' relationships with stakeholders. Companies have protected their margins by passing on higher production costs to consumers. Moreover, in order to increase their profits, companies also chose to increase their margins. It has been pointed out that the increase in profit margins in the euro area in 2021 and 2022 was due to the desire to catch up with the declines recorded by individual companies in 2020 due to the COVID-19 pandemic (Bénassy-Quéré, 2023). Therefore, businesses are accused of both 'Greed inflation' and profit-taking, as well as deliberately prolonging the inflationary environment (Dekimpe, van Heerde, 2023).

Thus, an increasing number of studies point to a relationship between dynamic profit growth and the overall price level. It is shown that the price-profit spiral has replaced the wage-price spiral (Dekimpe, van Heerde, 2023). For this reason, profits are considered to contribute to inflation (Weber, Wasner, 2023). To date, research on the mining and extraction industry in the European Union has not addressed the possibility of elevated margins. This gap provides a basis

for further research to extend previous studies. The next chapter describes the materials and methods that should enable replication of the research and use of the results.

3. Methodology

The aim of this article was to investigate the hypothesis of the occurrence of increased margin values in the mining and extraction industry in an environment of increased CPI inflation rates, i.e. the occurrence of the so-called 'Greed inflation' phenomenon.

The study used data relating to financial results from 812 companies operating in selected European countries: Belgium (BE), Finland (FI), France (FR), Italy (IT), Latvia (LV), Poland (PL), Sweden (SE) and Slovakia (SK). The selection of the sample was dictated by its availability - the countries were represented by a minimum of 25 companies in the industry that, for the years 2015-2022, provided information on the level of profit margins and operating turnover to the ORBIS database used in the study. The industry category 'Mining & Extraction' was assigned to a company according to the breakdown found in the ORBIS database. Similarly, for the margin indicator, which in the database used means the so-called gross profit margin, defined by the formula (*Orbis Internet User Guide, Bureau Van Dijk, A Moody's Analytics Company*):

$$\text{Gross profit margin (\%)} = \frac{\text{Profit before tax}}{\text{Operating income (turnover)}} \quad (1)$$

A selected quantitative methods was used to carry out the study, including: categorising enterprises by mean and standard deviation, and the Kruskal-Wallis test for non-parametric independent variables.

The selection of research methods contributed to the fulfilment of two research quality criteria: validity and reliability. Validity was obtained through the selection of appropriate indicators that enabled the study to be conducted. Reliability was achieved through the use of a reliable data source, making the research replicable.

4. Results and discussion

The study focused on analysing the hypothesis of the occurrence of elevated profit margins in the mining and extraction industry in an environment of elevated CPI inflation rates. From the perspective of mining companies, the ability to generate profits is extremely important. However, corporate profit growth is currently being monitored due to the level of inflation (Colonna, Torrini, Viviano, 2023).

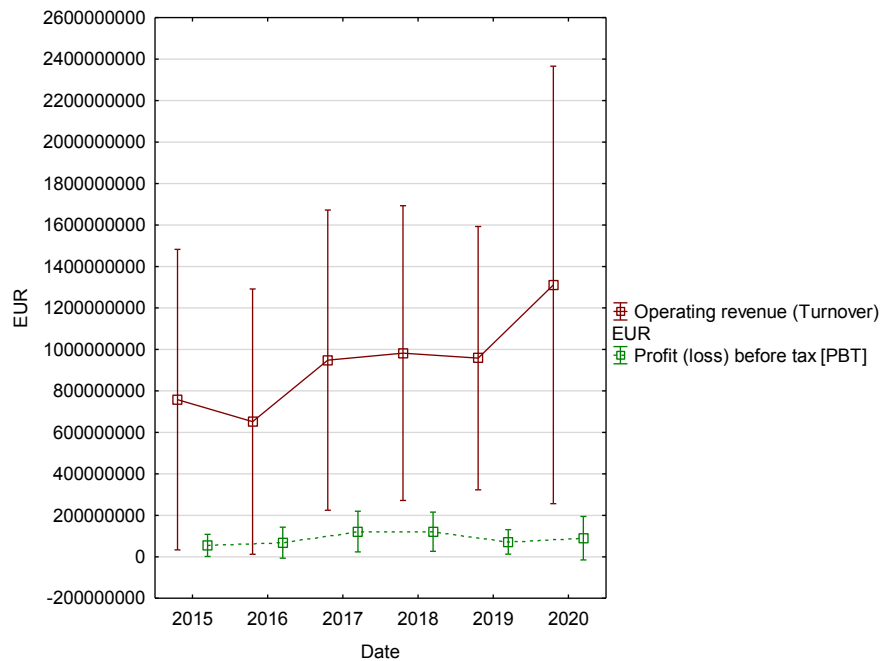


Figure 1. Evolution of the value of the margins of the surveyed companies in the period 2015-2020.

Source: own elaboration.

The initial identification of the disturbance in the dynamics of changes in the level of gross profit margins was based on the determination of the share of the number of companies outside the market equilibrium ranges. It was assumed that there is a range in the level of margins expected for the industry under the initial conditions, which is defined at the level of the country and the industry. Its determination was based on determining the average value of the margins for a given company (over the period 2015-2020) and then determining the standard deviation defining the limits of the range within which the observed margins could be considered expected. The limits of the ranges were thus determined by the formula:

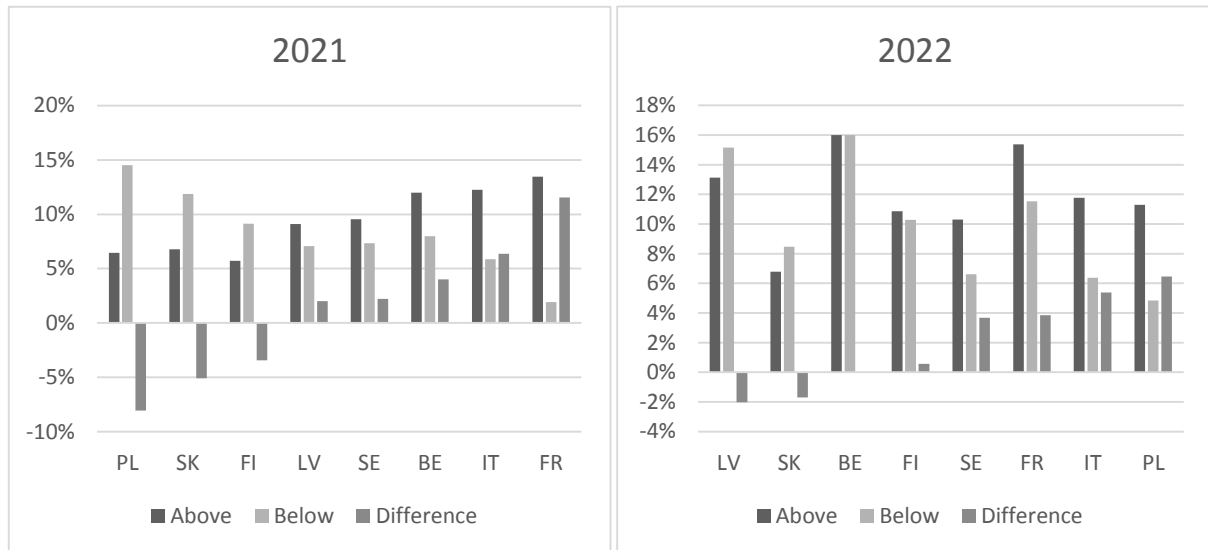
$$g = \frac{\sum_{t=2015}^{2020} m_i}{6} \pm 2 * \sigma \quad (2)$$

where:

g - the lower or upper limit of the range within which margin values are expected,

m - the margin value of the i -th company,

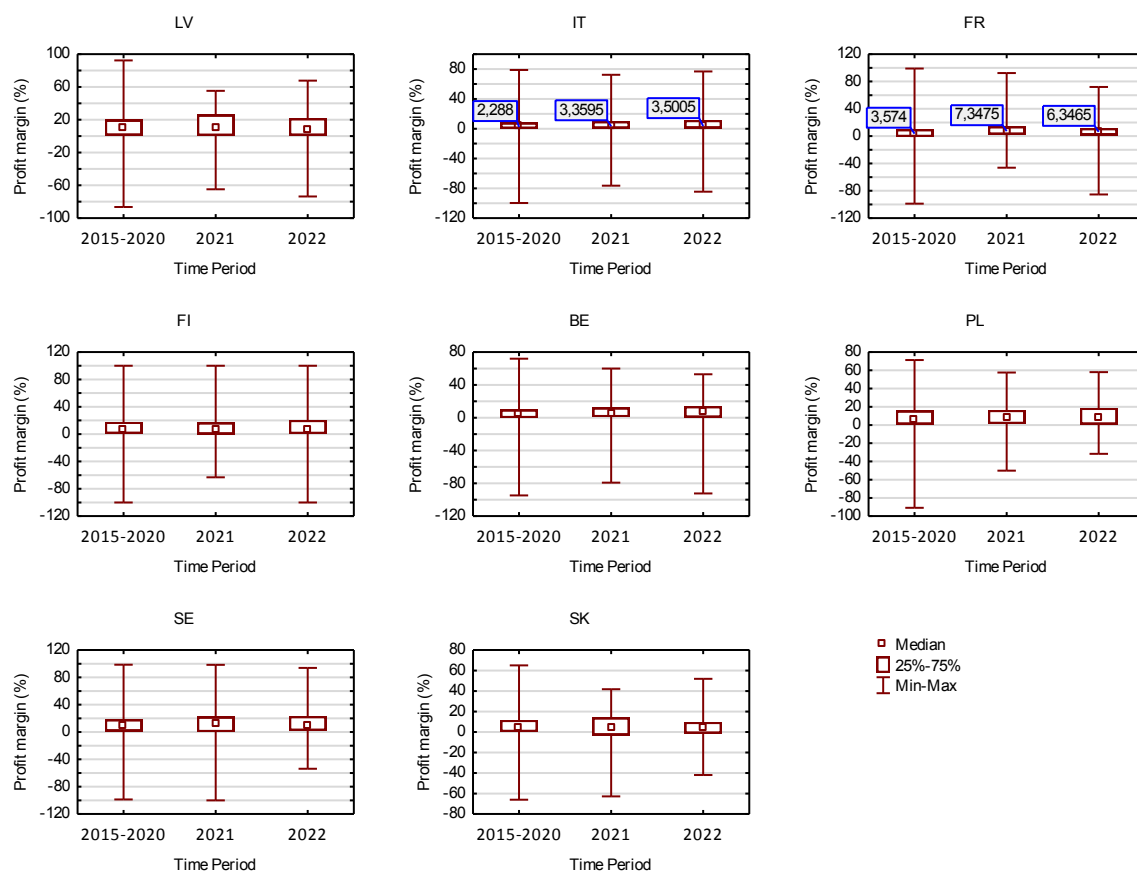
σ - the standard deviation of the gross profit margin values for 2016-2020 of the company in question.



Figures 2-3. Share of companies with under- or over-margins in 2021 and 2022 compared to 2015-2020 values by country.

Source: own elaboration.

According to the equilibrium assumption, not all companies in the industry will be within the expected range of margins, but the distribution outside this range should be similar in the absence of market disturbances. The next step, therefore, was to determine the countries that were characterised by a significantly higher proportion of companies with gross profit margins above, rather than below, the observed level. According to charts 4-5, it can be seen that only Italy, France and Sweden have a higher share of companies with above-margin levels compared to the number of companies with below-margin levels, indicating that the possible occurrence of 'Greed inflation' in the mining and extraction industry could only take place in these countries.



Figures 4-11. Distribution of median values and outliers for a set of margin scores over selected time periods in countries with a positive Kruskal-Wallis test.

Source: own elaboration based on ORBIS database.

A deeper examination of the distribution of margins was based on the results of the Kruskal-Wallis test, which is the equivalent of the parametric test of variance that indicates the occurrence of differences between the tested sets based on the median value. The p-value of the Kruskal-Wallis test for non-parametric independent variables indicated that only in the case of Italy and France, significant differences could be identified in the distribution of the margin indicator values in 2021 and 2022 compared to the values of 2015-2020. For the subsequent countries, the parameter value for the test was as follows: $p(\text{BE}) = 0.44$; $p(\text{FI}) = 0.53$; $p(\text{FR}) = 0.0028$; $p(\text{IT}) = 0.0053$; $p(\text{LV}) = 0.497$; $p(\text{PL}) = 0.52$; $p(\text{SE}) = 0.21$; $p(\text{SK}) = 0.64$. The average value of the margin ratio (shown in the x-y diagrams) for Italy remained at 2.3 per cent in 2015-2020, while in 2021 and 2022 it was, respectively: 3.4 and 3.5 per cent. For France, the differences were higher: in 2015-2020, the gross profit margin averaged 3.5 per cent, while in 2021 and 2022 it was 7.3 and 6.3 per cent, respectively.

The differences in the distribution of margin indicator values in 2021 and 2022 compared to 2015-2020 values in France and Italy were influenced by the increase in energy prices (González, 2022). Italy is dependent on energy imports and the increase in energy prices contributed significantly to inflation. In December 2022, energy prices in Italy were 70% higher compared to December 2021 (Simone, Pianta, 2023). In response to the energy crisis, Italy

decided to reduce the excise tax and VAT rate on energy products and introduced subsidies for companies (Amaglobeli et al., 2023; Simone, Pianta, 2023). In addition, a tax on additional profits made by energy companies was introduced (Amaglobeli et al., 2023). Simone and Pianta (2023) indicate that, without public control of energy markets, the Italian industry has made large profits.

France shows less dependence on energy imports compared to Italy, basing its energy sector on nuclear power and hydropower (Pinto et al., 2023; Plane, Vermersch, 2022). Energy prices in France rose more slowly than in other EU countries, which also contributed to a lower inflation rate. However, France was also affected by the energy crisis, forcing the French government to introduce a tariff shield. This shield included a discount on gas, electricity and fuel prices. Furthermore, in France, profit margins of non-financial companies remained relatively high compared to pre-pandemic times (Plane, Vermersch, 2022). At the same time, the change in aggregate profit margins was uneven, due to the support received by companies for the negative effects of the COVID-19 pandemic in the second half of 2020 and the first half of 2021. The increase in profit margins in non-financial companies in France was also due to support to pay energy bills and a reduction in the corporate contribution to value added (Bénassy-Quéré, 2023).

5. Conclusions

The study aimed to test the hypothesis of the occurrence of elevated profit margins in the mining and extraction industry in an environment of elevated CPI inflation rates, i.e. the occurrence of the so-called 'Greed inflation' phenomenon. The analysis showed that the countries that were characterised by a higher share of companies with inflated gross profit margins in 2015-2020 and in 2021-2022 were France, Sweden and Italy. The study did not reveal the prevalence of the phenomenon of overstated margins in the outlier category in the 2021 and 2022 periods analysed. Further analysis focused on a deeper investigation of the distribution of margins. The Kruskal-Wallis test was used, which indicated the existence of differences between the study sets, based on the median value of the margins. France and Italy showed significant differences between the distribution of margins in the period 2015-2020 and the distribution in 2021 and 2022. No significant differences were observed for the other countries.

There was a clear increase in margins for France and Italy in the 2021 and 2022 periods analysed, with the largest rise in France, where the median gross profit margin increased from 3.5 per cent in 2015-2020 to 7.3 and 6.3 per cent in 2021-2022 respectively.

In conclusion, the study suggests that the occurrence of increased gross profit margins is a phenomenon limited to selected countries, rather than generally observable in the global market. These findings can be valuable for understanding economic trends in specific regions and help to isolate countries where companies are experiencing higher margins compared to others. Our research provides fundamental information that can provide a starting point for decision-makers involved in the extractive sector at both EU and individual EU member state level. The extractive industry is regarded as one of the pillars of the European Union's development and of vital importance to the EU economy (Galaś et al., 2021; Yousefian et al., 2023). In addition, policy makers are concerned about energy and material independence, especially in metals.

Like any scientific article, this paper is not without research limitations. The literature review and research achieved the objective of the article - the analysis of the hypothesis of the occurrence of elevated profit margin values in the mining and extraction industry in a 'Greed inflation' environment. A significant limitation was the limited access to complete data. In addition, the analysis included countries that differ in terms of the availability of raw material deposits and also have varying levels of socio-economic development. As soon as more data becomes available, it would be worth expanding the area of analysis. This would significantly deepen the knowledge of the extractive sector in the European Union. In addition, the environmental factor, including the ecological footprint, is also worth considering in future studies. In view of the European Union's policy to move towards climate neutrality and sustainability, companies are increasingly emphasising environmental aspects in their strategies.

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IDENTIFICATION OF KEY ASPECTS OF BUILDING THE IMAGE OF THE TRICITY AGGLOMERATION BASED ON THE PLATFORM USERS' ENTRIES X

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Purpose: The purpose of the presented research is an attempt to identify words that could be used by local governments to build the image of the Tricity Agglomeration, as well as the cities of Gdańsk, Gdynia and Sopot themselves.

Design/methodology/approach: The study used nearly 650 000 posts by users of Platform X, made in the full calendar year of 2022, which contained references to the Tricity Agglomeration, Gdańsk, Gdynia and Sopot in their content. Statistical methods, Big Data, Text Mining, Bag of Words and Words Cloud were used in the analysis.

Findings: The study identified the most recognizable and important places, attractions, people, events, organizations and emotions for Internet users. Elements specific only to specific cities were identified, as well as those common to pairs of cities and the entire agglomeration. The survey also identified the most intractable, because they affect the largest number of people, problems of individual cities and agglomerations.

Social implications: The results of the presented research could be used by local governments to build the image of individual cities and the entire Tricity Agglomeration. Similar surveys could also be conducted for other cities. The knowledge gained in this way could contribute to a more complete evaluation of the authorities' efforts to date in building the image of cities.

Originality/value: The presented article is a voice in the discussion on the use of Big Data methods to support management processes and decision-making. It indicates that through the use of data analysis it is possible to obtain a lot of information that can be successfully used to build marketing strategies and create the image of cities. Successful efforts in this regard are of great value to local communities.

Keywords: image, Tricity Agglomeration, Gdańsk, Gdynia, Sopot, social platform X, big data, text mining.

Category of the paper: Research paper.

1. Introduction

The posts of users of social networks such as X (Twitter) are a valuable source of information that is successfully used by many audiences around the world. The attractiveness of this information channel is due to its simplicity of use and the formulation of short and concise messages. It has a wide reach and allows direct interaction. User posts are a valuable source of information that can be used, for example, by businesses or local governments. They are a source of information about the preferences and needs of respondents. They are also a source that allows to create an image, including the image of a place. The purpose of the presented research is an attempt to identify words that could be used by local governments to build the image of the Tricity Agglomeration (Trójmiasto), as well as the cities of Gdańsk, Gdynia and Sopot themselves.

2. Image of the place – a review of the literature

The modern development of cities often leads, on the one hand, to mutual resemblance between centers, and, on the other hand, to growing rivalry between them. A positive image can contribute to numerous benefits, such as increased recognition and interest in the place, and not only by tourists, but also, for example, by potential investors. It also helps to build the trust of residents in the city authorities. Local authorities therefore consciously work to build their position and competitive advantage. This advantage is built on the basis of two groups of resources. The first group is tangible resources, and the second group is intangible resources. The second group can include the image of the place. It is not something permanent, it often changes as the views and experiences of residents or tourists change.

According to the Dictionary of Foreign Words, the term image is derived from the German word *Visierung* and means likeness, portrait, depiction (Kubisa-Ślipko, 2006). The late 1950s and early 1960s saw an increase in scholarly interest in the concept of the image of a place. In 1956 and 1958, work on this issue was conducted by K.E. Boulding and P. Martineau, among others (Boulding, 1956). At that time, the researchers suggested that human behavior may be more influenced by images than by unbiased, real information about an object, phenomenon or environment. In the following years, interest in this subject did not diminish. In 1971, J.D. Hunt published a 414-page paper entitled *Image - a Factor in Tourism*. A period also began in which published works took on an interdisciplinary character. For this reason, different definitions of the concept can be found in the literature. In the 1970s, the concept of image was combined with a set of different types of features, which were not only the sum of these features in the imagination of the place, but also a set of interconnections and interactions between them (Oxenfeldt, 1974). The image of a place was formed in the human mind, regardless of whether

the person had previous contact with that place or not (Tuan, 1975). Thus, he was an idea of knowledge, superstition, prejudice, excitement, or emotion that an individual might have about the place (Lawson, Baud-Bovy, 1977). J.D. Fridgen in 1987 draws attention to the aspect of mental reflection of a place (Fridgen, 1987), J. Embacher and F. Buttle on the attribution of ideas or concepts to a place without necessarily having knowledge of that place (Embacher, Buttle, 1989), and G.R. Dowling writes that an image is „a set of meanings by which an object is known and by which people describe, remember and refer to it” (Dowling, 1986). In the 1990s, these definitions were supplemented by the notion of a mental construction that is prepared by potential viewers, who select a number of images from the set of impressions available to them (Fakeye, Crompton, 1991). One of the more popular definitions of the term image was presented in 1993 by P. Kotler, writing that the image of a place is the sum of beliefs, ideas and impressions that people relate to a place (Kotler, 1993). Thus, to sum up, we can say that the image of a place consists of knowledge, images, experiences and perceptions of that place, but also prejudices and a whole range of positive and negative emotions. The image is the sum of one's own experiences and knowledge, as well as the result of various messages, communications that an individual has to deal with. It has an individual, personal character, which can differ significantly from one individual to another.

Scientific works on place image attempt to distinguish different types of image factors. One proposal is to divide it into a cognitive factor of image and an affective factor of image (Lynch, 1960). The cognitive, or cognitive factor, refers to an individual's knowledge, facts or opinions about a place. The affective, or emotional, factor is subjective and often abstract. It reflects an individual's feelings, such as liking a place. It can also be irrational, as it is based, for example, on prejudices or fears (Burgess, 1978). Simplifying, we can say that the cognitive factor is the broad offer of a place, and the affective factor is the characteristics of that place. Therefore, between the cognitive factor and the affective factor, it is necessary to study the ongoing, changing relationship. In 1993, W. Gartner distinguished three groups of factors affecting the image of a place. In addition to the cognitive and affective factor, he proposed a conative, or behavioral, factor. This factor reflects an individual's willingness to take certain actions related to a place (Gartner, 1993). E. Glinska, M. Florek and M. Kowalewska in 2009 proposed a fourth evaluative factor, reflecting how a place is evaluated (Glinska et al., 2009). S. Baloglu and K.W. McCleary distinguished two other groups of factors that influence the image of a place. The first factor is one that describes the individual characteristics of individuals. These include the socio-demographic characteristics of individuals, such as age, gender, education, material status, and psychological characteristics, such as personality or professed values. The second factor is external, reflecting the individual's experience with a place, as well as the sources of information about the place from which the individual gains knowledge (Baloglu, McCleary, 1999). M.S. Roth and J.B. Romeo, meanwhile, adopted four dimensions of place image. The first dimension - modernity - describes a place through the use of state-of-the-art knowledge and technology. The second dimension - diversity - presents a wide, rich and attractive offer of the place. The third dimension is prestige, that is, good

reputation, high status and exclusivity. The last dimension is quality, which shows professionalism, responsibility, sustainability and efficiency (Roth, Romeo, 1992).

3. Place image and social media

Countries, regions, cities or, for example, the Tricity Agglomeration, in order to develop dynamically, should introduce and improve the marketing strategies used. The key to gaining an advantage for a place in the market is the ability to develop, implement and execute such a strategy. One of the key elements of a marketing strategy is building and creating a place's image. The development of the Internet and modern technology has contributed to the development of social media and a virtual community that uses a „keyboard” to regularly communicate with each other (Mehrabian, Ferris, 1967). Social media provides an opportunity for users to communicate, build relationships and interact with each other. 59.3% of online users aged 16-64 say they use the Internet primarily to search for information (age: 16-24 - 61.1%; age: 25-34 - 56.5%; age: 35-44 - 57.4%; age: 45-54 - 60.9% and age: 55-64 - 65.3%). 55.4% of respondents stay in touch with friends and family, and 51.2% follow news and events (Digital 2023...). Information posted on social networks such as, for example, Facebook, YouTube, Whatsapp, Instagram, Wechat, TikTok, FB Messenger and X (Twitter) have become particularly useful in the process of communication between web users (Digital 2022...). Recent surveys also indicate that entities (including businesses) most often choose sites such as: Facebook, Instagram, Whatsapp, YouTube, LinkedIn, X (Twitter), Telegram, FB Messenger, Skype and TikTok (Digital 2023...).

On the one hand, social media has facilitated the use of various types of marketing strategies, and on the other hand it has made it more difficult, as it has become a place of often uncontrolled emotions. Marketing strategies relating to the territory can be directed at four areas, i.e. the image of the place, the attractions of the place, its infrastructure and the people who inhabit the place. Image is understood as the overall image of a place, which includes an emotional dimension. The image, due to its emotional coloring, can be classified into positive, neutral or negative image. A positive image is associated with a set of positive associations, perceptions and opinions. It is an intangible resource, without physical form, but which allows a place to build a competitive advantage. It is also difficult to value, such as a place's reputation. A negative image is expressed in unfavorable opinions and perceptions about a place. It can hinder or impede the development of a place. A neutral image is expressed by typical, undistinguished opinions and perceptions. As a result, it can cause a place not to be quickly associated and distinguished by decision-makers. An attraction is something of particular interest, something that provides pleasure and enjoyment to the user. The word comes from the French language, *attraction*, and means, among other things, attraction. An attraction can also be something beautiful. It also allows us to get away from our

daily responsibilities and provides relaxation. It also enjoys the special interest of others. An attraction can be a lure, temptation, magnet, sensation or surprise of a place. This category can include, for example, festivals, concerts, matches, fairs, sports competitions, parks, tourist and natural attractions or, for example, the best pizzeria in Gdańsk¹. Infrastructure consists of public and private physical improvements that contribute to the attractiveness of a place. They testify to the economic potential of the place. It enables social (sports halls, auditoriums), economic and informational integration. Infrastructure also creates conditions for all acts of movement resulting from human action, i.e. spatial interaction. These include, for example, the flow of goods and information, the way to work, young people going to college, attending conferences and even the flow of knowledge. These are often very expensive investments that have been built over many years, with their own history. People, that is, specific individuals or groups of people who are identified with a place. They contribute to the fact that a place gets a human dimension. They can be as much a magnet as the attractions of a place.

4. Research methodology

For research purposes, 641 829 messages were downloaded via API X (Twitter) that contained at least one of the words in their content: Gdańsk, gdańsk, Gdansk, gdansk, Danzig, danzig, Sopot, sopot, Zopot, Gdynia, gdynia, Trójmiasto, Trojmiasto, 3City, 3city, Aglomeracja Trójmiejska (Tricity Agglomeration), Aglomeracja Trojmiejska, aglomeracja trójmiejska, aglomeracja trojmiejska, Dreistadt. The data covered one calendar year from 01.01.2022 to 31.12.2022. The messages included entries in multiple languages. Among the 10 most frequent languages, identified automatically by X (Twitter), were (Tab. 1):

Table 1.

The most commonly identified messaging languages

No.	Language	Number of messages
1	Polish	362 880
2	English	181 515
3	German	19 010
4	Spanish	16 762
5	Japanese	7 439
6	Romanian	4 842
7	French	4 534
8	Portuguese	3 629
9	other (unidentified)	2 423
10	Turkish	2 301

Source: own elaboration.

¹ "50 Top Pizza" - the best restaurants serving pizza in Europe. In the list (as of May 6, 2023), a pizzeria from Gdańsk, Pizzeria Ostro, was ranked 34th.

Since the analysis will be looking for words that can be used to build various marketing strategies, it was necessary to tokenize the texts, that is, to change the form of the data, from a message to a string of single phrases delimited by the „space” sign. Entries posted by users of social platform X (Twitter) are in a very informal form. Their authors use only selected rules of grammar, spelling and punctuation. Emojis, links to websites and hashtags also appear in the posts (Figure 1). In order to analyze only the words that carry the desired content, it is necessary to transform the messages into a set of standardized words.

@MiloszRom @FilipJedlinski Wylotówka na Trójmiasto
@Jong_hoho XDSDSDSSDD we love gdansk
the second im back on twitter Sebastian Danzig Fever Dream decides to tease the album AGAIN???
Live in Gdansk gave me goosebumps all those years ago. No one can say @davidgilmour and @PinkFloydTMR don't fight the good fight https://t.co/6W7hvmhxQP
Sopot i ogólnie Trójmiasto fajne miejsce do życia.
Danzig - Trouble
@Q_Jot Ja o 16:44 dokonałem zakupu 4 karnetów na Gdańsk także ten ☐
Gdynia: Przy brzegu przewrócił się jacht. Trwa akcja ratownicza https://t.co/NROF1LKfUi https://t.co/D4N7sL00PK
@gibon102 Ależ ten Gdańsk Pana w cynizm i pesymizm wpędził.
@SebastianDanzig SEBASTIAN DANZIG FEVER DREAM STOP IT

Figure 1. Example of the analyzed data.

Source: own elaboration.

First, messages written in Polish, of which there are 362 880 in the studied set, were filtered out, followed by tokenization of all messages. The tokenized dataset has 7 273 094 words². Subsequently, all letters were converted to lower case, all punctuation marks, numbers, emoji, web addresses, links to other entries and web addresses were removed.

In the next stage of data transformation, all words that do not carry the content sought in the study were removed from the set of words. These are the so-called stopwords. Since there is no standard library of such words for the Polish language, the elimination was carried out manually³, removing one-letter words such as: *i, z, o, w*, two-letter words: *from, to, for, to, on, because, that, we, him, me, tu, these, ...* In total, 560 different words were removed.

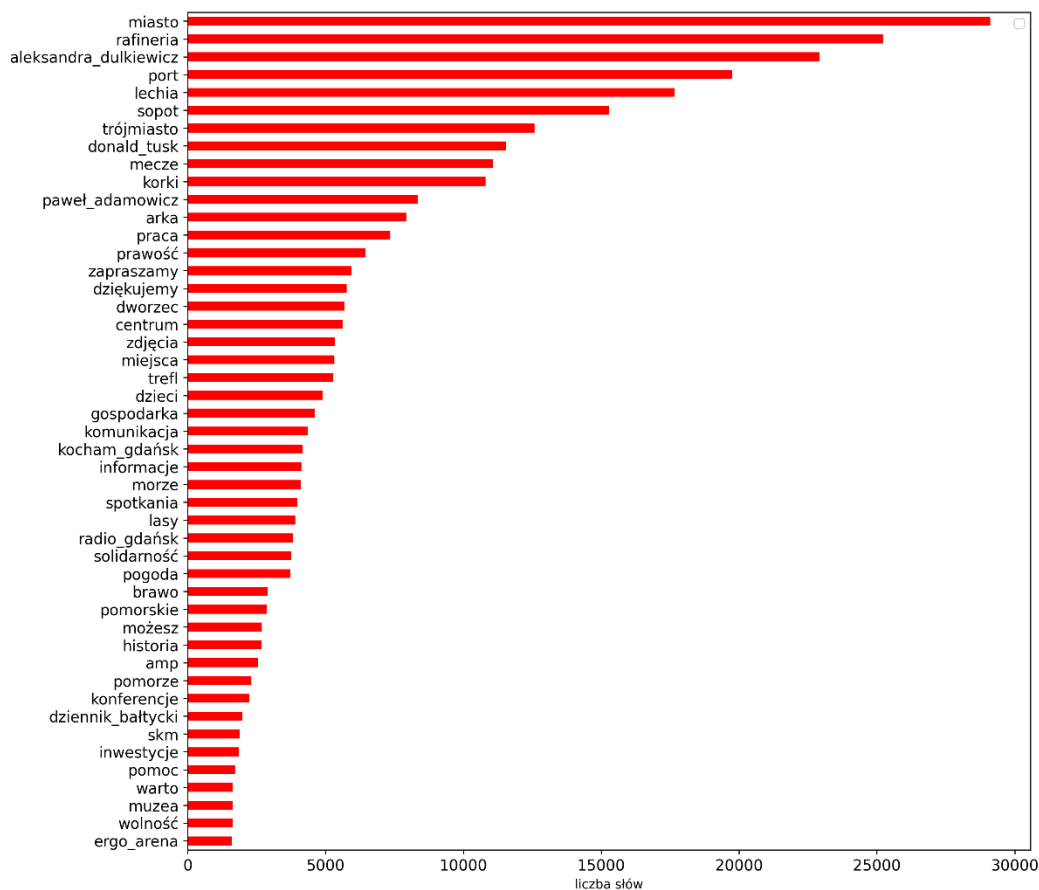
In the dataset prepared in this way, containing the cleaned entries, the notations of individual words were standardized. For example, the word "Gdańsk" was written by Internet users in a number of different ways (after converting the letters to lowercase): *gdansk, gdańsku, gdanska, gdańska, gdanskiej, gdańskw, gdańskich, gdański, miastogdańsk*. Similarly, references to specific people: *tusk, tuska, donaldtusk, donaldt, donald_tusk, donald_tuska*. All words were reduced to their basic forms and their notation was standardized. After all these transformations, 4 503 575 words remained in the dataset, which became the basis for further analysis.

² This is not the number of different words, but the number of consecutive words that appeared in the messages.

³ Since it is impossible to manually analyze 7000000 words, the 250 most frequent words were observed. After removing some of the words, the 250 most frequent words were determined again, until 250 words remained on the list, which were considered to be content carriers. This may mean that there were a number of words outside the analysis that were content carriers, but their number is a very small fraction of the total number of words.

5. Tricity agglomeration through the eyes of users of social network X – results of the research

The analysis of the words in the analyzed set made it possible to distinguish the most frequent words. 47 of them are shown in Figure 2. The words gdańsk, gdynia and polska (Poland), which appear much more frequently than the others, were initially removed from the list, which would reduce the readability of the figure. The frequencies are as follows: gdańsk – 237 980, gdynia 52 928, polska 43 022.



Legend: miasto – city, rafineria – refinery, port – seaport, trójmiasto – Tricity, mecze – matches, korki – traffic jams, praca – work, prawość – righteousness, zapraszamy – welcome, dziękujemy – thank you, dworzec – train station, centrum – center, zdjęcia – photos, miejsca – places, dzieci – kids, gospodarka – economy, komunikacja – public transport, kocham_gdańsk – I love Gdańsk, informacje – information, morze – sea, spotkania – meetings, lasy – forests, solidarność – solidarity, pogoda – weather, brawo – bravo, możesz – you can, historia – history, amp - Polish Academic Championships, pomorze – pomerania, konferencje – conferences, dziennik_baltycki - Baltic daily, skm - Rapid Urban Railway, inwestycje – investments, pomoc – help, warto – it's worth it, muzea – museums, wolność – freedom.

Figure 2. Structure of typical words associated with the Tricity Agglomeration.

Source: own elaboration.

To summarize the frequency of occurrence of the studied words, a so-called word cloud was constructed. In Figure 3, the word that occurs more often is written in a larger font and a more intense color. This makes it easier to focus on the most important words when analyzing the figure. It is also easier to interpret the content behind these words. It is easy to see, keywords

(Twitter) portal also wrote frequently about well-known people in the Tricity. Most often about Aleksandra Dulciewicz, Donald Tusk, Paweł Adamowicz, Kacper Płażyński, Krzysztof Skiba and Jacek Karnowski. A group that was very often associated with the Tricity Agglomeration were children. The Tricity Agglomeration is a participant in a competitive market game. This means that local governments should strive to use various media, including social networks, to monitor and analyze the insights of Internet users (Tab. 2).

The central part of the Tricity Agglomeration consists of three cities: Gdańsk, Gdynia and Sopot. Cities that lie next to each other so close that it is often difficult to see the internal boundaries between them. But they are three different cities, with different histories, their own pace of development and life, their own successes and failures. If so, can you see the image differences of these cities in text messages? What words do Internet users associate with a particular city? Which concepts that build the image of a place are common to the three cities? In Table 3, the main diagonal shows words that are specific to a city, e.g. Gdańsk is associated with righteousness, Westerplatte, equality or culture. Sopot is primarily Trefl Sopot, beach, Sopot molo, sunrises and sunsets. In text messages dedicated to Gdynia, you will find such words as Arka Gdynia, Navy, Gdynia Orłowo, Swedes or PKP (Polish National Railways).

Table 2.

Breakdown of typical words into four types of marketing strategies for the Tricity Agglomeration

IMAGE OF THE PLACE	ATTRACTIONS
Gdańsk, Gdynia, Sopot, Tricity, Poland, traffic jams, work, righteousness, welcome, thank you, economy, public transport, love Gdańsk, information, solidarity, weather, bravo, pomorskie, you can, history, Pomerania, investments, help, it's worth it, freedom, weekend, safety, summer, love, interesting, self-government, super, administration, see you, world, ecology, Europe, culture	Gdańsk, Gdynia, Sopot, Lechia, match, Arka, center, photos, places, Trefl, sea, meetings, Tri-City Landscape Park, Radio Gdańsk, Academic Championships of Poland, conferences, Baltic Daily, museums, Ergo Arena, Baltic Arena, gdańsk.pl, Westerplatte, parks, flowers, culture
INFRASTRUCTURE	PEOPLE
Refinery, seaport, train station, Rapid Urban Railway, Radio Gdansk, Baltic Daily, Ergo Arena, Baltic Arena, gdańsk.pl, Pomeranian Voivodship Office, shipyard, Gdansk Road and Greenery Management, culture	Aleksandra Dulciewicz, Donald Tusk, Paweł Adamowicz, Kacper Płażyński, Krzysztof Skiba, Jacek Karnowski, children

Source: own elaboration.

Words common to the city pairs were placed in Table 3 off the main diagonal. Common words appearing in text messages about Gdańsk and Sopot are, e.g: Tricity Landscape Park, history, sea, Ergo Arena, self-government. The similarity of Gdańsk and Gdynia is expressed by the words, e.g.: seaport, traffic jams, matches, work, shipyard, public transport, summer. Gdynia and Sopot are linked by words such as welcome, thank you, festival or you can. In Table 3 you can also see an interesting breakdown of text messages containing words: Germans, Swedes, Scandinavians and refugees. From the context of the content of these messages, it is all about Ukrainians. It is clear that in the messages about Gdańsk, Germans are

mentioned. In news concerning Gdynia about Scandinavians, including Swedes and concerning Sopot about refugees.

Table 3.

Individuality and similarities of the cities of the Tricity Agglomeration

	Gdańsk	Gdynia	Sopot
Gdańsk	Aleksandra Dulkiewicz, refinery, Lechia Gdansk, Donald Tusk, Paweł Adamowicz, weather, righteousness , I love Gdańsk , Radio Gdańsk, children, Baltic Daily, Krzysztof Skiba, SKM - Rapid Urban Railway, investments, Pomeranian Voivodship Office, Westerplatte, conferences, museums, Baltic Arena, freedom , help , Kacper Płażyński, it's worth it , equality , Gdańsk Oliwa, see you , super , <i>Germany</i> , we're waiting , culture , Lech Wałęsa, airport, Academic Championships of Poland, flowers, Gdańsk Roads and Greenery Management, gdańsk.pl, safety , heartily	Poland , seaport, traffic jams, matches, welcome , work, train station, <i>bravo</i> , thank you , sea , economy, center, solidarity , public transport, meetings , history , shipyard, <i>cooperation</i> , summer, weekend, transport, Ukrainians	Poland , Tricity Landscape Park, welcome , thank you , sea , solidarity , meetings , history , Ergo Arena, <i>self-government</i> , Ukrainians
Gdynia		Arka Gdynia, PKP - Polish National Railways, Pendolino, Navy, Gdynia Orlowo, madness , <u>Swedes</u> , <u>Scandinavians</u> , Wojciech Szczurek, opportunities , Gdynia Chylonia	Poland , welcome , thank you , sea , solidarity , meetings , history , festival, <u>you can</u> , Ukrainians
Sopot			Jacek Karnowski, Trefl Sopot, Sopot Kamienny Potok, beach, Sopot molo, sunny , menu, tastings, sunrise , sunset , briskly, accommodation, concert, <u>refugees</u> , righteousness , pubs, recommend , friends , welcome , Europe , Grunwaldzka Street

Source: own elaboration.

In the text messages analyzed, words were identified that are common to the three cities, and thus can be a **starting point when building the image of the Tricity Agglomeration**. Let's call these words „common”. They are: **sea**, **meetings**, **welcome**, **thank you**, **history**, **Poland**, **solidarity** and **Ukraine** (Figure 7). In addition to the „common” words, Figure 7 shows the words connecting the text messages for the 3 pairs of cities analyzed, i.e. Gdańsk and Gdynia, Gdańsk and Sopot, and Gdynia and Sopot. Let's call these words „partially common”. They are:

1. Gdańsk - Gdynia: **bravo, economy, cooperation, weekend, public transport, center, seaport, train station, work, transport, shipyard, matches and summer.**
2. Gdańsk-Sopot: **Tricity Landscape Park, self-governance and Ergo Arena.**
3. Gdynia - Sopot: **festival and you can.**

Figure 4 shows a word cloud associated with the city of Gdańsk, Figure 5 with the city of Gdynia and Figure 6 with the city of Sopot. The words shown are written in Polish. In Table 3 in Legend, the same words are translated.

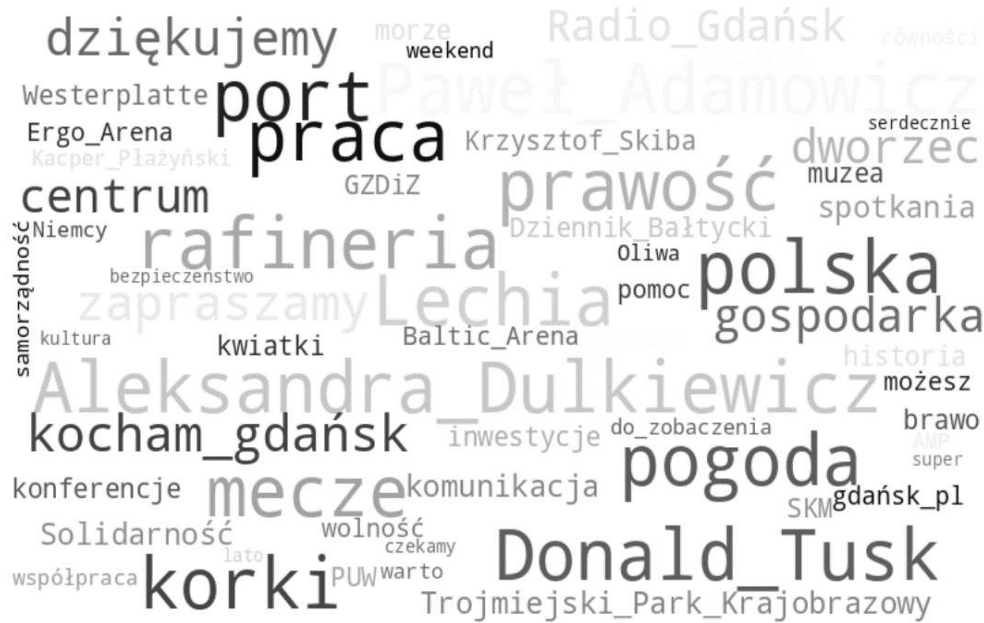


Figure 4. Word cloud associated with the city of Gdańsk.

Source: own elaboration.



Figure 5. Word cloud associated with the city of Gdynia.

Source: own elaboration.

"Gdynia for children", "Poland's Riviera" or "Discover Sopot with us". Gdańsk attempts to promote itself in many places around the world. It uses such slogans (words) as: "Gdańsk is alive here!", "Gdańsk releases energy", "Let's get to know each other in Gdańsk", "Welcome to Gdansk", „It's nice to have you in Gdańsk” as well as "Time together in Gdansk, Sopot and Gdynia". One of the most recent advertising spots of the city of Gdansk contains two words that were included in the list of words supporting the process of building the image of cities and the Tricity Agglomeration (see Table 3). These words are: freedom and sea. The content of the presented spot about Gdansk is:

*People say that this is where it all began, that there is always a smell of freedom, the sea and something else that is hard to name in the air. To smell it, you have to be here. People say it's the smell of the north, the sea and mystery. How to tell the story of this city? How to describe the smell of mystery? Maybe like this: This magical city has guarded its secret for a thousand years. People say that despite this, it generously bestows gifts on those who have the courage to reach for it. All you have to do is extend your hand. **Gdańsk can be yours. For a while, or forever.** How to tell the story of this city? How to describe the smell of mystery? How to describe the smell of the north? People say that this is where it all began, that there is a smell of freedom, the sea and something else in the air. What is hard to name.*

An image analysis of the spot ([https://visitgdansk.com/...](https://visitgdansk.com/)) made it possible to highlight even more words. These are: beach, shipyard, port, center, Tricity Landscape Park, Gdańsk Oliva, museum, flowers, festival, solidarity and weekend. If we add the words freedom and sea to the set of these words, we get 13 words, which the authors also identified and presented in Table 3. However, there are many more words that could be used in future promotional strategies of the studied region, as indicated above.

6. Conclusion

The analysis indicates that careful observation of social media can assist local governments in building city marketing strategies. The study identified the most recognizable and most important places, attractions, people, events, organizations and emotions for Internet users, which could be used by local governments to build the image of individual cities and the entire Tricity Agglomeration. This knowledge can contribute to a more complete evaluation of the city government's promotional activities to date. The survey also indicated the most onerous, because they affect the largest number of people, problems of cities and agglomerations. Traffic jams turned out to be the dominant problem. They appear in the analysis at the 10th place of the most frequent words. It should also be remembered that the image of a place is dynamic. The opinion of the place may change with social media users, along with the acquired knowledge and experience of these people. It can also change as a result of a well

and consistently prepared marketing strategy, which, based on the information obtained from the users themselves, will provide the desired image of the area. Such observations should be carried out systematically in order to react quickly and make adjustments in the construction of the perception of a place, if necessary. It will be good practice to combine various types of research techniques to deepen the knowledge of the studied place. Therefore, it seems reasonable that today's local governments should use the results of research conducted in the area of social media with greater intensity.

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EDUCATIONAL AND DIDACTIC TOOLS DEVELOPMENT – MODERN CONSTRUCTION MANAGEMENT PROJECTS

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Purpose: This paper aims to explore the dynamic evolution of the European construction industry in recent years, focusing on diverse domains such as environmental protection, occupational safety and health (OSH), data protection, HR, career development, waste management, urban mining, infrastructure maintenance, and modern information technologies. It emphasizes the evolving role of the project manager in construction, who now integrates knowledge with IT and management skills, and the necessity for contemporary managerial education to prepare construction staff comprehensively in these areas.

Design/Methodology/Approach: The research employs a multi-faceted approach, analyzing the latest educational materials developed under the Erasmus+ CLOEMC VI, 3Msite and the ID4Ex projects. It examines educational strategies, including the creation and implementation of new teaching methods, and evaluates the qualifications and educational pathways of construction managers in 14 countries. The study also considers the impact of language skills and worker mobility across the EU.

Findings: The study reveals the critical need for multidisciplinary collaboration in the construction industry, especially in the renovation of historic buildings. It underscores the importance of involving diverse professionals such as archaeologists, surveyors, engineers, and architects. The research identifies the increasing relevance of ecological, sociological, technological, and health considerations in managing modern, multi-ethnic, and multi-cultural construction sites.

Research Limitations/Implications: Future research should expand on the interdisciplinary collaboration models and explore the long-term impacts of these educational approaches on construction project success. The study's scope is limited to Europe and might not fully represent global construction industry trends.

Practical Implications: The findings suggest modifications in construction management practices, emphasizing the need for updated educational programs and methodologies. These changes are expected to enhance project efficiency, safety, and sustainability.

Social Implications: The research highlights the significant social impact of incorporating comprehensive training in the construction industry, which can lead to improved public safety, better quality of life, and enhanced environmental stewardship.

Originality/Value: This paper offers a novel insight into the intersection of construction management, education, and technology in the European context. It provides valuable guidelines for educators, policymakers, and construction industry professionals, addressing the urgent need for a holistic approach in construction management education.

Keywords: project and construction management, modern education of managers, pedagogical and didactic tools, fuzzy logic, EU projects.

Category of the paper: viewpoint, research paper.

1. Introduction

The European construction industry has been developing exceptionally intensively in recent years. These changes are observed in various areas, such as: environmental protection, raising employee awareness of safety and health issues on construction sites (OSH), data protection, human resources management and the career path of particularly talented personnel, waste management, mining urban, infrastructure maintenance management and the use of modern information technologies. In order to properly prepare construction staff in these fields, an appropriate approach to education and teaching methods should be implemented. The authors decided to present to interested parties Erasmus+ projects related to education of construction managers development:

- a set of seven latest manuals that will be prepared during the implementation of the sixth stage of the Erasmus+ CLOEMC project (VI),
- assumptions of the use of Immersive Design in the education of specialists in the renovation of historic buildings (ID4EX),
- the most important aspects relating to the management of modern, multi-ethnic, and multi-cultural construction with aspects of ecology, sociology, technology, and health on the construction site, as part of the Erasmus+ 3Msite project methodology.

2. Erasmus+ CLOEMC VI Project

2.1. Project's objectives

The project discussed in this article is based on the results of Erasmus+ CLOEMC VI, titled: "COMMON LEARNING OUTCOMES FOR EUROPEAN MANAGERS IN CONSTRUCTION, PART VI" - number 2022-1-PL01-KA220-HED-000087357, is implemented from December 1, 2022, up to May 31, 2025. The project's logo and QR code are shown in Fig. 1. The Phase V CLOEMC project (realized in years 2019-2022) closely

related to the issue of continuous improvement and unification of the system of education, certification, assessment, and comparison of managerial qualifications of employees related to the construction industry in the European Community countries, in accordance with the assumptions of the EU Directive 89/48/EEC on regulated professions. It also contributed to increasing mobility on the European labor market and effective exchange of knowledge and experience between experts from different countries. Thanks to the CLOEMC V project, the collection of the Construction Manager's Library was expanded by seven textbooks namely: M26: Mentoring and coaching in construction, M27: Archaeological and heritage protection aspects in construction, M28: Breakthrough innovations in construction management, M29: Modern circular economy in construction, M30: Affordable housing, M31: Social sustainability in construction, M32: Crisis management of the COVID-19 epidemic in the construction industry.



Figure 1. Logo and QR of the CLOEMC VI project.

Source: Own source.

The CLOEMC VI project - in response to the needs of the modern world - will support the development of high-quality vocational education and training with an emphasis on work-based learning, providing the best approach to education and learning, combined with the needs of people working in the European labor market in the construction sector. It will also contribute to increasing the innovative managerial competences of engineers, construction managers and government officials, enabling multicultural exchange of knowledge and best practices between EU countries. Moreover, it will ensure the implementation of modern and unified mechanisms for the recognition, assessment, certification, and compensation of qualifications of all employees employed in the construction industry. The project will also enable the improvement of language skills, as the planned textbooks will be prepared in Polish, English, Turkish, Italian and German versions (with an extended summary in Icelandic). However, the international Partnership will not only strengthen cooperation between the industry and the educational sector but will also consolidate the mobility of construction staff in the global and multicultural environment of construction companies throughout the EU.

2.2. Project questionnaire and beneficiaries' opinions

Project team decided to check how the suggested conspectuses of the manuals fulfill the needs of the managers from construction industry. Conspectuses could be found here: <https://www.cloemcvi.il.pw.edu.pl/wp-content/uploads/2023/08/WP3-conspectuses-final-draft-29082023.pdf>.

Conspectuses were tested in the series of multiplier events and during other dissemination actions. Questionnaire 1 is available at:

https://www.cloemcvi.il.pw.edu.pl/?page_id=1018&lang=en;

and was distributed in paper version as well. Please feel free to answer the questions. Testing of target groups in country of venue for better engagement of stakeholders and target groups and share know how in the subjects foreseen for the manuals. Results of the survey were the base for establishing detailed content related contents of 7 manuals. Results (average scores) from nearly 200 responses from Poland, Italy, Turkey, Ireland, and Germany are presented in table 1.

Table 1.

Assessment of manuals according to the questionnaire no 1 (grades from 1 to 5)

Manual title	Final grade (avg. score)
M33: DESIGN AND EXECUTION OF FACADES FOR CONSTRUCTION MANAGERS	4,39
M34: DIGITAL TWIN IN CONSTRUCTION	4,49
M35: URBAN MINING IN CONSTRUCTION	4,32
M36: ENVIRONMENTAL IMPACTS OF EARTHQUAKES AND MINING FOR CONSTRUCTIONS MANAGERS	4,40
M37: LOGISTICS IN CONSTRUCTION	4,61
M38: GREEN TECHNOLOGY FOR CONSTRUCTION MANAGERS	4,47
M39: TALENT MANAGEMENT AND FUTURE COMPETENCES OF CONSTRUCTION MANAGERS	4,29
Is the presented scope of knowledge important for Building Managers for qualifications recognition?	4,40
Are the manuals properly responding to the industry needs in respect of the managerial knowledge?	4,37
Will you participate (or delegate the personnel) in the Postgraduate Studies based on the created manuals?	4,28

Source: CLOEMC VI project working materials, 2023.

2.3. Project results

As part of the CLOEMC VI project, seven more manuals (M) for the Construction Manager's Library (CML) will be created, namely:

- M33: Design and construction of facades in construction - this manual focuses on issues related to the design, implementation of innovative solutions and coordination of efficient and safe (Fig. 2) execution of sustainable and environmentally responsive building facades on the EU market, in particular in urban space. The Manual will also enable interested parties to understand and recognize the most important legal regulations related to the construction of facades in the European Community countries.

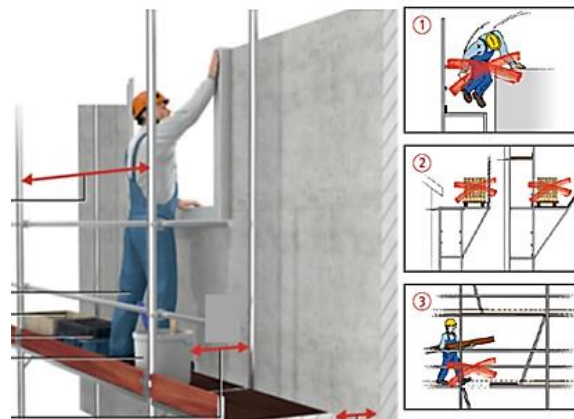


Figure 2. Efficient and safe construction of building facades on the EU construction market.

Source: BG BAU.

- M34: Digital twins in construction - the textbook covers the aspect of optimizing and modernizing the everyday work of construction managers by using available modern and innovative digital tools, including: such as: scanning, use of drones, GIS, BIM, IoT, Augmented and Mix Reality (augmented and mixed reality - Fig. 3).

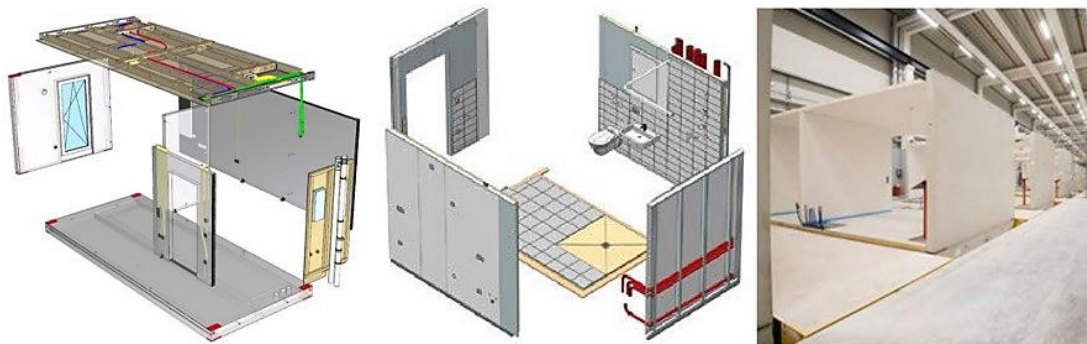


Figure 3. Individual modules of the facility in a digital version.

Source: BG BAU.

- M35: Urban mining in construction - the manual presents in detail modern methods of recycling and management of construction and demolition waste in construction (Fig. 4).



Figure 4. Recycling in construction.

Source: Own source.

- M36: Environmental effects of earthquakes in construction - the textbook presents contemporary methods of everyday use of the latest, innovative tools that enable minimizing the impact of earthquakes on the construction investment process, starting from the design of the facility in specific areas prone to earthquakes (Fig. 5), including those related to mining, to safe operation and maintenance.



Figure 5. Soil, foundations and safety of facilities in construction.

Source: Own source.

- M37: Logistics in construction - is a modern textbook combining the issues of optimized and safe implementation of construction processes, combined with efficient logistics of deliveries to the construction site, which is currently one of the important success factors in the implementation of investment projects. In addition, it also contains the most important guidelines and recommendations relating to sustainable investment financing, green construction, supply chains, proper flow of information between all participants of the construction process, starting from the planning phase (Fig. 6) and modeling of construction processes, through the stage of facility implementation, until the operation of the building.



Figure 6. Safely designed construction site and logistics in construction.

Source: Own source.

- M38: Green technology in construction - is an innovative textbook reflecting the latest global trends relating to ecological construction, in accordance with the assumptions of the European Green Deal policy, in the area of ecological and environmentally sustainable construction (Fig. 7) and green industry.



Figure 7. Environmentally sustainable and state-of-the-art ecological construction.

Source: Own source.

- M39: Talent management and future competences of construction managers. Obtaining and maintaining a competitive advantage currently requires companies to be highly flexible in their operations, react quickly and adapt to changes. However, if employees have outdated knowledge and do not have access to important information, it often turns out that it is simply impossible for the company to compete on the market. Therefore, constant updating of knowledge, further training of staff, and development of employee competences are necessary for the proper functioning of a given organization on the construction market. It is also necessary to develop solutions and take actions that will enable companies to attract and retain the best, most talented and most valuable employees (Fig. 8). The manual will present new trends and needs regarding human resources management and continuous personal and professional development of staff in the construction industry due to, among others, factors such as: the new reality on the labor market, the variability of the construction sector conditions and employment uncertainty resulting from the post-COVID-19 pandemic situation and the war in Ukraine, as well as the complexity and ambiguity of the needs of the entire European community. Especially in modern organizations in the construction industry, which also employ refugees and immigrants, the ability to properly direct the career path of talented and gifted employees is particularly important.



Figure 8. Aspects of human resources management in construction.

Source: Own source.

The new CML manuals will also contain the best practical case studies in the area of construction design and implementation, covering important aspects of a manager's daily work and the effective exchange of knowledge and experience between experts from different European countries (Fig. 9). Additionally, the project will largely contribute to eliminating certain restrictions resulting from, among others: from the mismatch of cultural differences and deficiencies in specific skills of personnel employed in economic sectors related to construction.



Figure 9. The latest textbooks of the Construction Managers Library (in red).

Source: Own work.

All textbooks from the Construction Managers' Library are the basis for the recognition of managerial qualifications in construction on a European scale, as well as used to verify the acquired theoretical knowledge by candidates for obtaining the EURBE (European Building Expert) card, issued by AEEBC (www.aeebc.org). The scope of knowledge presented in the textbooks is essential in the activities of managers - construction engineers managing projects in the conditions of a modern market economy. They are addressed to engineers and construction managers, architects and other employees related to the construction industry, as well as students completing construction studies. CML textbooks are also the basic source of substantive information for postgraduate studies in Construction Management organized by the Department of Production Engineering and Management in Construction at the Faculty of Civil Engineering of the Warsaw University of Technology. (since 2017, the studies have been accredited by an international organization - Royal Institution of Chartered Surveyors (RICS) www.rics.org (as the only postgraduate studies for construction specialists in Poland). For detailed information about the project, please visit www.cloemcVI.il.pw.edu.pl.

3. Erasmus+ ID4Ex Project

3.1. Project background

The imperative of preserving and rehabilitating built heritage underscores the need for innovative methodologies that not only honor historical authenticity but also address contemporary challenges. Built heritage, with its architectural and cultural significance, serves as a tangible chronicle of human progress. However, the intricate nature of heritage preservation requires a nuanced approach that seamlessly integrates traditional methods with modern

technologies (Balzani et al., 2020; Raco, 2023; Rosłon et al., 2022). In this context, the ID4Ex project (Immersive Design for Heritage Rehabilitation) takes center stage (figure 10).

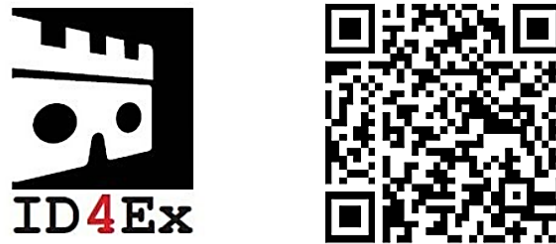


Figure 10. ID4Ex project logo and QR code for project the website.

Source: Nowak et al., 2023.

The venture's initiation stems from a dual recognition: the critical importance of digitizing and modernizing the construction sector, and the unique challenges posed by built heritage rehabilitation. Recognizing the limitations of conventional approaches, ID4Ex places a strategic emphasis on immersive design technologies, notably extended reality (XR) tools like Virtual Reality (VR) and Augmented Reality (AR) (Kaczorek et al., 2022). (figure 11). These technologies serve as catalysts for a transformative shift in the rehabilitation paradigm, not only by offering advanced restoration tools but also by enabling multi-disciplinary teams to co-operate through virtual experiences (Camiz, 2021; Sezer, 2019) (figure 12).

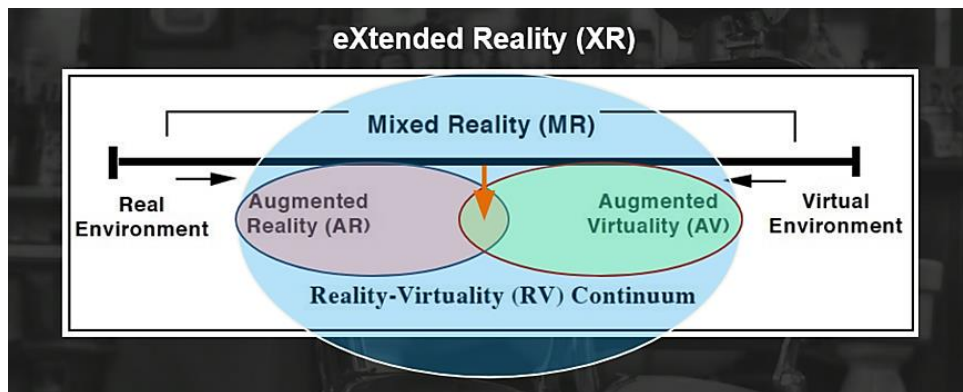


Figure 11. Extended reality definition.

Source: ID4Ex learning materials, based on Milgram et al., 1995.

Project management within ID4Ex is a crucial issue. The project recognizes the necessity for improving communication frameworks between specialists from of different backgrounds and means of remote collaboration (Bekar et al., 2018; Nicał et al., 2018). Built heritage is a complex ecosystem, demanding expertise from various fields. Architects, civil engineers, conservators, historians, digital artists, and technology specialists converge in a multidisciplinary team, each contributing unique insights to ensure that immersive technologies align with preservation principles. The emphasis on teamwork, coordination, and comprehensive training programs speaks to the project's commitment to cultivating a collaborative environment.

3.2. Project objectives and goals

The ID4Ex project (Immersive Design for Heritage Rehabilitation) is underpinned by a set of robust objectives and goals, collectively designed to usher in a new era in the preservation and rehabilitation of built heritage. Each facet of the project is meticulously crafted to address the evolving needs of the heritage rehabilitation sector and to harness the transformative potential of immersive design technologies.

1. Upgrading Training Programs

The primary goal is to elevate and innovate existing training programs in the heritage rehabilitation sector. This involves integrating the latest immersive design methods and tools into training modules, ensuring that professionals are equipped with the skills needed to navigate both virtual and dimensional environments. To provide a comprehensive educational framework that goes beyond static structures, incorporating time-based narratives and story spaces. This ensures that heritage professionals are not only proficient in the technical aspects of immersive design but also understand the dynamic, living tapestry of stories embedded in heritage sites.

2. Improving Teaching and Learning Effectiveness

ID4Ex project embraces an inclusive, immersive design approach to significantly enhance the effectiveness of teaching and learning in the heritage sector. To cultivate an educational landscape that fosters critical thinking and problem-solving, producing professionals who are not only adept in the application of immersive design but also possess a deep understanding of the cultural and historical contexts that underpin heritage rehabilitation.

3. Promoting Synergistic Use of Technologies

Another goal is to advocate for an integrated approach to technology by maximizing the synergetic use of up-to-date technologies. To seamlessly combine Virtual Reality (VR), Immersive Interactive Experience (IIE), advanced 3D modeling, and other cutting-edge tools. This integrated approach ensures a holistic understanding of built heritage, promoting a teamwork approach and emphasizing personal development among professionals (figure 12).

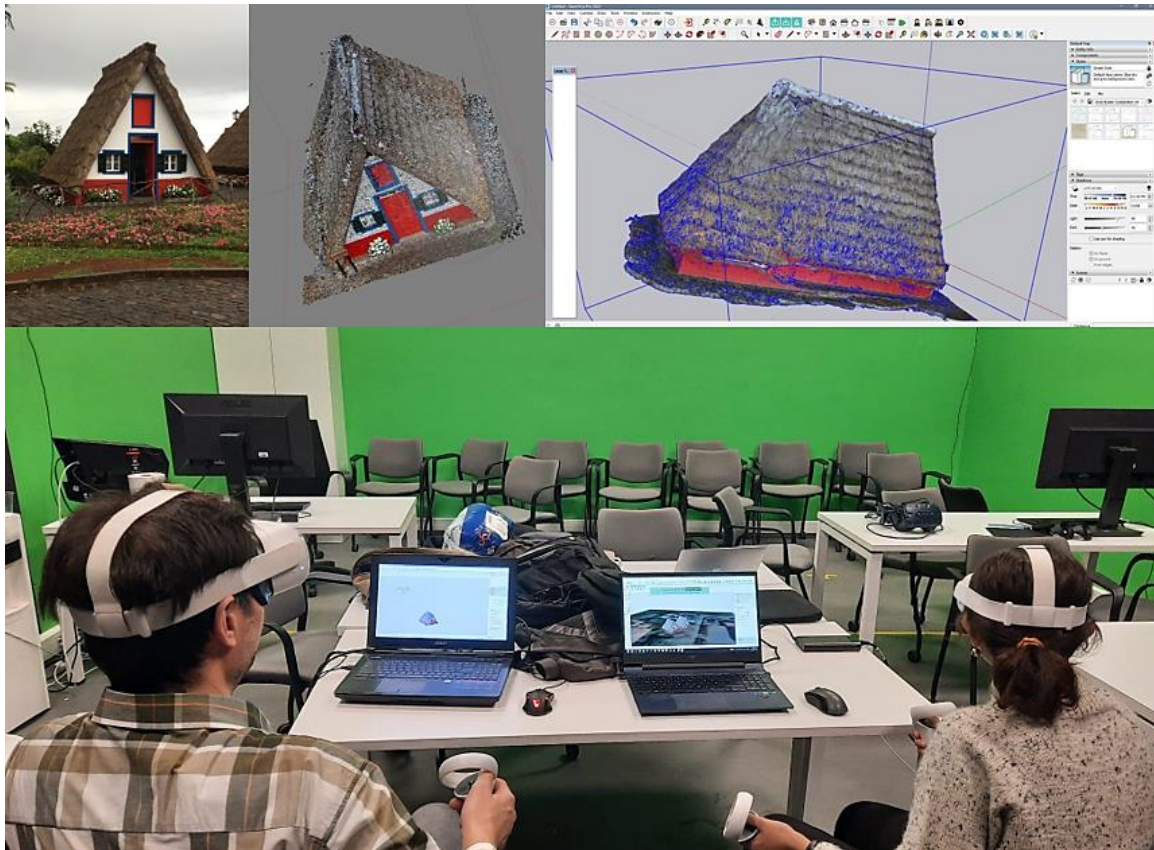


Figure 12. Collaborative work in a virtual environment – Santana house case study.

Source: ID4Ex learning materials.

4. Increasing Cooperation Among Educational Institutions and Enterprises

The project also helps to recognize the interdependence of academia and industry in successful heritage rehabilitation. It fosters collaboration among educational institutions and enterprises in the European Union, creating a dynamic ecosystem that not only enhances employability in the heritage sector but also bridges the gap between theoretical knowledge and practical industry demands.

5. Advancing Cross-Disciplinary Collaboration

The developed modules on managerial and soft skills are fostering multidisciplinary collaboration among project managers, architects, civil engineers, conservators, historians, digital artists, and technology specialists. By providing technological solutions and encouraging virtual collaboration, the project creates a blueprint for successful cross-disciplinary teamwork. This collaborative ethos ensures that heritage rehabilitation projects benefit from a rich tapestry of expertise, enriching the final outcomes.

The overarching aim of the ID4Ex project is to orchestrate a harmonious convergence of heritage preservation and digital innovation. By achieving these objectives and goals, the project endeavors to empower professionals, advance the sector's competencies, and ensure the sustainable future of our architectural and cultural treasures through the transformative lens of immersive design.

3.3. Project results

ID4Ex project developed a series of transformative results that underline the project's ambitious objectives. These outcomes not only propel the heritage rehabilitation sector into the digital age but also lay the groundwork for innovative, multidisciplinary collaborations and the widespread adoption of immersive design technologies.

1. Comparative Research on VR Technologies

A comprehensive exploration of Extended Reality (XR) technologies and their applications in the rehabilitation of built heritage. This research delves into best practices, emerging trends, and opportunities, providing a nuanced understanding of how immersive technologies can be optimally utilized in heritage preservation.

2. Training Modules for Immersive Design Experts

The development of detailed training modules that cover key aspects of immersive design in heritage contexts. These modules span from foundational immersive technologies and digital surveying to soft skills essential for successfully renovating heritage buildings with digital tools:

- Module 1 - Immersive technologies and tools.
- Module 2 - Digital survey and scan to BIM protocols.
- Module 3 - Immersive Technologies for Design in Heritage contexts.
- Module 4 - Immersive Technologies for Construction, Operation and Maintenance in Heritage contexts.
- Module 5 - Soft Skills for Successfully Renovating Heritage Buildings with Digital Tools.
- Module 6 - Green and sustainability skills.
- Module 7 - Managerial and financial skills for digital heritage protection.

3. Digital Training Toolkit for Immersive Design Experts

The creation of a digital training toolkit that houses a wealth of resources, including guides, software solutions, videos, e-learning platforms, 3D models, and presentations. The toolkit serves as a dynamic repository, providing experts with a diverse array of resources to enhance their immersive design capabilities. This digital infrastructure facilitates continuous learning and supports professionals in navigating the intricacies of heritage rehabilitation with immersive technologies.

4. Report on Pilot Actions for Immersive Design Experts

A detailed report showcasing the successes and lessons learned from practical applications of immersive design in built heritage rehabilitation. The report acts as a living document, helping trainers, tutors, and organizations to draw insights from the experiences documented, gleaming practical knowledge for their own immersive design endeavors.

By achieving these milestones, the project not only elevates the competencies of heritage professionals but also contributes to the broader conversation on the intersection of technology, culture, and historical preservation. The immersive design outcomes promise a sustainable and digitally enriched future for the built heritage.

3.4. Case Study - Digitally Preserving Santana Houses in Madeira with ID4Ex

The successful digital preservation of the Santana houses in Madeira (Portugal) stands as a tangible demonstration of the impactful contributions of the ID4Ex project. This case study delves into the collaborative efforts of a multinational, multidisciplinary team, influenced by the immersive design methodologies promoted by ID4Ex, to digitally safeguard these culturally significant structures (figure 12). The case study serves as one of the workshops in the developed training materials.

Employing photogrammetry techniques, the team meticulously captured high-resolution images from multiple perspectives to ensure an accurate representation. The integration of Extended Reality (XR) and advanced 3D modeling, in line with ID4Ex methodologies, added depth and interactive elements to the digital replicas of the Santana houses (figure 13).

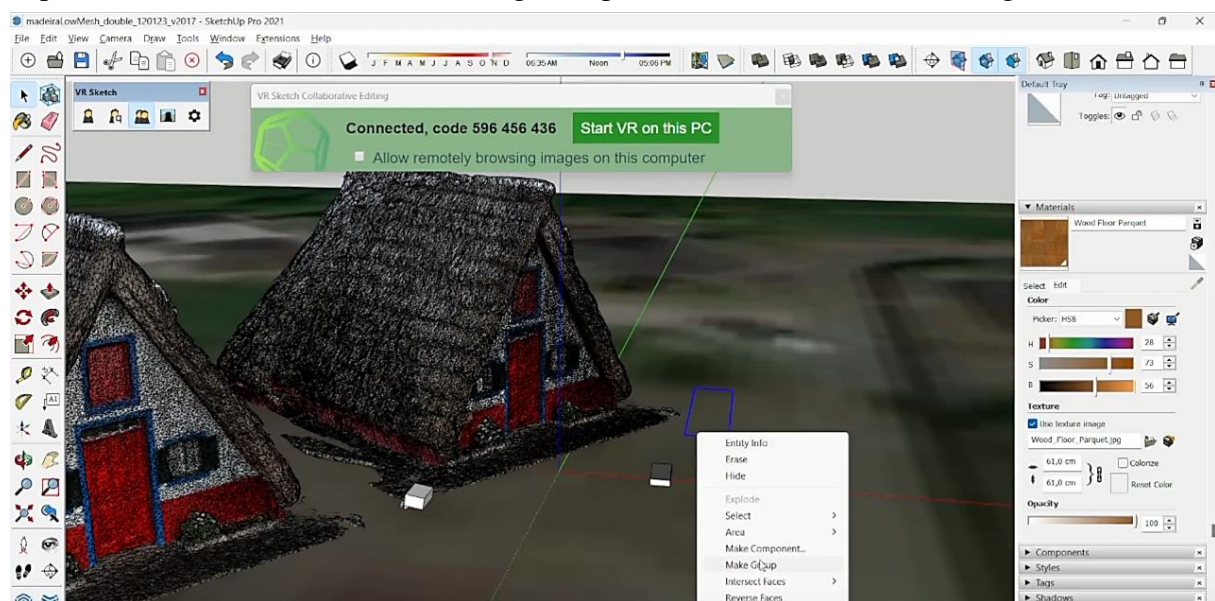


Figure 13. Santana house 3D model - case study.

Source: ID4Ex learning materials.

Beyond the specific achievements of this sub-project, the digital preservation of the Santana houses carries broader implications. The 3D models and VR experiences contribute significantly to educational initiatives, enabling virtual exploration for students and enthusiasts. Additionally, the digitally preserved Santana houses enhance tourism experiences, offering immersive attractions to a global audience. The case study is used in the ID4Ex materials in two workshops, on team collaboration in 3D environment, and on AR applications in heritage contexts.

In essence, the Santana houses case study serves as a practical testament to the applicability of ID4Ex's immersive design methodologies in safeguarding cultural heritage. More than a technological endeavor, it exemplifies ID4Ex's commitment to fostering collaborative, multidisciplinary approaches, ensuring a sustainable and digitally enriched future for cultural treasures worldwide.

4. Erasmus+ 3Msite Project

4.1. Project background

The Erasmus+ 3Msite project, i.e., "MANAGEMENT OF MODERN, MULTIETHNIC AND MULTICULTURAL CONSTRUCTION SITE WITH ASPECTS OF ECOLOGY, SOCIOLOGY, TECHNOLOGY AND HEALTH" - number 2022-1-PL01-KA220-HED-000087368, is implemented from December 1, 2022 - January 31, 2025. The project's logo and QR code are shown in Fig. 14.

The project concerns the issue of modern management of a multi-ethnic and multi-cultural construction site, taking into account aspects of environmental protection and ecology, sociology, health protection and occupational safety, as well as technical and technological issues of construction site development.



Figure 14. Logo and QR of the 3Msite project.

Source: Own work.

The global political and economic situation and the labor shortage in many European Union countries resulted in the implementation of new programs or amendments to the Act on Labor Promotion. According to Eurostat research, migrants play an important role in the labor markets of the European Union countries where they settle, and their participation is becoming more important in individual Member States, like Poland. However, cultural, and ethnic differences

are often a key aspect of the lack of social integration of such migrants. It should be emphasized that a significant number of foreigners are employed on construction sites due to the key role of construction in the EU national economy. With such major staffing problems, companies are recruiting employees from increasingly distant parts of the world: from Ukraine, Belarus Azerbaijan, Georgia, Tajikistan, Uzbekistan, Kazakhstan, Pakistan, Syria, and even from Nepal or Mongolia. This makes it necessary to take a different approach than usual when it comes to managing a multi-ethnic, multi-cultural construction site. Appropriate preparation, instruction and even education of employees in the field of cultural and technical differences, occupational health and safety at construction sites, environmental protection and ecology are also important.

4.2. Project objectives and goals

The main goals of the 3Msite project are: to facilitate migrants' integration in the new environment; improving the integration and diversity of the EU construction market; helping local management and employees understand migrants and employees with a different culture, religion, or ethnicity; teaching how to deal with such subordinates and co-workers while working on a construction site.

Additional, beneficial goals of the project are: improving knowledge in the field of construction site development and competences in the field of occupational health and safety and environmental protection; building an effective, loyal and motivated team of construction workers; educating EU citizens in a modern way; promotion of green deal policy and pro-ecological habits; improving effective communication on the construction site; increasing knowledge about conflict resolution; promoting appropriate behaviors and actions among subordinates; learning how to deal with difficult situations and with employees.

4.3. Project didactic results

The expected results of the project are:

- the 3Msite teaching methodology and
- four textbooks covering the following issues: formal, legal, technical and technological aspects of construction site development and management; sociological aspects of managing a multi-ethnic and multi-cultural construction site, occupational health and safety at the construction site; environmental protection on the construction site.

All textbooks will be based on experiences from European countries, written in three languages (English, Polish and Turkish) and developed by a multicultural team.

The results of the 3Msite project focus on the construction industry, but a large part of the project addresses general issues that are key to the existence of integrated and shared EU values. The project promotes and strengthens European ideas of social inclusion and increasing access to training and qualifications for all, especially the need to educate migrants on environmental issues, as EU ecological standards (e.g. sustainable development guidelines and the Green Deal)

are often not taught and understood outside Europe. The project is particularly important nowadays in the context of the ongoing war in Ukraine, a new wave of migrants and the need to function in a multicultural environment.

The 3Msite project raises a very important issue: the integration of refugees and migrants into the construction labor market. Currently, there are no training courses and manuals available on the issue of multiculturalism and how to deal with it on European construction sites. Therefore, the concept of combining economic, technological, environmental, sociological, and psychological issues proposed as part of the 3Msite methodology is unique and innovative. The recipients of the project are: both local construction workers and migrants, construction students, interns and construction engineers, construction management staff, stakeholders and associations operating in the construction sector, all enterprises related to the construction industry, universities and organizations dealing with the improvement of education professional. For detailed information about the project, please visit www.3Msite.il.pw.edu.pl.

4.4. Project's scientific proposal

Based on the 3Msite Project, we can consider the phenomenon of multiculturalism on the construction site. We can also characterize the so-called intercultural management in construction (construction site) in terms of universal problems - similar to those occurring in human resources management. At the same time, specific problems related to internationality should be taken into account. The results of the 3Msite project contribute to the development of multicultural team management in the construction industry (construction companies). During construction projects, major organizational unit are teams entrusted with certain tasks. The term "team" is understood as employees who interact cooperatively. The main features of the group are the mutual desire of cooperation, and perception of each other (team) as a unity. Within the team accepted and acceptable forms of action are in use. In case of multi-cultural teams, you can encounter problems in the functioning of these organizational structures, especially in terms of both the identification of the group and communication between its members. Ability to work effectively in a culturally diverse environment, tact, and tolerance in building interpersonal relationships, become today a respected asset of managers and construction workers.

Multicultural construction is considered to be the construction of a building with the participation of at least two groups of workers with different cultures, or a team of workers with internal cultural diversity (Pheng et al., 2000). The source of cultural diversity can be ethnicity, nationality (for the most part), religion, etc. It is obvious that IHRM (International Human Resource Management) will be more difficult, with increasing numbers of cultural diversity and their distance. As an intercultural management on construction site, is understood realization of fundamental function of management, taking into account cultural diversity as a factor affecting to staff cooperation, and subsequent operation of construction. Cultural diversity can be result of international recruitment to main contractor team (model b); it is also

possible cooperation of numerous diversity monoculture team (model a); as well as – both situation at the same time (model c), fig. 15. There are also other configuration possible, these three were considered as most typical.

The human resource management can be divided into the following approaches:

Ethnocentric with motto:

'this work in my country therefore, it must work in other countries also'.

Polycentric with motto:

'Local People know what is best for them. Let's give them some money and leave them alone as long as they make us a profit' (each country is different).

Geocentric with motto:

'Right Person for the Right Job' (global integration connect the good elements from each country to find one best way).

Cultural diversity could be the source of risk. There are many exterior and interior sources of risk occurring on multicultural construction site; among all, group of socio-cultural risk can be found, related with language, religion, and culture. Considering the insufficiently language skills, as well as differences in notional, cooperation could lead to misunderstanding and contention. Racism, ethnocentrism and stereotyping also perform as a challenge for intercultural management.

However, many companies derive profit from diversity, and use it as a competitive advantage. Multicultural workgroup often overtake these monocultures; especially at realization task, which demand creativity and multi-skill.

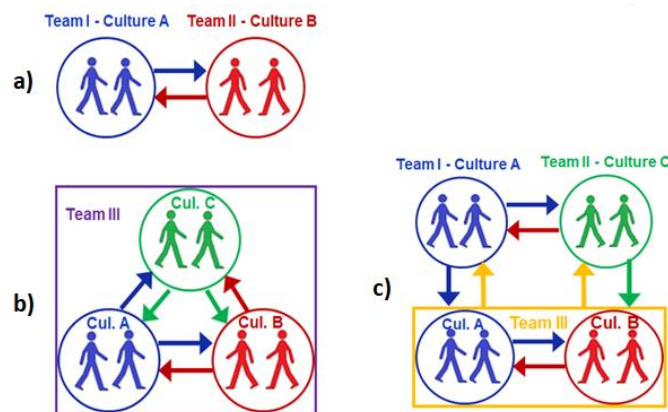


Figure 15. The structure of the working groups – team models.

Source: Own source.

From observations and analysis of literature (Kozłowski, 2004), several management principles in multicultural organizations can be deduced:

- reflexivity - the ability to identify the forms, manifestations and sources of multiculturalism,
- empathy - understand perceptions, feelings, motives and emotions of various groups,
- acceptance of diversity (differences),

- community - taking into account common interests, motivations and values of different groups and ethical orientation,
- compromise - the ability to make concessions with respect to different groups,
- continuous adaptation - sensitivity to cultural changes and new challenges,
- speed of action - the ability to predict cultural changes in conjunction with a preparing new patterns of action and standards before changes occur.

These guidelines are universal, introducing them to the construction site through managers, thereby providing strategy of behavioral shaping, organizing teams, and the last - their cooperation.

Authors suggest application of fuzzy decision support methods for the selection of a manager managing a multi-ethnic and multi-cultural construction site (figures 16-19) and formulas 1-3.

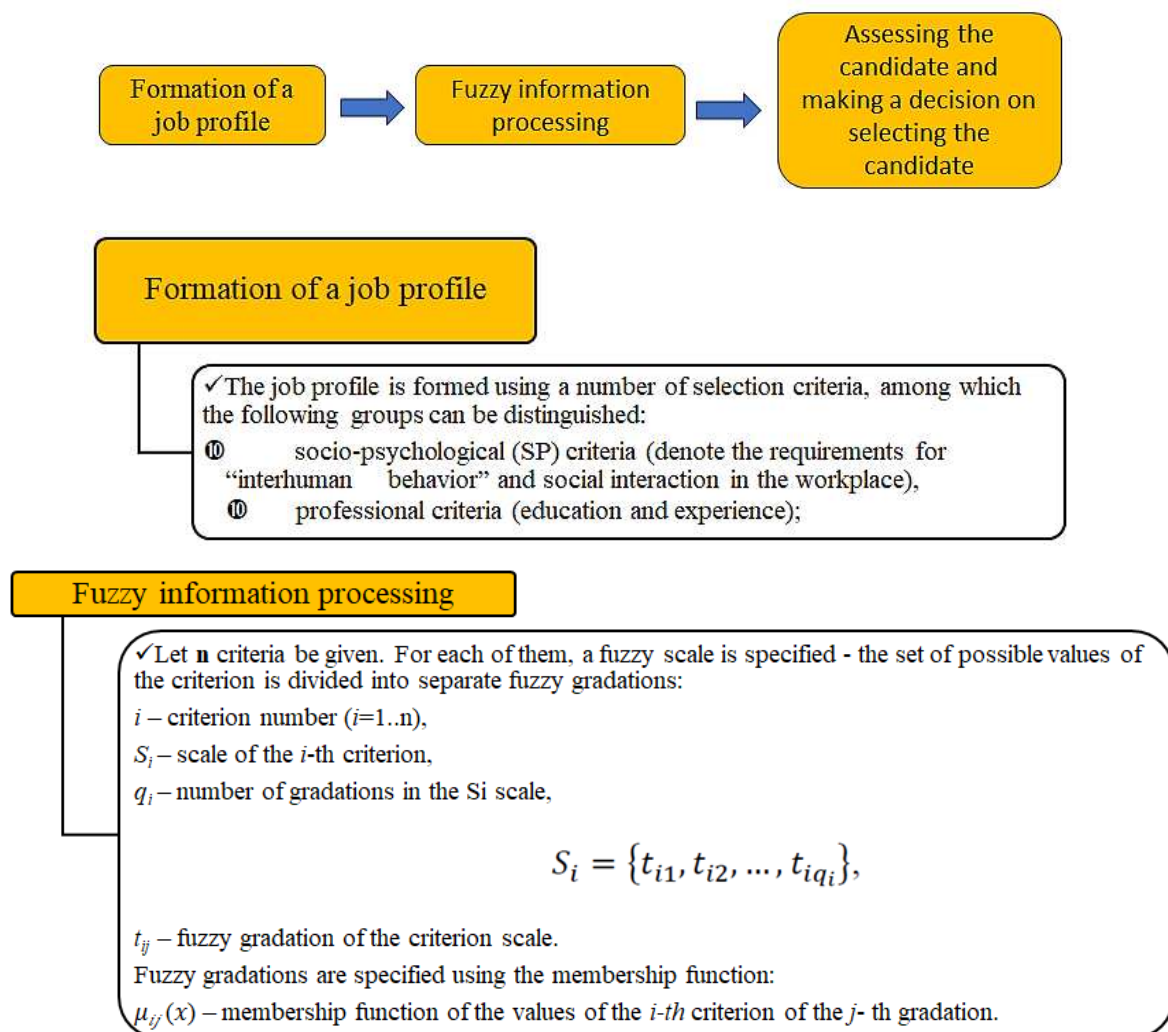


Figure 16. Stages of personnel selection using Fuzzy Logic.

Source: Ibadov et al., 2015.

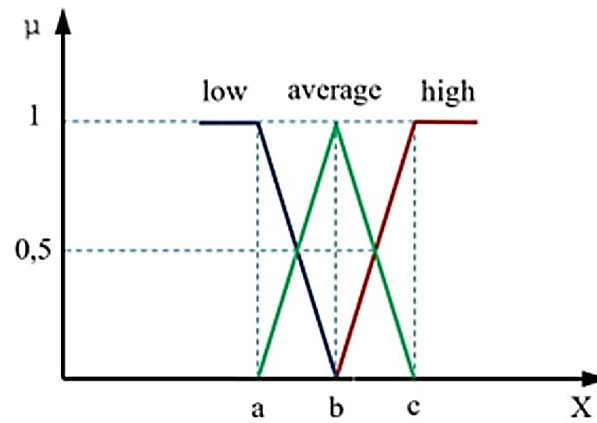


Figure 17. General idea of Fuzzy Logic – degree of membership.

Source: Ibadov, 2017.

The analytical form of membership function presented in figure 17 can be calculated as follows (Ibadov et al., 2015; Ibadov et al., 2019):

$$Low = (x; a, b) = \begin{cases} 1 & \text{for } x \leq a \\ \frac{b-x}{b-a} & \text{for } a \leq x \leq b \\ 0 & \text{for } x \geq b \end{cases} \quad (1)$$

$$Average = (x; a, b, c) = \begin{cases} 0 & \text{for } x \leq a \\ \frac{x-a}{b-a} & \text{for } a \leq x \leq b \\ \frac{c-x}{c-b} & \text{for } b \leq x \leq c \\ 0 & \text{for } x \geq c \end{cases} \quad (2)$$

$$High = (x; a, b) = \begin{cases} 0 & \text{for } x \leq b \\ \frac{x-b}{c-b} & \text{for } b \leq x \leq c \\ 1 & \text{for } x \geq c \end{cases} \quad (3)$$

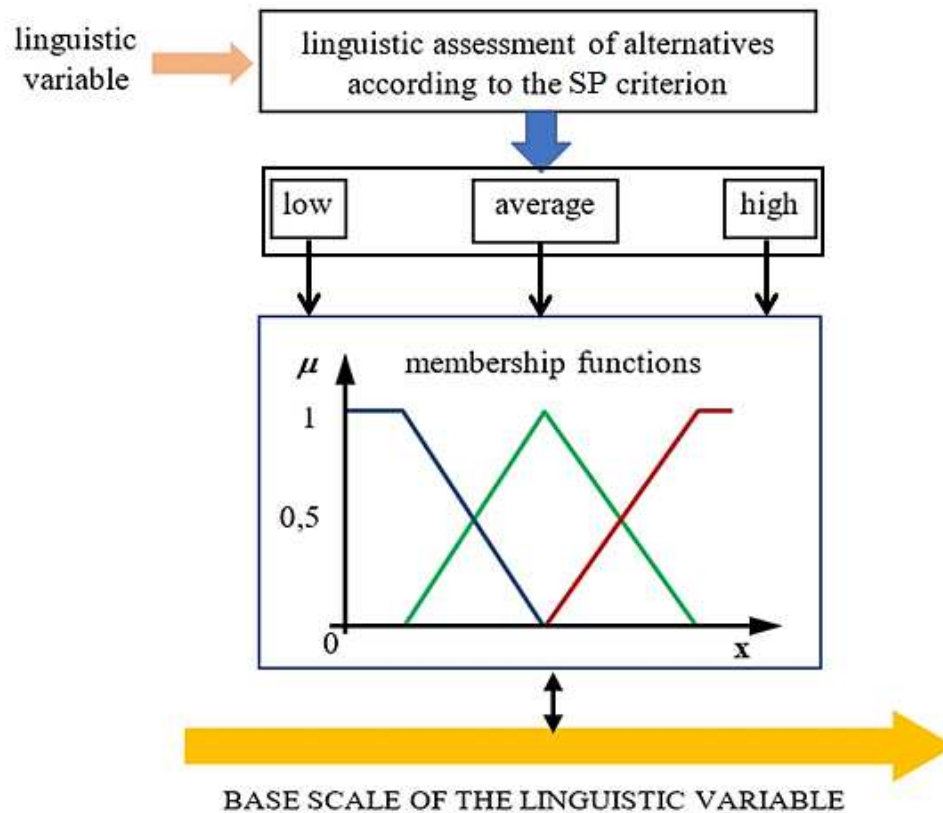


Figure 18. Conceptual model of fuzzy linguistic evaluation of alternative manager according to the degree of SP (Socio-Psychological criteria).

Source: Own source.

In figure 18 the μ is the degree of membership in the fuzzy set, x is the numerical value from the base scale according to the considered criterion. The assessment of candidates for managers and final decision-making process is subject to the following scheme (Ibadov et al., 2015; Ibadov et al., 2019) (figure 19).

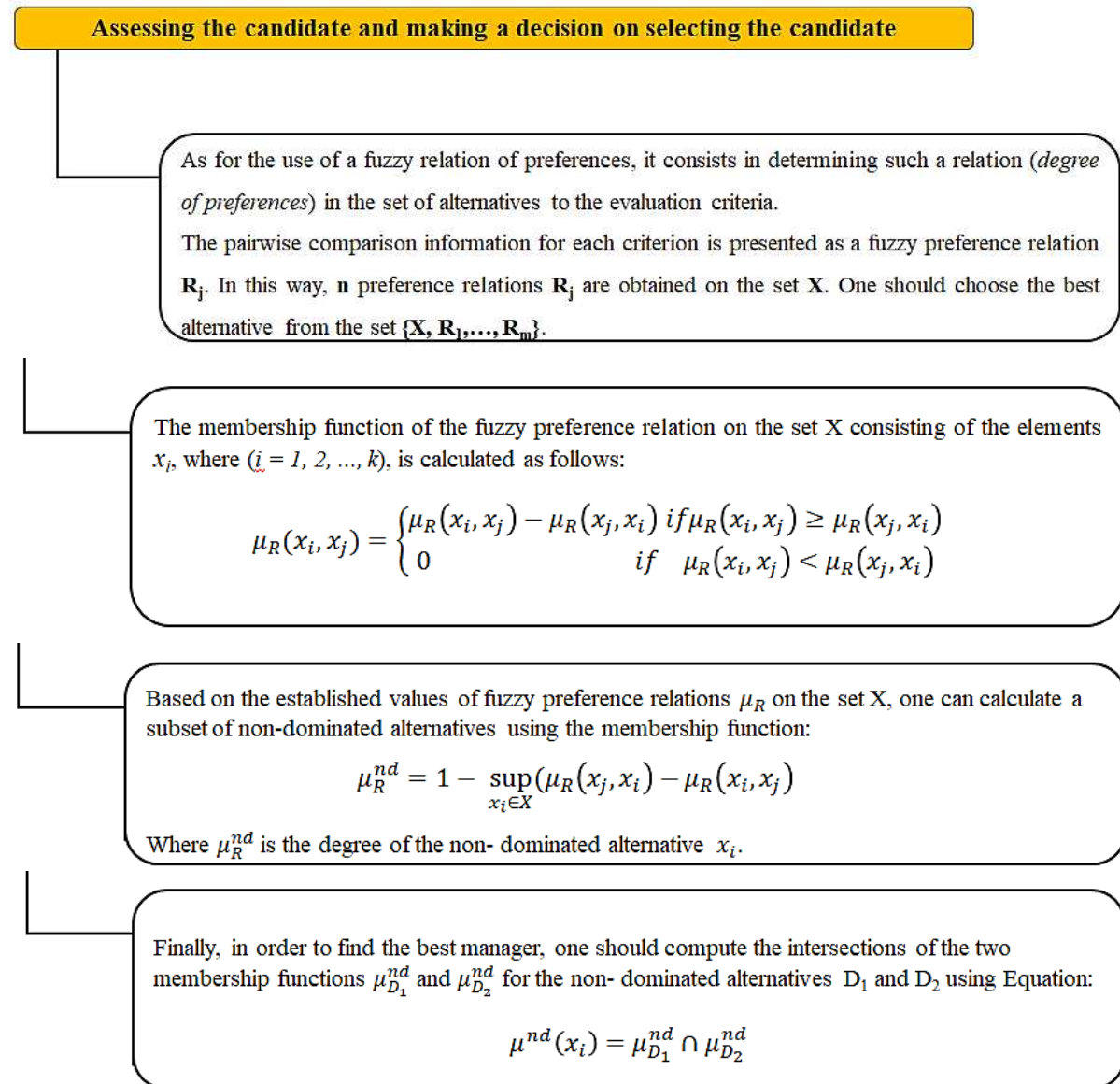


Figure 19. Assessing the candidate and decision making.

Source: Own source.

The higher the degree of non-dominance, the more preferable the alternative. In this way, it can be said that the thematic scope and results of the 3Msite project provide many opportunities for use in both teaching and scientific research.

5. Summary

The main result of the projects presented in this article is improvement of construction personnel education at all levels - from direct labor, through students and new graduates, to highly qualified managers. The above-mentioned projects also allow for the identification of needs in terms of qualifications of construction personnel, recognition of applied education systems, personnel certification and accreditation of studies (such as postgraduate studies titled "Construction Management" at WIL PW accredited by **IPMA** (International Project Management Association), **PSMB** (Polskie Stowarzyszenie Menedżerów Budownictwa – Polish Association of Building Managers) and **RICS** (Royal Institution of Chartered Surveyors) and studies titled "Psychology of Project Management in Construction (prepared in cooperation with lecturers of the Faculty of Psychology of the University of Warsaw - www.il.pw.edu.pl/studia-podyplomowe). They also facilitate programs and courses of technical schools and VET organizations in the EU. These projects use an innovative approach to education - immersive design, distance, and blended learning. Erasmus+ teaching projects are also extremely useful for strengthening cooperation between various entities in the European economic market: higher education institutions, professional bodies, companies, secondary schools, and enterprises. Projects create positive synergies for economic and educational systems. Detailed information for all interested persons can be found at: <https://erasmusplus.il.pw.edu.pl/>.

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ENHANCING COMMUNICATION COMPETENCES FOR MILITARY LEADERS THROUGH EQUINE-BASED LEARNING

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Purpose: The study explores the potential of equine-based learning training as a novel approach to enhance communication competencies among military leaders based on practical work with future leaders.

Design/methodology/approach: The research was conducted on 79 cadets from military academies in Poland, and an international group that included cadets from few European countries. The research took place between May 2021 and June 2022. The article provides an overview of the methodology which combined self-assessment questionnaires, interviews, participant observation, and analysis of personal diaries. The chosen methods aimed to capture both quantitative and qualitative data, enabling a comprehensive evaluation of the effectiveness of equine-based learning as a training process.

Findings: The study's results indicate the significant role played by the innovative training method of equine-based learning in improving communication competence. Effective communication is crucial for leaders in military organizations for several reasons: clear and concise communication is essential for conveying information, instructions, and expectations to a subordinate; effective communication is vital for building and maintaining strong relationships with subordinates and is crucial for resolving conflicts and addressing issues within the military organization.

Research limitations/implications: The research begins a more extensive study oriented towards leadership in organizations. The proposed training method - equine-based learning - demonstrated its usefulness in improving communication competence in a sample of military cadets. It is necessary to conduct similar research with the guidelines in the article on a more extensive research sample and extend the method to other managerial competencies.

Practical implications: The research suggests that there is scope to expand training for future leaders in military organizations. As one of the most critical competencies for military and civilian leaders, communication competencies are often taught traditionally without effectiveness. Enhancing communication competencies through equine-based learning achieves success, as evidenced by the research presented in the article.

Originality/value The publication refers to the method of training with horses. Equine-based learning has been used primarily in veterinary science, agricultural science and psychology. This article publishes the research results using this method to improve social skills.

Keywords: communication competencies, leader training, equine-based learning, military leadership.

Category of the paper: research paper.

1. Introduction

Effective communication is a critical skill for military leaders, as it plays a vital role in mission execution, team cohesion, and maintaining morale. The ability to convey information clearly, listen actively, and understand and empathize with others is essential for effective leadership in military contexts. However, traditional communication training methods may not always adequately address the complex and dynamic nature of communication in high-stress environments.

In recent years, there has been growing interest in alternative approaches to leadership training that incorporate experiential learning and non-traditional methods. One such approach is equine-based learning, which involves interactions between humans and horses to develop leadership and communication skills. Horses have a unique ability to provide immediate feedback and mirror human emotions and behaviors, making them ideal partners for leadership development.

Ongoing discussions regarding how best to develop leaders confirm that those who can harness the intellect of the body and brain have a unique advantage in today's complex and ignitable business environment (Cooper, 2000). The horses are excellent examples for guiding the learning process that facilitates these human-horse experiences (Bjönberg, 2015). It also offers the opportunity to develop lasting changes in an individual's awareness and actions regarding their leadership skills and authenticity (Gehrke, Baldwin, Schiltz, 2011). Thus, they differ from traditional leadership training and development programmes.

This article aims to explore the potential of equine-based learning training as a novel approach to enhance communication competences among military leaders. By reviewing existing literature on equine-based learning and its impact on communication skills development, it can gain insights into the effectiveness of this approach in military contexts.

The review will examine studies that have investigated the effects of equine-based learning on communication competences, including active listening, non-verbal communication, empathy, and assertiveness. It will also explore the underlying mechanisms of equine-based learning, such as the development of emotional intelligence and self-awareness, which are crucial for effective communication.

Traditional communication training methods often focus on theoretical knowledge and role-playing exercises, which may not fully capture the complexities of real-world communication challenges. Equine-based learning offers a unique and experiential approach to communication skills development, providing managers with a dynamic and immersive training experience.

Horses have a natural ability to sense and respond to human emotions and behaviors, making them powerful partners in developing communication competences. When interacting with horses, military leaders must learn to communicate effectively using non-verbal cues, body language, and emotional intelligence. Horses provide immediate and honest feedback,

reflecting the leader's communication style and effectiveness. This real-time feedback allows military leaders to gain insights into their communication strengths and areas for improvement.

Equine-assisted learning (EAL) is a facilitated, reflective discussion method based on interpretation of equine behavior in a group experiential setting that has been used to improve confidence, self-assurance, verbal and nonverbal communication, focus, mindfulness, and coping strategies in populations of students, medical students, corporate groups, and career professionals (Rentko et al., 2023).

Equine based learning (which it can be found under different nomenclature as: equine assisted education, horse assisted education, horse assisted learning) is an innovative method of human learning involving horses. It aims to develop the person broadly - self-awareness, leadership, psychological and social skills- and to help him/her change. The essence of this method is to create a space where we can experience ourselves in a relationship with a horse.

Several methods for learning with horses have emerged since the Professional Association of Therapeutic Horsemanship International first began to uncover the human-equine relationship's potential for healing in the late 1960s (Andersen et al., 2023).

The method described here regards horses as facilitators. Alongside human experts, they conduct experiential exercises in the field and arena. There is no riding involved, and no need for experience with horses.

People can learn through direct participation in the relationship during the workshops using EBL. There are no signposts, tried-and-tested rules and techniques of behaviour. Each step comes from taking responsibility, having courage and making a decision. Learning is multi-level, involves the whole person, and occurs in an actual situation. The horse's behaviour is authentic; thus, it is a real relationship, communication, and leadership. Such an experience is different from human-to-human role-playing.

Equine-based learning also enhances active listening skills, as managers must attune themselves to the horse's non-verbal cues and respond accordingly. By practicing active listening with horses, managers can develop the ability to listen attentively to their employees, understand their needs and concerns, and respond empathetically.

Moreover, equine-based learning promotes the development of emotional intelligence, which is crucial for effective communication. Emotional intelligence involves recognizing and managing one's own emotions and understanding and empathizing with the emotions of others. Horses are highly sensitive to human emotions, and managers must learn to regulate their emotions and communicate in a calm and assertive manner (Sheade, 2020). This emotional awareness and regulation translate into improved communication skills in the workplace, as managers can better understand and respond to the emotions of their employees.

In conclusion, equine-based learning training offers a novel and experiential approach to enhancing communication competences among leaders in military organizations. By leveraging the unique qualities of horses, such as their ability to provide immediate feedback and mirror human emotions and behaviors, equine-based learning provides a dynamic and immersive

training experience. The existing literature suggests that equine-based learning can significantly improve communication skills, including active listening, non-verbal communication, empathy, and assertiveness. Incorporating equine-based learning into military leaders training programs can offer army a valuable tool for developing effective communication competences and fostering a positive and collaborative work environment

2. Literature review

Since the practice of incorporating Human-Animal Interaction (HAI) into therapeutic and educational settings has grown in popularity (Nimer, Lundahl, 2007.), there has been a call to conduct evidence-based research on its effects on child physical and mental health, well-being, and development (Esposito, McCune, Griffin, Maholmes, 2011). Along with a call for clinical trials and examination of treatment effects in various populations, the importance of examining biobehavioral and physiological responses to HAI were emphasized (Esposito et al., 2011).

The application of horses helping humans is well documented in other fields. In psychotherapy horses have been shown to help patients suffering from trauma experience bonding, reduce psychological distress, and improve well-being (Herbette, Guilmot, Heeren, 2011; Yorke, Adams, Coady, 2008). In the medical field horses have been shown to help medical students hone their communication skills prior to working with patients, develop compassion, and practice presence (Carroll, 2017; Walsh, Blakeney, 2013).

Publications in equine-based learning (horse-assisted education, equine-assisted learning) were sporadic until 2020 and mainly concerned veterinary science. During the COVID-19 pandemic, work and human relationships changed to a virtual environment, to which new methods of teaching communicative competence can be attributed (Davis, 2023). Still, 63% of all publications are in veterinary and agricultural sciences, but publications in health sciences (8.8%) and social sciences (13.6%) have emerged.

Psychological research has highlighted the effects of exercise with horses on mental health, especially with people with PTSD syndrome. Also, there is extensive research suggesting that working with EBL helps withdrawn or anxious people reintegrate into society. The most common outcomes from the equine learning program studied for this article, from the case-studies and the thematic analysis includes; behavioural changes, stress relief, mind and body awareness and control, forming a relationship with an intuitive practitioner, guided meditations as a means of creating independent meditation techniques and re-engagement with education, work, friendships and family relationships (Townsend, Hood, 2019).

In 2017, books were published on using horses in various therapies and as a tool for experimental education. It featured descriptions of exercises, analyses of influences and ways of analysing work with horses (Hallberg, 2017; Burgon, 2014). A lot of space was also devoted to the description and characteristics of the teacher/facilitator, who is responsible for the success or failure of the whole training process (Stock, Kolb, 2021).

Of particular note is an article that describes equine-based learning as a programme which involves innovative, underutilised, and motivating techniques and strategies that provide a dynamic process of building and developing leadership skills through horse-human interactions. The article offers a systematic literature review of the EBL method as innovative in teaching leadership competencies (Bilginoğlu, 2021).

Several studies have explored the impact of equine-based learning on communication competences in various settings, including leadership development programs and team-building exercises. These studies consistently demonstrate positive outcomes in communication skills development among participants.

The study conducted by Kummer and colleagues (Bilginoğlu, 2021) examined the effects of equine-assisted leadership training on communication competences among managers in a corporate setting. The participants engaged in activities such as leading horses through obstacle courses and non-verbal communication exercises. The findings revealed significant improvements in active listening, non-verbal communication, empathy, and assertiveness among the participants. The experiential nature of the training allowed managers to practice and refine their communication skills in a dynamic and engaging environment.

Another study by Perkins and colleagues (2018) explored the impact of equine-based learning on communication competences in a team-building context. The participants engaged in collaborative activities with horses, such as guiding them through a series of tasks. The findings showed that the participants developed stronger communication skills, including effective teamwork, clear and concise communication, and adaptability. The interactive nature of the activities with horses allowed participants to experience the immediate impact of their communication choices and adjust their approach accordingly.

In contrast, when it comes to methods of using horses in a military context, research primarily refers to military veterans who have experienced trauma. The most recent literature review on this topic can be found in Marchand (2023). There is limited research on the military and military training methods, so it remains to be seen whether equine-based learning can be used in officer training, using communication competence as an example.

3. Methodology

Methodology employed in conducting the research, which aimed to evaluate the effectiveness of equine-based learning as method to enhance communication competencies among military leaders. The study utilized a combination of self-assessment questionnaires, pre and post-course, as well as interviews with participants and analysis of their personal diaries.

To ensure a comprehensive understanding of the participants' experiences, a mixed-methods approach was adopted. The use of self-assessment questionnaires allowed for quantitative data collection, enabling the measurement of participants' perceptions and changes in various aspects before and after the course. These questionnaires were carefully designed to capture relevant information related to the training process and its impact on the participants, based on previous literature review.

In addition to the questionnaires, qualitative data was gathered through interviews with the participants. These interviews provided an opportunity to delve deeper into their experiences, allowing for a more nuanced understanding of the effects of equine-based learning. The interviews were semi-structured, allowing for flexibility while ensuring that key topics were covered consistently across all participants.

To further enrich the qualitative data, participants were also encouraged to maintain personal diaries throughout the training process. These diaries served as a reflective tool, enabling participants to document their thoughts, emotions, and observations during their interactions with the horses. The analysis of these diaries provided valuable insights into the participants' subjective experiences and the transformative nature of equine-based learning.

Participants were subjected to participant observation during all assignments throughout the course. This method was intended to verify the correctness of the tasks set and their evaluation.

The research was conducted over a period of 10 weeks, during which participants engaged in a series of equine-based learning sessions. The training process involved various activities, such as observation, building trust, following, verbal and non-verbal communication exercises. The participants' progress was monitored throughout the course, ensuring a comprehensive evaluation of the training's effectiveness.

The research was conducted among 2nd and 3rd year cadets from military academies in Poland, Portugal, Austria, Latvia and Romania.

The cadets were given a self-assessment form on communication competence to complete before the course started. In addition, they were assessed by experts (3) on verbal communication, public speaking, and non-verbal communication. The self-assessment form consisted of 10 closed questions with answers on a scale of 1 to 5 (1 lack of communication skills and competencies at the verbal and non-verbal level; 5 communication skills and competencies at a level requiring no further training). The exact form of assessment was used

at the end of the course. In addition, the cadets kept a diary describing the tasks, feelings, fears, and successes after each session. The respondents described their emotions and those of the people they observed. This diary formed part of the final competence assessment. Participant observation was carried out by the teachers and the other workshop participants during the tasks.

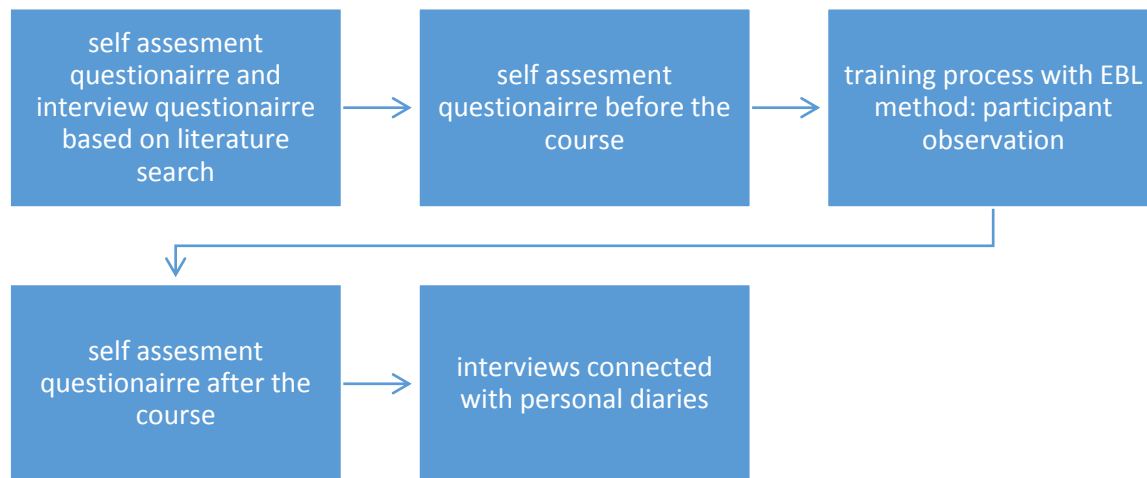


Figure 1. Methodology process.

The workshop consisted of 6 meetings. One meeting lasted between 6 and 8 hours, during which the participants performed the tasks and observed the other participants. Task 5 was done multiple times with different people in the leader position.

Prior to conducting the interviews, an ethnographic approach was taken to begin the research, since few days were spent in the field observing the training before conducting interviews (Van Maanen, 2011). Field notes were kept during that time, which ultimately influenced the development of subsequent interview questions. The purpose of the qualitative study was to answer the question, “What factors of experiential learning in the context of equine-assisted learning contribute to communication competences development?” Semi-structured individual interviews lasting approximately an hour were conducted using an interview protocol to understand the experience of engagement with horses in an organizational learning exercise and how participation in this exercise benefit individuals on a personal and organizational level. From the 72 interviews, 609 pages of transcribed text were analyzed and 963 codable moments were identified using a coding software program (Kuckartz, Radiker, 2019). These codable moments initially fell into 68 codes. Through constant comparative method, the number of codes was reduced as similarities in the data were identified and thematic categories emerged, which allowed us to generalize our findings (Glaser, Strauss, 2017). During the research conducted, results were achieved on the following levels: knowing oneself, communicating at a basic level, building trust, recognising one's role in a team, and being able to communicate non-verbally in an international environment.

4. Results

A qualitative study was conducted with 72 cadets from military universities in European Union (Poland, Portugal, Latvia, Romania, Austria).

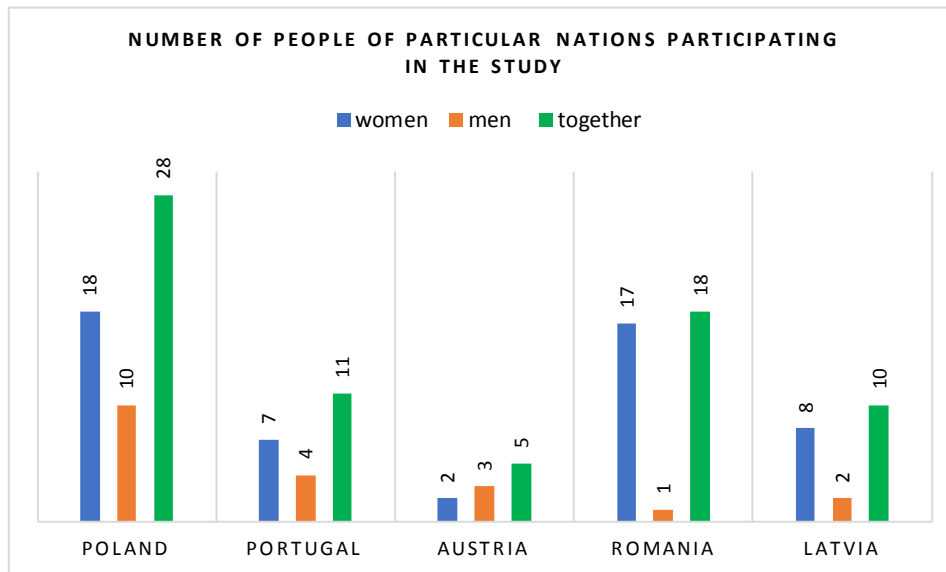


Figure 2. Number of people of particular nations participating in the study.

After each task, the participant was to write their observations and reflections in a diary. What they realised, what strengths and weaknesses they have concerning communication skills.

Table 1.

Learning activities and comments from diaries

No.	Learning task	Activities	Representative quotes (diary)
1	Observation of herd behaviour	The course participants were given a herd of horses to observe while they were at large in a fenced paddock. They had the task of monitoring the hierarchy in the herd, how priority was set, and how the animals communicated with each other	<i>Teacher say, 'Think about a time when you were having to deal with new people and the feedback you were getting from them, and how did you respond? How did you act? Is that similar to how you acted with the horses?'</i> She was 100% right.
2	Establishing contact	One by one, the participants entered a 20m diameter round pen. The most distrustful horses are selected for this task. The participant is tasked with approaching the horse, causing it not to run away and, with the man gone, to come the horse of its own accord.	<i>I found the task at this class stressful, by the number of people watching me, as I don't feel comfortable in the centre of attention. Because it was my second meeting so closely with a horse, I was afraid I wouldn't be able to do it, but I didn't feel anxious about the horse but about my communication abilities. At the same time, I noticed that thanks to the classes and the contact with the animals, I forgot about my private problems. The classes allowed me to clear my head and focus on the task and what was happening to the recipient of my message.</i>

Cont. table 1.

3	Following (non-verbal communication)	The participants individually entered a round pen with a diameter of 20m. There were three gates set up in the centre. He had the task of making the animal follow him through the set 3 gates with his posture and tone of voice. The participant was not allowed to use a halter or, in any other way, forcibly cause it to follow. In two places, the horse was to stand and observe the participant back.	<i>The exercise showed that horses and people can have completely different personalities and be uncomfortable in each other's company, which is why not everyone did the exercise. I must approach each person/horse with a different attitude, tone, and posture. Hardening into one attitude causes more problems than I thought.</i>
4	Working in pairs (verbal communication)	One person gets a horse on a halter, and the other, with their eyes covered, puts their hand on the horse's shoulder. In front of them, they have an obstacle course of gates to cross. The leader explains the path before them so the blind person and the horse pass the obstacle course without harming them.	<i>I felt much more comfortable leading the horse rather than walking beside it. After all the classes, I have gained a lot of confidence in the horses, no longer fear them, and feel more comfortable doing the tasks we have to do in the classes. It is the same when working with people. I have learnt what and how to show the other person to go with me. How do we explain to him what will be in front of us? The confidence-building tasks above all drew my attention to building confidence in myself and trusting my abilities. And that if I trust myself, others will trust me.</i>
5	Giving instructions (verbal communication)	An obstacle course in a fenced area includes gates, a slalom and a bridge. One person designated as leader stands in the middle. The other three people stay with the horse. All persons are blindfolded. One person leads the horse, and the others put their hand on either side of its shoulder blades. The leader's task is to lead the team through the obstacle course.	<i>The exercise made me realise I needed more self-confidence, making it hard to do the obstacle course task. The horse I was doing the task with sensed my stress as I could feel the horse slowing down a step to match my step. As a leader, I already know that I need to embrace the whole group, not just speak to the person who seems to be most active (the person leading the horse), but convey information in a way that everyone understands me (the people walking on either side of the horse).</i>

The overall level of change in the communicative competence of military leaders was examined, as well as its dependence on nation, gender and experience.

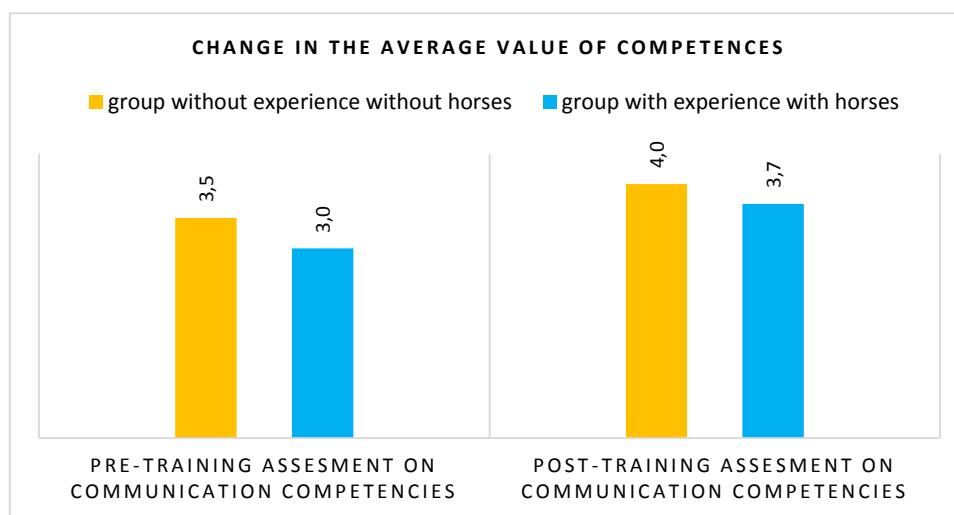


Figure 3. Change in the average value of competences.

As for the group of people (larger) who had no previous experience with horses, progress can be seen in verbal and non-verbal communication. The graph shows the results of cadets from the four countries, as the Portuguese had all experience with horses. Austria's result shows no change in competence due to the small number of participants (5). The largest groups were from Poland (28) and Romania (18); we can see the impact of verbal and non-verbal communication competencies.

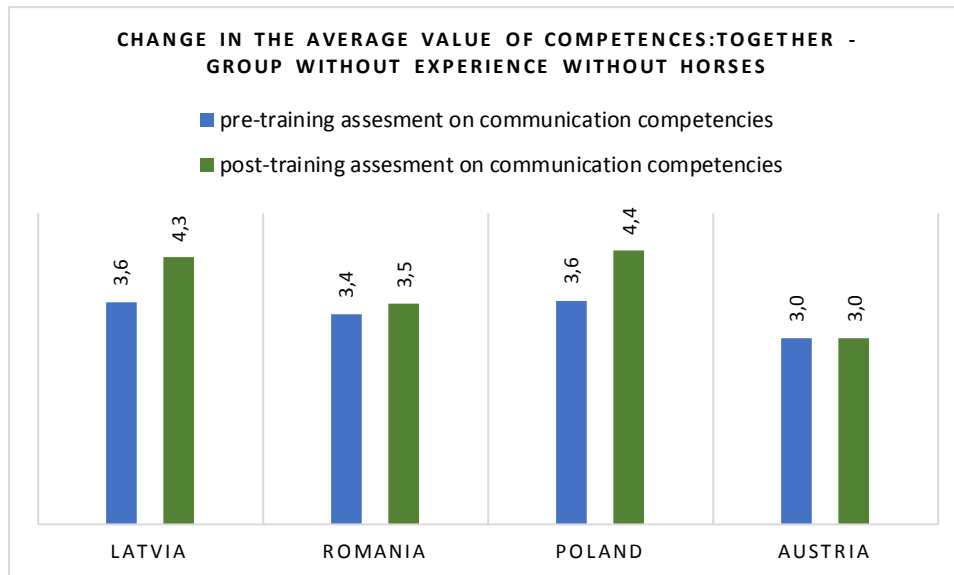


Figure 4. Change in the average value of competences: together – group without experience with horses.

Regarding the cadets from the two countries that include horse riding in their programme, namely Poland and Portugal, we can see a significant improvement in competence among the men from Poland. At the same time, it remained at one level among the Portuguese.

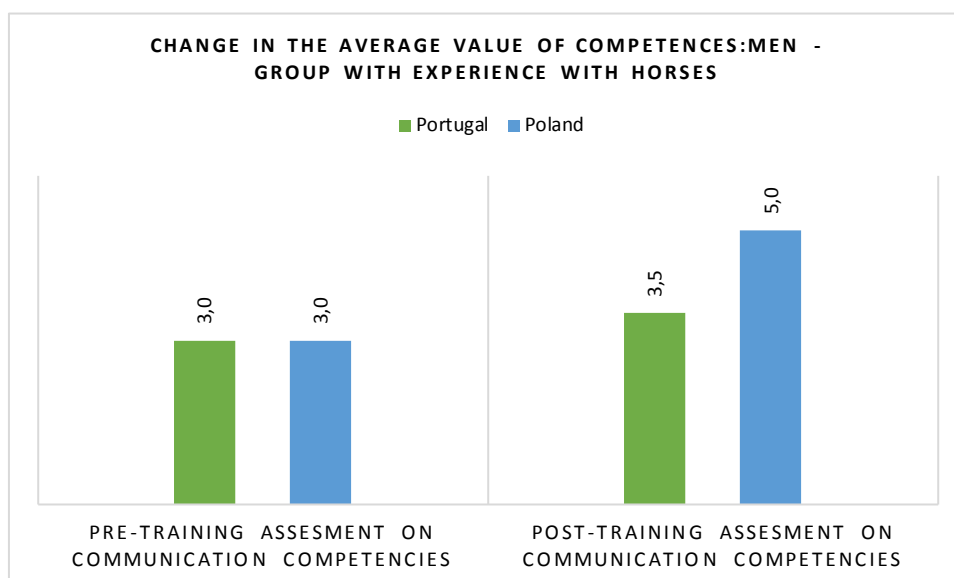


Figure 5. Change in the average value of competences: together – group with experience with horses.

The results are different among women. As far as Polish women are concerned, they show an increase in competence, as do Portuguese women. Only Litvianian women has no change in their competencies.

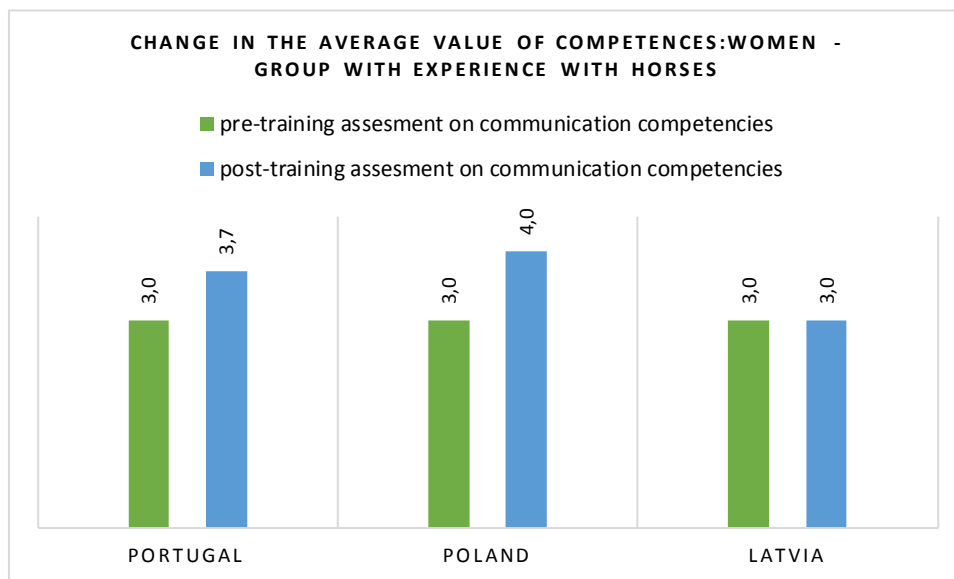


Figure 6. Change in the average value of competences: women – group with experience with horses (due to the nations).

The research results prove that exercises with horses aimed at improving communication competence improve in military leaders, regardless of gender, nationality or previous experience with horses.

5. Discussion

By understanding the impact of equine-based learning on communication skills development, military organizations can make informed decisions about incorporating this approach into their leadership training programs. Ultimately, the goal is to equip military leaders with the necessary communication competences to effectively lead their teams and accomplish their missions.

While there is existing research on equine-based learning in various contexts, there is a need for further exploration of its application in military leadership training. This article aims to contribute to the existing body of knowledge by highlighting the potential of equine-based learning as a valuable tool for enhancing communication competences among military leaders.

Research on a group of cadets had the advantage that research in the army could be called 'laboratory' research. There was no room for personal resentment or refusal to perform tasks here. A handicap in terms of communicative competence was that working in an international environment, the cadets had to speak a language that was not native to any - English.

At the same time, speaking a foreign language facilitated the issue of non-verbal communication, as even among themselves, the cadets often used facial expressions or gestures to achieve the goal of being understood.

As for a linguistic perspective, especially with communicative competence, the question arises about how much the study group members found it difficult to express their opinions in a foreign language. That is, how much of the research results are reliable during the tasks and the final interview. The same exercises should be conducted in the local language, and results should be compared.

Looking from the perspective of the research group, one has to question whether the research sample was sufficient to draw such far-reaching conclusions. In addition, it should be emphasised that the cadets from Poland and Portugal mostly had previous experience with equestrianism, and this may distort the outcome of the study, as they behave more freely around horses and use different communication techniques than humans. For this reason, it is advisable to adapt the tasks to the other groups in terms of experience. It should be noted that those who had previous experience with horses (rode horses) raised their level of competence less than those with no prior contact with horses.

It should also be asked how representative the results of the Austrian and Latvian cadets are. The Austrians partly had a top-down negative attitude towards the exercises given, considering them "meaningless" and "useless". The question is whether this is a national or cultural trait or whether such representatives happened to be in the group.

The cadets taking part in the training were assigned to it by order, which made it impossible to work only with those interested in the subject. Hence, comments such as "it doesn't do anything" or "working with a dumb animal is very different from commanding people" may appear in diaries and during the interview.

To achieve the total result of the research on equine-based learning to improve communication competence, we must focus on a more extensive research group and limit ourselves to one nation. Research should also be done separately among people with equine experience and those without. The specific organisational culture of an institution such as the military also influences the results. The extent of communication competence among soldiers differs from that required by civilian organisations. It would be necessary to carry out training to improve communication competence among employees of institutions with different organisational cultures to draw generalising conclusions.

While equine-based learning is a promising approach to enhancing communication competences among military leaders, further research is needed to explore its long-term effects and its applicability to different organizational contexts, as civilian world.

However, traditional communication training methods may not always adequately address the complex and dynamic nature of communication in the workplace.

6. Conclusion

In recent years, there has been growing interest in alternative approaches to leadership training that incorporate experiential learning and non-traditional methods. One such approach is equine-based learning, which involves interactions between humans and horses to develop leadership and communication skills. Horses have a unique ability to provide immediate feedback and mirror human emotions and behaviors, making them ideal partners for leadership development.

While equine-based learning has been primarily explored in military leadership training, its potential for enhancing communication competences in civilian organizations is promising. By leveraging the unique qualities of horses, such as their ability to provide immediate and honest feedback, equine-based learning can offer managers a dynamic and immersive training experience that enhances their communication skills.

Equine-based learning also promotes self-awareness, as managers must reflect on their communication style and its impact on the horse's response. This self-reflection allows managers to identify their strengths and areas for improvement, leading to personal growth and enhanced communication competences. By gaining insights into their communication patterns and receiving immediate feedback from the horse, managers can make adjustments and refine their communication skills.

Incorporating equine-based learning into manager training programs can offer several benefits for organizations. Firstly, it provides a unique and engaging learning experience that breaks away from traditional classroom settings. The hands-on nature of equine-based learning allows managers to apply their communication skills in a real-world context, making the training more practical and impactful.

Secondly, equine-based learning fosters a sense of teamwork and collaboration. Managers often participate in group activities and exercises with horses, requiring effective communication and coordination among team members. These activities promote a sense of unity and shared purpose, enhancing team dynamics and communication within the organization.

Furthermore, equine-based learning can help managers develop a more empathetic and understanding approach to communication. By interacting with horses, managers learn to read non-verbal cues and respond appropriately, which translates into improved empathy and understanding of their employees' non-verbal communication.

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THE EFFECT OF THE FORM AND LEVEL OF STUDY ON THE TYPE OF PRO-ENVIRONMENTAL ACTIONS TAKEN BY STUDENTS OF HIGHER EDUCATION INSTITUTIONS IN POLAND

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Purpose: The study was conducted to assess the influence of the form and level of study on the type of pro-environmental activities undertaken by university students in Poland.

Design/methodology/approach: The study used a proprietary survey questionnaire consisting of 16 mixed questions. Surveys were collected electronically via the Interankiety.pl online platform between January and March 2023.

Findings: The form and level of study are of little importance to the rationale of tertiary students in Poland when taking pro-environmental actions. Non-stationary students are more likely to be persuaded to take the actions by potential reductions in living costs, while second-level students are more likely to be encouraged to take these actions by caring for their surroundings and the environment.

Research limitations/implications: The research presented in this article has some limitations. Firstly, it was conducted only in Poland, and secondly, only selected pro-environmental measures were taken into account.

Practical implications: Demonstrate the importance of eco-innovation, including its division into product, process and organisational, in the process of creating environmental awareness among students of higher education institutions in Poland.

Social implications: The results of the research should lead universities and state institutions to intensify their various environmental activities.

Originality/value: Evaluation of the influence of the form and level of studies on the type of environmental activities undertaken by university students in Poland.

Keywords: environmental awareness, environmental education, environmental action, ecology, eco-innovation.

Category of the paper: Research paper.

1. Introduction

A domain of today's continuously developing society, there is a very visible trend towards environmental protection. Undoubtedly, the growing environmental awareness of urban and rural residents, which creates the so-called environmental sensitivity of both social groups and individuals, contributes to this (Omoogun et al., 2016). Ecological awareness (Güven, Uyulgan, 2021; Grodzinska-Jurczak, 2000) is understood as "an understanding of the threats posed by the poor state of the environment and the role of the anthropogenic factor in shaping it" (Matel, 2016, p. 57), ecological awareness is not only knowledge of the environment, but first and foremost recognition of the environment as a value and active actions for its protection (Tuszyska, 2017). Improving environmental awareness and sensitivity will help people live in a healthier and safer environment, which is only possible through environmental education (Cetin, Nisanci, 2010).

There are many concepts that refer to environmental improvement. When considering some of them, it is worth noting the so-called futurological vision, whose creator is A. Toffler. He puts forward a very promising forecast for the future that "with the development of an information-based civilisation, ethics will change - it will be the so-called prosumer ethics, which means that man will reject the ethic of getting rich characteristic of the industrial formation, while personal, intellectual, and spiritual values will become important. Thus, human attitudes will become more eco-ethical" (Bugiel, 2002, p. 73).

A. Kuzior, on the other hand, believes that on the basis of two sciences: ecophilosophy and systematic zoology, the socioeconomic and ecological order indicated in the concept of sustainable development can be created (Kuzior, 2007).

Analysing the above trends, one can undoubtedly conclude that the concept of Corporate Social Responsibility is becoming a derivative of them (Wolniak, 2016). One of its key demands is to care for the environment (Sánchez-Torné et al., 2020) by initiating diverse activities that improve its quality, control environmental issues (shaping pro-environmental attitudes of employees). It should not be forgotten that financial benefits are not in all cases the motivation for implementing the concept of Social Responsibility (Jha, Cox, 2015). It is also worth emphasising that pro-environmental attitudes should be shaped not only in the work environment, but at a much earlier stage, before a person enters adulthood. A favourable tool for achieving this goal will be the already mentioned, multifaceted environmental education, which includes diverse forms and encourages innovation. Attention must be paid to the complexity of this process (Ober, 2022), prompting reflection and subsequent effective pro-environmental action.

Referring to the above considerations, the main objective of the study presented in this paper is to assess the impact of the form and level of study on the type of pro-environmental activities undertaken by university students in Poland. The study hypothesises that the form and level of

study differentiate the rationale of university students in Poland when taking pro-environmental actions. The study used a proprietary survey questionnaire consisting of 16 mixed questions. Surveys were collected electronically via the Interankiety.pl online platform between January and March 2023.

The structure of the remainder of the article begins with a review of the literature on environmental education, followed by a characterisation of selected activities that foster environmental protection. This is followed by a description of the methodology used in this study and the results of the analysis and discussion. Finally, conclusions are presented from a scientific and practical point of view.

2. Theoretical background

The literature offers a diverse approach to environmental education (Juzefovi, 2015). It can be defined as 'preparation for participation in response to the global environmental crisis, including the problem of climate change' (Kozłowska, 2021, p. 130). An interesting approach to this issue is presented by H. Sommer and G. Zakrzewski, who believe that "environmental education should not only be implemented through the institutionalised introduction of further subjects in this area, but should also find expression in a programme of unconventional yet effective activities addressed to individual communities" (Sommer, Zakrzewski, 2017, p. 271). Experts emphasise that this concept can be equated with education for sustainable development (Kuzior, 2014) or climate education (Pihkala, 2020). As mentioned earlier, environmental education leads to the creation of pro-environmental attitudes in society and the taking of specific actions to protect the environment. These can include: the use of alternative energy sources (Kuziemska et al., 2015; Gajdzik et al., 2023), the use of alternative and/or environmentally friendly forms of transport (Paziak, Szymaska, 2019), saving of available resources sources energy (Ysik, 2016; Kalda, Fornagiel, 2014), saving of available water resources (Rumianowska, 2013), using modern and energy efficient lighting (Bialoń, Wener, 2015), using rainwater (Bąk, Królikowska, 2016), buying second-hand items (Wilczak, 2019) or repairing damaged electronic equipment (Kubala, Stelmach, 2023). The conscious implementation of these measures will undoubtedly improve the quality of the environment, protecting society from climate catastrophe.

3. Materials and Methods

The study was conducted to assess the influence of the form and level of study on the type of pro-environmental activities undertaken by university students in Poland. The following research questions were formulated:

- Is the uptake of any pro-environmental activities by university students in Poland dependent on the form and/or level of their studies?
- Does the form and/or level of study have an impact on the type of pro-environmental activities undertaken by students at higher education institutions in Poland?
- Does the form and/or level of study make a difference in the rationale of tertiary students in Poland in taking pro-environmental action?
- Do the opinions of students at higher education institutions in Poland on the pro-environmental measures needed to be taken by state institutions and their home university in the near future depend on the form and/or level of their studies?
- Is the assessment of tertiary students in Poland regarding the impact of particular eco-innovations on creating environmental awareness linked to the form and/or level of their studies?
- Does the form and/or level of study influence university students' assessment of the level of environmental awareness in Poland?

The study used a proprietary survey questionnaire consisting of 16 mixed questions. The questionnaires were collected electronically via the Interankiety.pl online platform between January and March 2023. The main focus of this statistical analysis was eco-innovation and the evaluation of its impact on the type of pro-environmental behaviour undertaken in terms of the form and level of study of university students in Poland.

The following statistical methods were used during the analysis: the Shapiro-Wilk test, the Mann-Whitney U test and Pearson's χ^2 test of independence.

The survey was conducted among 1,000 students, including 598 men (59.80%), 376 women (37.60%), and 26 persons of the other sex (2.60%). The majority of students surveyed were studying stationary (69.10%); nearly one in three respondents were studying non-stationary (30.90%). The majority of respondents were in first-degree studies (81.10%); nearly one in five survey participants were in second-degree studies (18.90%).

4. Results and Discussion

4.1. Influence of form and level of study on taking any environmental action

The undertaking of any environmental activities by the students surveyed was not dependent on their form of study. The vast majority of respondents, both stationary and non-stationary students, performed environmental protection activities, with a slightly higher percentage of the former group (82.20% and 78.96%, respectively). However, this difference was not statistically significant, as shown by analysis with Pearson's χ^2 test: $\chi^2(1) = 1.46$; $p = 0.226$; $\phi = 0.038$.

In contrast, the level of study was important for the students surveyed to engage in any pro-environmental activities. Although both first- and second-level students overwhelmingly performed the above-mentioned activities, the percentage of such cases was lower in the former group (80.02% and 86.24%, respectively). The difference observed was found to be statistically significant, as determined by the results of the analysis with Pearson's χ^2 test: $\chi^2(1) = 3.88$; $p < 0.05$; $\phi = -0.062$ (Table 1).

Table 1.

Relationship between the level of study and their taking any environmental action

		Level of study				X ² test	ϕ
		1st degree (n = 811)		2nd degree (n = 189)			
		n	%	n	%		
Taking any environmental action	Yes	649	80.02%	163	86.24%	$\chi^2(1) = 3.88$; $p < 0.05$	-0.062

Source: own elaboration.

4.2. Influence of the form and level of study on the type of environmental action taken

Some of the pro-environmental actions taken by the students surveyed were significantly related to their form of study. It turned out that stationary students were more likely than non-stationary students to use alternative and/or environmentally friendly forms of transport (37.50% and 21.72% respectively); and less likely to use modern and energy-efficient lighting (61.80% and 70.08%, respectively). These differences reached statistical significance, as found in the results of the analysis with Pearson's χ^2 test, both for the use of alternative and/or green forms of transport: $\chi^2(1) = 19.29$; $p < 0.001$; $\phi = 0.154$; and the use of modern and energy-efficient lighting: $\chi^2(1) = 5.1$; $p < 0.05$; $\phi = -0.079$.

The remaining pro-environmental activities did not differ significantly in terms of their uptake between stationary and non-stationary students. In the former group, alternative energy sources were used almost as often as in the latter (34.51% and 35.25% respectively); available energy and/or water resources were saved slightly less often (61.62% and 68.44% respectively), second-hand items were purchased (45.42% and 51.23% respectively) and damaged electronic equipment was repaired (47.71% and 50.41% respectively); and rainwater was used more often

(41.55% and 37.70% respectively). However, the differences observed between the two groups proved to be insignificant. As the analysis with Pearson's χ^2 test showed, there was no statistically significant relationship between the form of study of the respondents and the type of environmental activities they conducted, such as the use of alternative energy sources: $\chi^2(1) = 0.04$; $p = 0.839$; $\phi = -0.007$; saving available energy and/or water resources: $\chi^2(1) = 3.43$; $p < 0.064$; $\phi = -0.065$; using rainwater: $\chi^2(1) = 1.05$; $p = 0.306$; $\phi = 0.036$; buying second hand items: $\chi^2(1) = 2.31$; $p = 0.129$; $\phi = -0.053$; and repairing broken electronic equipment: $\chi^2(1) = 0.5$; $p = 0.481$; $\phi = -0.025$ (Table 2).

Table 2.

Relationship between the form of study and the type of environmental activities they undertake

Type of environmental action taken		Form of study				X ² test	ϕ
		Stationary (n = 568)		Non-stationary (n = 244)			
		n	%	n	%		
Use of alternative energy sources	Yes	196	34.51%	86	35.25%	$\chi^2(1) = 0.04$; $p = 0.839$	-0.007
	Not	372	65.49%	158	64.75%		
Use of alternative and/or environmentally friendly forms of transport	Yes	213	37.50%	53	21.72%	$\chi^2(1) = 19.29$; $p < 0.001$	0.154
	Not	355	62.50%	191	78.28%		
Saving available energy and/or water resources	Yes	350	61.62%	167	68.44%	$\chi^2(1) = 3.43$; $p < 0.064$	-0.065
	Not	218	38.38%	77	31.56%		
Use of modern and energy-efficient lighting	Yes	351	61.80%	171	70.08%	$\chi^2(1) = 5.1$; $p < 0.05$	-0.079
	Not	217	38.20%	73	29.92%		
Use of rainwater	Yes	236	41.55%	92	37.70%	$\chi^2(1) = 1.05$; $p = 0.306$	0.036
	Not	332	58.45%	152	62.30%		
Buying second-hand items	Yes	258	45.42%	125	51.23%	$\chi^2(1) = 2.31$; $p = 0.129$	-0.053
	Not	310	54.58%	119	48.77%		
Repair of damaged electronic equipment	Yes	271	47.71%	123	50.41%	$\chi^2(1) = 0.5$; $p = 0.481$	-0.025
	Not	297	52.29%	121	49.59%		

Source: own elaboration.

The level of study of the students surveyed also influenced some of the environmental actions they took. First-degree students were more likely than second-degree students to use alternative energy sources (36.67% and 26.99%, respectively); and less likely to conserve available energy and/or water resources (61.33% and 73.01%, respectively), buy second-hand items (45.15% and 55.21%, respectively), and repair damaged electronic equipment (46.07% and 58.28%, respectively). Based on the results of the analysis with Pearson's χ^2 test, the above differences were considered statistically significant, both in terms of the use of alternative energy sources: $\chi^2(1) = 5.38$; $p < 0.05$; $\phi = 0.081$; Saving available resources of energy sources and/or water: $\chi^2(1) = 7.68$; $p < 0.01$; $\phi = -0.097$; buying second-hand items: $\chi^2(1) = 5.3$; $p < 0.05$; $\phi = -0.081$; as well as repair damaged electronic equipment: $\chi^2(1) = 7.78$; $p < 0.01$; $\phi = -0.098$.

For the other pro-environmental actions taken by the students surveyed, there was no significant relationship with their level of study. It appeared that first- and second-level students were similarly likely to undertake the other activities, with the former group having

a slightly higher proportion of those using alternative and/or environmentally friendly forms of transport (33.28% and 30.67%, respectively); and a lower proportion of those using modern and energy-efficient lighting (63.79% and 66.26%, respectively) and using rainwater (40.06% and 41.72%, respectively). Analysis using Pearson's χ^2 test showed that there were no statistically significant differences between the two groups in terms of both the use of alternative and/or environmentally friendly forms of transport: $\chi^2(1) = 0.4$; $p = 0.526$; $\phi = 0.022$; use of modern and energy-efficient lighting: $\chi^2(1) = 0.35$; $p = 0.557$; $\phi = -0.021$; as well as the use of rainwater: $\chi^2(1) = 0.15$; $p = 0.7$; $\phi = -0.014$.

4.3. Influence of the form and level of study on the extent to which individual prerequisites encourage environmental action

The degree to which respondents were encouraged to take pro-environmental action by the issue of reducing the cost of living differed between stationary and non-stationary students. It turned out that in the former group, cost-of-living reduction was less likely to encourage the above-mentioned activities ($M_{\text{Stationary}} = 3.93$; $SD_{\text{Stationary}} = 0.91$ and $M_{\text{Non-stationary}} = 4.06$; $SD_{\text{Non-stationary}} = 0.91$). This difference was statistically significant, as shown by analysis with the Mann-Whitney U test: $Z = -2$; $p < 0.05$; $r_g = -0.09$.

The form of study of the respondents, in turn, did not significantly differentiate the degree to which they were prompted to take pro-environmental action for other reasons. Following an ecological trend was such a rationale for stationary and non-stationary students at the same level ($M_{\text{Stationary}} = 2.49$; $SD_{\text{Stationary}} = 1.11$ and $M_{\text{Non-stationary}} = 2.49$; $SD_{\text{Non-stationary}} = 1.19$). Slightly greater differences between the two groups were reported for concern for the environment and surroundings ($M_{\text{Stationary}} = 3.75$; $SD_{\text{Stationary}} = 0.9$ and $M_{\text{Non-stationary}} = 3.79$; $SD_{\text{Non-stationary}} = 0.94$), concern for the health of oneself, family, and loved ones ($M_{\text{Stationary}} = 4.19$; $SD_{\text{Stationary}} = 0.85$ and $M_{\text{Non-stationary}} = 4.2$; $SD_{\text{Non-stationary}} = 0.85$), concern about creating a deficit in available resources ($M_{\text{Stationary}} = 3.42$; $SD_{\text{Stationary}} = 1.01$ and $M_{\text{Non-stationary}} = 3.43$; $SD_{\text{Non-stationary}} = 1.07$), and the desire to improve quality of life ($M_{\text{Stationary}} = 3.95$; $SD_{\text{Stationary}} = 0.94$ and $M_{\text{Non-stationary}} = 3.97$; $SD_{\text{Non-stationary}} = 0.96$); in each case a higher degree among non-stationary students. The results of the analysis with the Mann-Whitney U-test indicate that there were no statistically significant differences between the two groups in terms of the degree of encouragement to take pro-environmental actions by premises such as caring for the surroundings and the environment. $Z = -0.91$; $p = 0.36$; $r_g = -0.04$; Concern for the health of oneself, family and loved ones: $Z = -0.19$; $p = 0.851$; $r_g = -0.01$; concern for creating a deficit in available resources: $Z = -0.27$; $p = 0.79$; $r_g = -0.01$; desire to increase quality of life: $Z = -0.36$; $p = 0.715$; $r_g = -0.02$ and following the trend of ecology: $Z = -0.07$; $p = 0.946$; $r_g = 0$ (Table 3).

Table 3.

Relationship between respondents' form of study and the degree to which they were encouraged by particular premises to take pro-environmental action

	Form of study	Descriptive statistics					Stand error.	Mann-Whitney U test	r _g
		Mean ± Standin g dev.	Median [Q25 - Q75]	Min. - Max.	Confidence interval				
					-95.00%	+95.00%			
Caring for the surroundings and the environment	Stationary (n = 568)	3.75 ± 0.9	4 [3-4]	1-5	3.68	3.83	0.04	Z = -0.91; p = 0.36	-0.04
	Non-stationary (n = 244)	3.79 ± 0.94	4 [3-4]	1-5	3.67	3.91	0.06		
Taking care of yourself, your family and your loved ones	Stationary (n = 568)	4.19 ± 0.85	4 [4-5]	1-5	4.12	4.26	0.04	Z = -0.19; p = 0.851	-0.01
	Non-stationary (n = 244)	4.2 ± 0.85	4 [4-5]	1-5	4.09	4.31	0.05		
Concern for the creation of a deficit in available resources	Stationary (n = 568)	3.42 ± 1.01	3 [3-4]	1-5	3.33	3.50	0.04	Z = -0.27; p = 0.79	-0.01
	Non-stationary (n = 244)	3.43 ± 1.07	3.5 [3-4]	1-5	3.29	3.56	0.07		
Reduction in maintenance costs	Stationary (n = 568)	3.93 ± 0.91	4 [3-5]	1-5	3.85	4.00	0.04	Z = -2; p < 0.05	-0.09
	Non-stationary (n = 244)	4.06 ± 0.91	4 [4-5]	1-5	3.95	4.18	0.06		
Willingness to improve quality of life	Stationary (n = 568)	3.95 ± 0.94	4 [3-5]	1-5	3.88	4.03	0.04	Z = -0.36; p = 0.715	-0.02
	Non-stationary (n = 244)	3.97 ± 0.96	4 [3-5]	1-5	3.85	4.09	0.06		
Keeping up with the green trend	Stationary (n = 568)	2.49 ± 1.11	2 [2-3]	1-5	2.39	2.58	0.05	Z = -0.07; p = 0.946	0.00
	Non-stationary (n = 244)	2.49 ± 1.19	2.5 [1 - 3]	1-5	2.34	2.64	0.08		

Source: own elaboration.

The level of study differentiated the degree of encouragement of pro-environmental actions by also one premise, in this case care for the surroundings and the environment. It turned out that first-degree students were less likely than second-degree students to take pro-environmental actions under the influence of the aforementioned premise ($M_{1 \text{ degree}} = 3.72$; $SD_{1 \text{ degree}} = 0.92$ and $M_{2 \text{ degree}} = 3.94$; $SD_{2 \text{ degree}} = 0.87$). Based on the results of the analysis with the Mann-Whitney U test, the above difference was considered statistically significant. $Z = -2.55$; $p < 0.05$; $r_g = -0.13$.

The other rationales similarly encouraged the students surveyed to take pro-environmental actions, regardless of their level of study. First-degree students were slightly less likely than second-degree students to be driven by concern for the health of themselves, family and loved ones ($M_{1 \text{ degree}} = 4.16$; $SD_{1 \text{ degree}} = 0.87$ and $M_{2 \text{ degree}} = 4.32$; $SD_{2 \text{ degree}} = 0.74$), concern for creating a deficit in available resources ($M_{1 \text{ degree}} = 3.41$; $SD_{1 \text{ degree}} = 1.02$ and $M_{2 \text{ degree}} = 3.45$;

$SD_{2 \text{ degree}} = 1.05$) and reducing the cost of living ($M_{1 \text{ degree}} = 3.95$; $SD_{1 \text{ degree}} = 0.92$ and $M_{2 \text{ degree}} = 4.05$; $SD_{2 \text{ degree}} = 0.87$); and more so the desire to increase quality of life ($M_{1 \text{ degree}} = 3.97$; $SD_{1 \text{ degree}} = 0.95$ and $M_{2 \text{ degree}} = 3.91$; $SD_{2 \text{ degree}} = 0.91$) and following the trend of ecology ($M_{1 \text{ degree}} = 2.49$; $SD_{1 \text{ degree}} = 1.14$ and $M_{2 \text{ degree}} = 2.47$; $SD_{2 \text{ degree}} = 1.12$). These differences were found to be statistically insignificant, in terms of the degree of encouragement of ecological activities by both concern for the health of oneself, family and loved ones: $Z = -1.67$; $p < 0.094$; $r_g = -0.08$; concern about creating a deficit in available resources: $Z = -0.58$; $p = 0.559$; $r_g = -0.03$; reducing the cost of living: $Z = -1.17$; $p = 0.24$; $r_g = -0.06$; desire to improve quality of life: $Z = 0.88$; $p = 0.377$; $r_g = 0.04$; as well as following the ecology trend: $Z = 0.36$; $p = 0.716$; $r_g = 0.02$.

4.4. Influence of the form and level of study on opinions about the environmental measures needed to be taken by state institutions and the home university in the near future

Opinions differed between stationary and non-stationary students on the two environmental measures needed to be taken by state institutions in the near future. The former group attributed greater importance to the expansion of the clean transport zone ($M_{\text{Stationary}} = 3.41$; $SD_{\text{Stationary}} = 1.16$ and $M_{\text{Non-stationary}} = 3.02$; $SD_{\text{Non-stationary}} = 1.3$) and the elimination of pollution emission sources ($M_{\text{Stationary}} = 3.96$; $SD_{\text{Stationary}} = 1.01$ and $M_{\text{Non-stationary}} = 3.69$; $SD_{\text{Non-stationary}} = 1.18$). Analysis with the Mann-Whitney U-test showed that the differences recorded were statistically significant, both in terms of opinion on the extension of the clean transport zone: $Z = 4.12$; $p < 0.001$; $r_g = 0.16$; and opinions on the elimination of emission sources: $Z = 3.03$; $p < 0.01$; $r_g = 0.12$.

The form of study of the respondents was not important for their assessment of the importance of other pro-environmental measures to be taken by state institutions in the near future. Stationary students attributed less importance than non-stationary students to the creation of new cycle paths ($M_{\text{Stationary}} = 3.57$; $SD_{\text{Stationary}} = 1.12$ and $M_{\text{Non-stationary}} = 3.59$; $SD_{\text{Non-stationary}} = 1.19$); and more importance to the creation of cycle parking facilities ($M_{\text{Stationary}} = 3.14$; $SD_{\text{Stationary}} = 1.14$ and $M_{\text{Non-stationary}} = 3.09$; $SD_{\text{Non-stationary}} = 1.23$), increasing subsidies for the purchase of various environmentally friendly solutions ($M_{\text{Stationary}} = 3.69$; $SD_{\text{Stationary}} = 1.09$ and $M_{\text{Non-stationary}} = 3.66$; $SD_{\text{Non-stationary}} = 1.21$), promoting environmentally friendly solutions to a greater extent ($M_{\text{Stationary}} = 3.51$; $SD_{\text{Stationary}} = 1.02$ and $M_{\text{Non-stationary}} = 3.46$; $SD_{\text{Non-stationary}} = 1.14$) and supporting the implementation of eco-innovations ($M_{\text{Stationary}} = 3.7$; $SD_{\text{Stationary}} = 0.95$ and $M_{\text{Non-stationary}} = 3.62$; $SD_{\text{Non-stationary}} = 1.04$). The differences found were considered, based on the results of the Mann-Whitney U-test analysis, to be statistically insignificant, both with regard to the creation of new cycle paths: $Z = -0.59$; $p = 0.558$; $r_g = -0.02$; Creation of parking facilities for cyclists: $Z = 0.27$; $p = 0.784$; $r_g = 0.01$; increase in subsidies for the purchase of various environmental solutions: $Z = -0.07$; $p = 0.948$; $r_g = 0$; Promoting eco-friendly solutions more widely: $Z = 0.42$; $p = 0.675$; $r_g = 0.02$; as well as supporting the implementation of eco-innovations: $Z = 1.03$; $p = 0.302$; $r_g = 0.04$ (Table 4).

Table 4.

Relationship between the form of study of the respondents and their opinions on the pro-environmental measures that state institutions in the near future

	Form of study	Descriptive statistics						Mann-Whitney U test	r_g
		Mean \pm Standard deviation	Median [Q25 - Q75]	Min. - Max.	Confidence interval		Stand error.		
					-95.00%	+95.00%			
Extension of the Clean Transport Zone	Stationary (n = 691)	3.41 \pm 1.16	3 [3-4]	1-5	3.32	3.50	0.04	Z = 4.12; p < 0.001	0.16
	Non-stationary (n = 309)	3.02 \pm 1.3	3 [2-4]	1-5	2.88	3.17	0.07		
Creation of new cycle paths	Stationary (n = 691)	3.57 \pm 1.12	4 [3-4]	1-5	3.49	3.65	0.04	Z = -0.59; p = 0.558	-0.02
	Non-stationary (n = 309)	3.59 \pm 1.19	4 [3-5]	1-5	3.46	3.73	0.07		
Creation of parking facilities for cyclists	Stationary (n = 691)	3.14 \pm 1.14	3 [2-4]	1-5	3.05	3.22	0.04	Z = 0.27; p = 0.784	0.01
	Non-stationary (n = 309)	3.09 \pm 1.23	3 [2-4]	1-5	2.96	3.23	0.07		
Increase in subsidies for the purchase of various environmental solutions	Stationary (n = 691)	3.69 \pm 1.09	4 [3-5]	1-5	3.61	3.78	0.04	Z = -0.07; p = 0.948	0.00
	Non-stationary (n = 309)	3.66 \pm 1.21	4 [3-5]	1-5	3.52	3.80	0.07		
Promoting more environmentally friendly solutions	Stationary (n = 691)	3.51 \pm 1.02	4 [3-4]	1-5	3.44	3.59	0.04	Z = 0.42; p = 0.675	0.02
	Non-stationary (n = 309)	3.46 \pm 1.14	4 [3-4]	1-5	3.34	3.59	0.06		
Eliminating sources of pollutant emissions	Stationary (n = 691)	3.96 \pm 1.01	4 [3-5]	1-5	3.89	4.04	0.04	Z = 3.03; p < 0.01	0.12
	Non-stationary (n = 309)	3.69 \pm 1.18	4 [3-5]	1-5	3.56	3.82	0.07		
Supporting the implementation of eco-innovation	Stationary (n = 691)	3.7 \pm 0.95	4 [3-4]	1-5	3.63	3.77	0.04	Z = 1.03; p = 0.302	0.04
	Non-stationary (n = 309)	3.62 \pm 1.04	4 [3-4]	1-5	3.51	3.74	0.06		

Source: own elaboration.

However, among the pro-environmental measures that the home university in the near future, stationary and non-stationary students differed significantly in their assessment of the importance of greening the University. It turned out that in the former group, the issue of greening the University was considered more important than among non-stationary students ($M_{\text{Stationary}} = 3.93$; $SD_{\text{Stationary}} = 1.07$ and $M_{\text{Non-stationary}} = 3.73$; $SD_{\text{Non-stationary}} = 1.12$). This difference was statistically significant, as shown by analysis with the Mann-Whitney U test: $Z = 2.64$; $p < 0.01$; $r_g = 0.1$.

The other activities to be undertaken by the home university in the near future were rated similarly by the respondents, regardless of the form of study. Stationary and non-stationary students rated the relevance of activities in the form of organising conferences and/or symposia to publicise and promote pro-environmental activities the same or almost the same ($M_{\text{Stationary}} = 2.79$; $SD_{\text{Stationary}} = 1.01$ and $M_{\text{Non-stationary}} = 2.79$; $SD_{\text{Non-stationary}} = 1.07$), organising competitions for the best pro-environmental solutions ($M_{\text{Stationary}} = 3.29$; $SD_{\text{Stationary}} = 1.05$ and $M_{\text{Non-stationary}} = 3.28$; $SD_{\text{Non-stationary}} = 1.1$) and promoting waste separation and resource saving ($M_{\text{Stationary}} = 3.9$; $SD_{\text{Stationary}} = 1.01$ and $M_{\text{Non-stationary}} = 3.89$; $SD_{\text{Non-stationary}} = 1.08$). Slightly greater differences, in favour of the former group, were found when assessing the relevance of activities involving support for environmentally friendly projects ($M_{\text{Stationary}} = 3.88$; $SD_{\text{Stationary}} = 0.96$ and $M_{\text{Non-stationary}} = 3.83$; $SD_{\text{Non-stationary}} = 1.02$), promotion of healthy lifestyles and nutrition ($M_{\text{Stationary}} = 3.72$; $SD_{\text{Stationary}} = 1.1$ and $M_{\text{Non-stationary}} = 3.68$; $SD_{\text{Non-stationary}} = 1.06$) and the inclusion of education in the area of sustainability in all fields and levels of study ($M_{\text{Stationary}} = 3.34$; $SD_{\text{Stationary}} = 1.09$ and $M_{\text{Non-stationary}} = 3.3$; $SD_{\text{Non-stationary}} = 1.16$). As shown by the Mann-Whitney U test analysis, the respondents' form of study did not significantly differentiate their assessment of the relevance of the pro-environmental activities needed to be undertaken by their home university in the near future, such as organising conferences and/or symposia to publicise and promote pro-environmental activities: $Z = -0.09$; $p = 0.928$; $r_g = 0$; organising competitions for best pro-environmental solutions: $Z = 0.11$; $p = 0.909$; $r_g = 0$; Supporting environmentally friendly projects: $Z = 0.38$; $p = 0.704$; $r_g = 0.02$; promoting healthy living and eating: $Z = 0.79$; $p = 0.432$; $r_g = 0.03$; promoting waste separation and resource conservation: $Z = -0.34$; $p = 0.734$; $r_g = -0.01$; and mainstreaming education in the area of sustainability in all fields and levels of study: $Z = 0.35$; $p = 0.726$; $r_g = 0.01$ (Table 5).

Table 5.

Relationship between the form of study and their opinions on the environmental measures that their home university in the near future

	Form of study	Descriptive statistics					Stand error.	Mann-Whitney U test	r_g
		Mean \pm Standing dev.	Median [Q25 - Q75]	Min. - Max.	Confidence interval				
					-95.00%	+95.00%			
Organising conferences and/or symposia to publicise and promote environmental activities	Stationary (n = 691)	2.79 \pm 1.01	3 [2-3]	1-5	2.71	2.86	0.04	Z = -0.09; p = 0.928	0.00
	Non-stationary (n = 309)	2.79 \pm 1.07	3 [2-4]	1-5	2.67	2.91	0.06		
Organising competitions for the best environmental solutions	Stationary (n = 691)	3.29 \pm 1.05	3 [3-4]	1-5	3.22	3.37	0.04	Z = 0.11; p = 0.909	0.00
	Non-stationary (n = 309)	3.28 \pm 1.1	3 [3-4]	1-5	3.15	3.40	0.06		

Cont. table 5.

Supporting environmentally friendly projects	Stationary (n = 691)	3.88 ± 0.96	4 [3-5]	1-5	3.81	3.95	0.04	Z = 0.38; p = 0.704	0.02
	Non-stationary (n = 309)	3.83 ± 1.02	4 [3-5]	1-5	3.72	3.95	0.06		
Promoting a healthy lifestyle and diet	Stationary (n = 691)	3.72 ± 1.1	4 [3-5]	1-5	3.63	3.80	0.04	Z = 0.79; p = 0.432	0.03
	Non-stationary (n = 309)	3.68 ± 1.06	4 [3-4]	1-5	3.56	3.79	0.06		
Promoting waste separation and resource conservation	Stationary (n = 691)	3.9 ± 1.01	4 [3-5]	1-5	3.83	3.98	0.04	Z = -0.34; p = 0.734	-0.01
	Non-stationary (n = 309)	3.89 ± 1.08	4 [3-5]	1-5	3.77	4.01	0.06		
Integration of education for sustainable development in all fields and levels of study	Stationary (n = 691)	3.34 ± 1.09	3 [3-4]	1-5	3.26	3.42	0.04	Z = 0.35; p = 0.726	0.01
	Non-stationary (n = 309)	3.3 ± 1.16	3 [3-4]	1-5	3.17	3.43	0.07		
Greening the University	Stationary (n = 691)	3.93 ± 1.07	4 [3-5]	1-5	3.85	4.01	0.04	Z = 2.64; p < 0.01	0.10
	Non-stationary (n = 309)	3.73 ± 1.12	4 [3-5]	1-5	3.60	3.85	0.06		

Source: own elaboration.

The evaluation of some environmental measures in terms of the necessity for state institutions to undertake them in the near future differed among first and second degree students. In the former group, the importance of measures involving the creation of new cycling paths was less highly ($M_{1 \text{ degree}} = 3.54$; $SD_{1 \text{ degree}} = 1.14$ and $M_{2 \text{ degree}} = 3.75$; $SD_{2 \text{ degree}} = 1.13$), bike parking facilities for cyclists ($M_{1 \text{ degree}} = 3.08$; $SD_{1 \text{ degree}} = 1.16$ and $M_{2 \text{ degree}} = 3.33$; $SD_{2 \text{ degree}} = 1.16$), increased subsidies for the purchase of various environmental solutions ($M_{1 \text{ degree}} = 3.65$; $SD_{1 \text{ degree}} = 1.13$ and $M_{2 \text{ degree}} = 3.84$; $SD_{2 \text{ degree}} = 1.1$) and support the implementation of eco-innovations ($M_{1 \text{ degree}} = 3.64$; $SD_{1 \text{ degree}} = 0.97$ and $M_{2 \text{ degree}} = 3.82$; $SD_{2 \text{ degree}} = 1$). The differences found between the two groups were considered, based on the results of the analysis with the Mann-Whitney U test, to be statistically significant, in terms of opinion regarding both the creation of new cycle paths: $Z = -2.46$; $p < 0.05$; $r_g = -0.11$; Creation of parking facilities for cyclists: $Z = -2.76$; $p < 0.01$; $r_g = -0.13$; Increased subsidies for the purchase of various environmentally friendly solutions: $Z = -2.12$; $p < 0.05$; $r_g = -0.1$; as well as supporting the implementation of ecoinnovations: $Z = -2.32$; $p < 0.05$; $r_g = -0.11$.

However, the level of study was not significant for the opinions of the students surveyed about other environmental measures that state institutions in the near future. First-degree students attributed slightly less importance than second-degree students to measures such as the extension of the clean transport zone ($M_{1 \text{ degree}} = 3.27$; $SD_{1 \text{ degree}} = 1.2$ and $M_{2 \text{ degree}} = 3.38$; $SD_{2 \text{ degree}} = 1.3$), promoting environmentally friendly solutions to a greater extent ($M_{1 \text{ degree}} = 3.48$; $SD_{1 \text{ degree}} = 1.07$ and $M_{2 \text{ degree}} = 3.59$; $SD_{2 \text{ degree}} = 1.02$) and elimination of

pollution emission sources ($M_{1 \text{ degree}} = 3.86$; $SD_{1 \text{ degree}} = 1.07$ and $M_{2 \text{ degree}} = 3.96$; $SD_{2 \text{ degree}} = 1.1$). However, these differences were not significant. As shown by the analysis with the Mann-Whitney U test, the study level of the respondents did not differentiate their opinions on the importance of the environmental measures needed to be taken by state institutions, such as the extension of the clean transport zone. $Z = -1.44$; $p = 0.149$; $r_g = -0.07$; promoting environmental solutions more widely: $Z = -1.17$; $p = 0.241$; $r_g = -0.05$; and elimination of emission sources: $Z = -1.43$; $p = 0.153$; $r_g = -0.07$ (Table 6).

Table 6.

Relationship between respondents' level of study and their opinions on the environmental measures that state institutions in the near future

	Level of study	Descriptive statistics						Mann-Whitney U test	r_g
		Mean \pm Standin g dev.	Median [Q25 - Q75]	Min. - Max.	Confidence interval		Stand error.		
					-95.00%	+95.00%			
Extension of the Clean Transport Zone	1st degree (n = 811)	3.27 \pm 1.2	3 [3-4]	1-5	3.18	3.35	0.04	Z = -1.44; p = 0.149	-0.07
	2nd degree (n = 189)	3.38 \pm 1.3	4 [3-4]	1-5	3.19	3.57	0.09		
Creation of new cycle paths	1st degree (n = 811)	3.54 \pm 1.14	4 [3-4]	1-5	3.46	3.61	0.04	Z = -2.46; p < 0.05	-0.11
	2nd degree (n = 189)	3.75 \pm 1.13	4 [3-5]	1-5	3.59	3.91	0.08		
Creation of parking facilities for cyclists	1st degree (n = 811)	3.08 \pm 1.16	3 [2-4]	1-5	3.00	3.16	0.04	Z = -2.76; p < 0.01	-0.13
	2nd degree (n = 189)	3.33 \pm 1.16	3 [3-4]	1-5	3.16	3.49	0.08		
Increasing subsidies for the purchase of various environmental solutions	1st degree (n = 811)	3.65 \pm 1.13	4 [3-5]	1-5	3.57	3.73	0.04	Z = -2.12; p < 0.05	-0.10
	2nd degree (n = 189)	3.84 \pm 1.1	4 [3-5]	1-5	3.68	3.99	0.08		
Increased promotion of environmental solutions	1st degree (n = 811)	3.48 \pm 1.07	4 [3-4]	1-5	3.40	3.55	0.04	Z = -1.17; p = 0.241	-0.05
	2nd degree (n = 189)	3.59 \pm 1.02	4 [3-4]	1-5	3.44	3.73	0.07		
Elimination of emission sources	1st degree (n = 811)	3.86 \pm 1.07	4 [3-5]	1-5	3.79	3.93	0.04	Z = -1.43; p = 0.153	-0.07
	2nd degree (n = 189)	3.96 \pm 1.1	4 [4-5]	1-5	3.80	4.12	0.08		
Supporting the implementation of eco-innovation	1st degree (n = 811)	3.64 \pm 0.97	4 [3-4]	1-5	3.58	3.71	0.03	Z = -2.32; p < 0.05	-0.11
	2nd degree (n = 189)	3.82 \pm 1	4 [3-5]	1-5	3.68	3.96	0.07		

Source: own elaboration.

Among the pro-environmental activities needed to be undertaken by the home university in the near future, opinions on two such activities differed among first- and second-degree students. The former group attributed less importance to activities such as the support of environmentally friendly projects ($M_{1 \text{ degree}} = 3.84$; $SD_{1 \text{ degree}} = 0.97$ and $M_{2 \text{ degree}} = 3.97$; $SD_{2 \text{ degree}} = 1.01$) and the inclusion of education in the area of sustainability in all fields and

levels of study ($M_{1 \text{ degree}} = 3.29$; $SD_{1 \text{ degree}} = 1.12$ and $M_{2 \text{ degree}} = 3.5$; $SD_{2 \text{ degree}} = 1.06$). Both of these differences reached statistical significance, as demonstrated by analysis with the Mann-Whitney U test. Therefore, the level of study of the respondents differed in their assessment of the importance of environmental activities on the part of the home university, such as supporting environmentally friendly projects: $Z = -2.07$; $p < 0.05$; $r_g = -0.1$ and the inclusion of education in the area of sustainability in all fields and study levels: $Z = -2.17$; $p < 0.05$; $r_g = -0.1$.

Opinions on other pro-environmental activities that the home university of the students surveyed were not dependent on their level of study. Evaluation of the importance of the activity of organising conferences and/or symposiums to publicise and promote environmental activities was almost the same among first and second degree students ($M_{1 \text{ degree}} = 2.78$; $SD_{1 \text{ degree}} = 1.04$ and $M_{2 \text{ degree}} = 2.8$; $SD_{2 \text{ degree}} = 0.98$). In the first group, activities such as organising competitions for the best environmental solutions were considered slightly less necessary ($M_{1 \text{ degree}} = 3.26$; $SD_{1 \text{ degree}} = 1.08$ and $M_{2 \text{ degree}} = 3.41$; $SD_{2 \text{ degree}} = 1.02$), promoting healthy lifestyles and nutrition ($M_{1 \text{ degree}} = 3.67$; $SD_{1 \text{ degree}} = 1.11$ and $M_{2 \text{ degree}} = 3.85$; $SD_{2 \text{ degree}} = 0.98$), promoting waste separation and resource conservation ($M_{1 \text{ degree}} = 3.88$; $SD_{1 \text{ degree}} = 1.02$ and $M_{2 \text{ degree}} = 3.98$; $SD_{2 \text{ degree}} = 1.05$) and greening the university ($M_{1 \text{ degree}} = 3.85$; $SD_{1 \text{ degree}} = 1.09$ and $M_{2 \text{ degree}} = 3.96$; $SD_{2 \text{ degree}} = 1.06$). The results of the analysis with the Mann-Whitney U-test clearly indicate that the two groups did not differ statistically significantly in their evaluations of the pro-environmental activities needed to be undertaken by the home university such as both organising conferences and/or symposia to promote and promote pro-environmental activities: $Z = -0.1$; $p = 0.923$; $r_g = 0$; Organising environmental competitions: $Z = -1.94$; $p < 0.053$; $r_g = -0.09$; Promotion of healthy lifestyles and nutrition: $Z = -1.82$; $p < 0.068$; $r_g = -0.09$; promoting waste separation and resource conservation: $Z = -1.47$; $p = 0.142$; $r_g = -0.07$; as well as greening the University: $Z = -1.36$; $p = 0.175$; $r_g = -0.06$.

4.5. Influence of form and level of study on the assessment of the impact of individual product, process, organisational, and marketing innovations on the creation of environmental awareness

Among product innovations, stationary and non-stationary students differed in their assessment of the two types of innovation in terms of their impact on creating environmental awareness. In the former group, a greater impact was attributed to innovative means of transport ($M_{\text{Stationary}} = 3.27$; $SD_{\text{Stationary}} = 1.04$ and $M_{\text{Non-stationary}} = 3.07$; $SD_{\text{Non-stationary}} = 1.13$), while a lesser impact was attributed to improving the technical properties of products to extend their life cycle ($M_{\text{Stationary}} = 3.59$; $SD_{\text{Stationary}} = 0.95$ and $M_{\text{Non-stationary}} = 3.68$; $SD_{\text{Non-stationary}} = 1.07$). Based on the results of the analysis with the Mann-Whitney U test, the above differences were considered statistically significant, both in terms of assessing the impact of innovative means of transport: $Z = 2.34$; $p < 0.05$; $r_g = 0.09$; and evaluation of the impact of improving the technical characteristics of products to extend their life cycle: $Z = -2$; $p < 0.05$; $r_g = -0.08$.

Stationary students rated at almost the same level as non-stationary students the impact on creating environmental awareness of product innovations such as innovative renewable energy

solutions ($M_{\text{Stationary}} = 3.58$; $SD_{\text{Stationary}} = 0.91$ and $M_{\text{Non-stationary}} = 3.61$; $SD_{\text{Non-stationary}} = 1.02$) and the reduction of toxic substances through the use of new raw materials and intermediates ($M_{\text{Stationary}} = 3.69$; $SD_{\text{Stationary}} = 0.96$ and $M_{\text{Non-stationary}} = 3.7$; $SD_{\text{Non-stationary}} = 0.99$), while the impact of the reduction of non-recyclable elements through the use of new raw materials and intermediates was slightly weaker ($M_{\text{Stationary}} = 3.63$; $SD_{\text{Stationary}} = 0.94$ and $M_{\text{Non-stationary}} = 3.71$; $SD_{\text{Non-stationary}} = 0.96$). As the analysis of the Mann-Whitney U test showed, there were no statistically significant differences between the two groups in the assessment of the impact on creating environmental awareness of product innovations in the form of both innovative renewable energy solutions: $Z = -0.75$; $p = 0.453$; $r_g = -0.03$; reduction of non-recyclable items through the use of new raw materials and semi-finished products: $Z = -1.54$; $p = 0.124$; $r_g = -0.06$; as well as the reduction of toxic substances through the use of new raw materials and intermediates: $Z = -0.41$; $p = 0.685$; $r_g = -0.02$ (Table 7).

Table 7.

Relationship between respondents' form of study and their assessment of the impact of particular product innovations on creating environmental awareness

	Form of study	Descriptive statistics						Mann-Whitney U test	r_g
		Mean \pm Standing dev.	Median [Q25 - Q75]	Min. - Max.	Confidence interval		Stand error.		
					-95.00 %	+95.00 %			
Innovative solutions for renewable energy sources	Stationary (n = 691)	3.58 \pm 0.91	4 [3-4]	1-5	3.52	3.65	0.03	Z = -0.75; p = 0.453	-0.03
	Non-stationary (n = 309)	3.61 \pm 1.02	4 [3-4]	1-5	3.50	3.73	0.06		
Innovative means of transport	Stationary (n = 691)	3.27 \pm 1.04	3 [3-4]	1-5	3.19	3.34	0.04	Z = 2.34; p < 0.05	0.09
	Non-stationary (n = 309)	3.07 \pm 1.13	3 [2-4]	1-5	2.95	3.20	0.06		
Improving the technical properties of products to extend their life cycle	Stationary (n = 691)	3.59 \pm 0.95	4 [3-4]	1-5	3.52	3.67	0.04	Z = -2; p < 0.05	-0.08
	Non-stationary (n = 309)	3.68 \pm 1.07	4 [3-4]	1-5	3.56	3.80	0.06		
Reduction of non-recyclable components by using new raw materials and semi-finished products	Stationary (n = 691)	3.63 \pm 0.94	4 [3-4]	1-5	3.56	3.70	0.04	Z = -1.54; p = 0.124	-0.06
	Non-stationary (n = 309)	3.71 \pm 0.96	4 [3-4]	1-5	3.60	3.82	0.05		
Reduction of toxic substances through the use of new raw materials and intermediates	Stationary (n = 691)	3.69 \pm 0.96	4 [3-4]	1-5	3.62	3.76	0.04	Z = -0.41; p = 0.685	-0.02
	Non-stationary (n = 309)	3.7 \pm 0.99	4 [3-4]	1-5	3.59	3.81	0.06		

Source: own elaboration.

In contrast, none of the process innovations differed between stationary and non-stationary students in their assessment of their impact on creating environmental awareness. The former group attributed a slightly lower, often almost the same impact as the latter group to each of the process innovations analysed, that is, innovative recycling methods ($M_{\text{Stationary}} = 3.81$; $SD_{\text{Stationary}} = 0.89$ and $M_{\text{Non-stationary}} = 3.85$; $SD_{\text{Non-stationary}} = 0.96$), innovative upcycling methods ($M_{\text{Stationary}} = 3.66$; $SD_{\text{Stationary}} = 0.91$ and $M_{\text{Non-stationary}} = 3.68$; $SD_{\text{Non-stationary}} = 1.01$), innovative wastewater and grey water treatment methods ($M_{\text{Stationary}} = 3.67$; $SD_{\text{Stationary}} = 0.92$ and $M_{\text{Non-stationary}} = 3.68$; $SD_{\text{Non-stationary}} = 1.02$), use of innovative energy saving technologies in the production and delivery of products ($M_{\text{Stationary}} = 3.6$; $SD_{\text{Stationary}} = 0.91$ and $M_{\text{Non-stationary}} = 3.61$; $SD_{\text{Non-stationary}} = 0.94$) and the development and implementation of environmentally friendly innovative production and product delivery methods ($M_{\text{Stationary}} = 3.53$; $SD_{\text{Stationary}} = 0.93$ and $M_{\text{Non-stationary}} = 3.62$; $SD_{\text{Non-stationary}} = 0.98$). Analysis with the Mann-Whitney U test showed that there were no statistically significant differences between the two groups in terms of assessing the impact on creating environmental awareness of both innovative recycling methods: $Z = -0.95$; $p = 0.34$; $r_g = -0.04$; Upcycling: $Z = -0.71$; $p = 0.478$; $r_g = -0.03$; Treatment of wastewater and grey water: $Z = -0.67$; $p = 0.504$; $r_g = -0.03$; Use of innovative energy-saving technologies in the production and delivery of products: $Z = -0.14$; $p = 0.888$; $r_g = -0.01$; as well as the development and implementation of environmentally friendly innovative production and product supply methods: $Z = -1.5$; $p = 0.133$; $r_g = -0.06$.

The remote organisation of learning with the use of innovative IT tools was the only organisational innovation that differed in terms of the assessment of its impact on the creation of environmental awareness between stationary and non-stationary students. In the former group, the impact of the aforementioned organisational innovation was rated lower compared to non-stationary students ($M_{\text{Stationary}} = 3.03$; $SD_{\text{Stationary}} = 1.11$ and $M_{\text{Non-stationary}} = 3.23$; $SD_{\text{Non-stationary}} = 1.23$). Based on the results of the analysis with the Mann-Whitney U test, the above difference was considered statistically significant: $Z = -2.47$; $p < 0.05$; $r_g = -0.1$.

For the other organisational innovations analysed, there were no significant differences in the ratings of their impact between the groups of stationary and non-stationary students. The impact of remote work organisation with the use of innovative IT tools on the creation of environmental awareness was rated slightly lower among stationary students compared to non-stationary students ($M_{\text{Stationary}} = 3.13$; $SD_{\text{Stationary}} = 1.05$ and $M_{\text{Non-stationary}} = 3.27$; $SD_{\text{Non-stationary}} = 1.15$). The same was true for evaluations of innovations such as the pro-environmental reorganisation of the company ($M_{\text{Stationary}} = 3.36$; $SD_{\text{Stationary}} = 0.92$ and $M_{\text{Non-stationary}} = 3.39$; $SD_{\text{Non-stationary}} = 1.01$) and the introduction of new quality management systems ($M_{\text{Stationary}} = 3.32$; $SD_{\text{Stationary}} = 0.97$ and $M_{\text{Non-stationary}} = 3.34$; $SD_{\text{Non-stationary}} = 0.99$). In contrast, the creation of an environmental risk department and/or unit in terms of its impact on creating environmental awareness was rated slightly better in the former group ($M_{\text{Stationary}} = 3.17$; $SD_{\text{Stationary}} = 1$ and $M_{\text{Non-stationary}} = 3.1$; $SD_{\text{Non-stationary}} = 1.05$). However, these differences did not reach statistical significance, as shown by the Mann-Whitney U test analysis. This means that the respondents' form of study did not significantly differentiate their

assessments of the impact of organisational innovations, such as remote work organisation with the use of innovative IT tools, on creating environmental awareness: $Z = -1.95$; $p < 0.051$; $r_g = -0.08$; pro-environmental corporate reorganisation: $Z = -0.95$; $p = 0.343$; $r_g = -0.04$; introduction of new quality management systems: $Z = -0.36$; $p = 0.716$; $r_g = -0.01$; and the creation of a department and / or cell of environmental risk: $Z = 1.03$; $p = 0.301$; $r_g = 0.04$ (Table 8).

Table 8.

Relationship between respondents' form of study and their assessment of the impact of particular organisational innovations on creating environmental awareness

	Form of study	Descriptive statistics					Stand error.	Mann-Whitney U test	r_g
		Mean \pm Standing dev.	Median [Q25 - Q75]	Min. - Max.	Confidence interval				
					-95.00%	+95.00%			
Remote organisation of learning with innovative information tools	Stationary (n = 691)	3.03 \pm 1.11	3 [2-4]	1-5	2.95	3.12	0.04	Z = -2.47; p < 0.05	-0.10
	Non-stationary (n = 309)	3.23 \pm 1.23	3 [2-4]	1-5	3.10	3.37	0.07		
Remote working with innovative information tools	Stationary (n = 691)	3.13 \pm 1.05	3 [2-4]	1-5	3.05	3.21	0.04	Z = -1.95; p < 0.051	-0.08
	Non-stationary (n = 309)	3.27 \pm 1.15	3 [2-4]	1-5	3.14	3.39	0.07		
Pro-ecological company reorganisation	Stationary (n = 691)	3.36 \pm 0.92	3 [3-4]	1-5	3.29	3.43	0.03	Z = -0.95; p = 0.343	-0.04
	Non-stationary (n = 309)	3.39 \pm 1.01	3 [3-4]	1-5	3.28	3.51	0.06		
Introduction of new quality management systems	Stationary (n = 691)	3.32 \pm 0.97	3 [3-4]	1-5	3.25	3.40	0.04	Z = -0.36; p = 0.716	-0.01
	Non-stationary (n = 309)	3.34 \pm 0.99	3 [3-4]	1-5	3.23	3.45	0.06		
Creation of an environmental risk department and/or unit	Stationary (n = 691)	3.17 \pm 1	3 [3-4]	1-5	3.10	3.25	0.04	Z = 1.03; p = 0.301	0.04
	Non-stationary (n = 309)	3.1 \pm 1.05	3 [2-4]	1-5	2.98	3.21	0.06		

Source: own elaboration.

Among the marketing innovations, green marketing - the introduction of environmentally friendly marketing methods - was the only one that differed in the assessment of its impact on the creation of environmental awareness between stationary and non-stationary students. It turned out that the former group perceived greater importance of the above-mentioned innovation for creating environmental awareness ($M_{\text{Stationary}} = 3.17$; $SD_{\text{Stationary}} = 1.07$ and $M_{\text{Non-stationary}} = 2.96$; $SD_{\text{Non-stationary}} = 1.16$). Based on the results of the analysis with the Mann-Whitney U test, the above difference reached statistical significance: $Z = 2.39$; $p < 0.05$; $r_g = 0.09$.

The form of study of the respondents, on the other hand, had no significance for their evaluation of the other marketing innovations in terms of their impact on creating environmental awareness. Among stationary and non-stationary students, the impact of innovations involving the introduction of new sales channels based, for example, on healthy food and/or ecology was rated at the same level ($M_{\text{Stationary}} = 3.17$; $SD_{\text{Stationary}} = 0.97$ and $M_{\text{Non-stationary}} = 3.17$; $SD_{\text{Non-stationary}} = 1.04$). In the former group, a slightly higher impact was attributed to innovations such as innovative information campaigns promoting environmental care ($M_{\text{Stationary}} = 3.21$; $SD_{\text{Stationary}} = 0.99$ and $M_{\text{Non-stationary}} = 3.14$; $SD_{\text{Non-stationary}} = 1.07$); changing product packaging to eco-friendly and/or biodegradable ($M_{\text{Stationary}} = 3.75$; $SD_{\text{Stationary}} = 0.99$ and $M_{\text{Non-stationary}} = 3.6$; $SD_{\text{Non-stationary}} = 1.06$); and changing product names to suggest that they were produced by a natural method ($M_{\text{Stationary}} = 2.7$; $SD_{\text{Stationary}} = 1.12$ and $M_{\text{Non-stationary}} = 2.59$; $SD_{\text{Non-stationary}} = 1.2$). The results of the Mann-Whitney U-test analysis indicate that there are no statistically significant differences between the two groups in terms of the evaluation of the impact on creating environmental awareness of marketing innovations such as innovative information campaigns promoting environmental care: $Z = 0.57$; $p = 0.566$; $r_g = 0.02$; introduction of new sales channels based, for example, on healthy food and/or ecology: $Z = -0.04$; $p = 0.97$; $r_g = 0$; changing product packaging to organic and/or biodegradable: $Z = 1.62$; $p = 0.104$; $r_g = 0.06$; and changing product names to suggest that they were produced by a natural method: $Z = 1.39$; $p = 0.165$; $r_g = 0.05$.

The analysis showed that the study level of the respondents differentiated their assessment of the impact of two product innovations on the creation of environmental awareness. First-degree students perceived less impact than second-degree students on innovative means of transport ($M_{1 \text{ degree}} = 3.17$; $SD_{1 \text{ degree}} = 1.09$ and $M_{2 \text{ degree}} = 3.37$; $SD_{2 \text{ degree}} = 1.01$) and the reduction of non-recyclable items through the use of new raw materials and semi-finished products ($M_{1 \text{ degree}} = 3.62$; $SD_{1 \text{ degree}} = 0.95$ and $M_{2 \text{ degree}} = 3.79$; $SD_{2 \text{ degree}} = 0.94$). As shown by the analysis with the Mann-Whitney U test, the differences recorded reached statistical significance, both when assessing the impact of innovative means of transport: $Z = -2.31$; $p < 0.05$; $r_g = -0.11$; as well as the assessment of the impact of the reduction of non-recyclable items through the use of new raw materials and intermediates: $Z = -2.35$; $p < 0.05$; $r_g = -0.11$.

First-degree students also attributed a lower impact on creating environmental awareness to product innovations such as innovative renewable energy solutions than second-degree students ($M_{1 \text{ degree}} = 3.57$; $SD_{1 \text{ degree}} = 0.94$ and $M_{2 \text{ degree}} = 3.68$; $SD_{2 \text{ degree}} = 0.94$), improving the technical characteristics of products to extend their life cycle ($M_{1 \text{ degree}} = 3.61$; $SD_{1 \text{ degree}} = 0.97$ and $M_{2 \text{ degree}} = 3.67$; $SD_{2 \text{ degree}} = 1.08$), and reduction of toxic substances through the use of new raw materials and intermediates ($M_{1 \text{ degree}} = 3.67$; $SD_{1 \text{ degree}} = 0.98$ and $M_{2 \text{ degree}} = 3.78$; $SD_{2 \text{ degree}} = 0.93$). Differences were found to be statistically insignificant based on the results of the analysis with the Mann-Whitney U test, with regard to the assessment of the impact of both innovative renewable energy solutions: $Z = -1.14$; $p = 0.254$; $r_g = -0.05$; improving the technical properties of products to extend their life cycle: $Z = -1.27$; $p = 0.205$; $r_g = -0.06$; and reducing toxic substances through the use of new raw materials and intermediates: $Z = -1.56$; $p = 0.119$; $r_g = -0.07$ (Table 9).

Table 9.

Relationship between respondents' level of study and their assessment of the impact of individual product innovations on creating environmental awareness

	Level of study	Descriptive statistics					Stand error.	Mann-Whitney U test	r _g
		Mean ± Standard deviation	Median [Q25 - Q75]	Min. - Max.	Confidence interval				
					-95.00%	+95.00%			
Innovative solutions for renewable energy sources	1st degree (n = 811)	3.57 ± 0.94	4 [3-4]	1-5	3.51	3.64	0.03	Z = -1.14; p = 0.254	-0.05
	2nd degree (n = 189)	3.68 ± 0.94	4 [3-4]	1-5	3.54	3.81	0.07		
Innovative means of transport	1st degree (n = 811)	3.17 ± 1.09	3 [2-4]	1-5	3.09	3.24	0.04	Z = -2.31; p < 0.05	-0.11
	2nd degree (n = 189)	3.37 ± 1.01	4 [3-4]	1-5	3.23	3.51	0.07		
Improving the technical properties of products to extend their life cycle	1st degree (n = 811)	3.61 ± 0.97	4 [3-4]	1-5	3.54	3.68	0.03	Z = -1.27; p = 0.205	-0.06
	2nd degree (n = 189)	3.67 ± 1.08	4 [3-4]	1-5	3.52	3.83	0.08		
Reduction of non-recyclable components by using new raw materials and semi-finished products	1st degree (n = 811)	3.62 ± 0.95	4 [3-4]	1-5	3.56	3.69	0.03	Z = -2.35; p < 0.05	-0.11
	2nd degree (n = 189)	3.79 ± 0.94	4 [3-4]	1-5	3.66	3.93	0.07		
Reduction of toxic substances through the use of new raw materials and intermediates	1st degree (n = 811)	3.67 ± 0.98	4 [3-4]	1-5	3.61	3.74	0.03	Z = -1.56; p = 0.119	-0.07
	2nd degree (n = 189)	3.78 ± 0.93	4 [3-4]	1-5	3.65	3.92	0.07		

Source: own elaboration.

In the case of process innovations, the assessment of the impact of two such innovations on creating environmental awareness also differed between first- and second-degree students. In the former group, less impact was attributed to the use of innovative energy-saving technologies in the production and delivery of products ($M_{1 \text{ degree}} = 3.57$; $SD_{1 \text{ degree}} = 0.91$ and $M_{2 \text{ degree}} = 3.74$; $SD_{2 \text{ degree}} = 0.92$) and the development and implementation of environmentally friendly innovative production and product delivery methods ($M_{1 \text{ degree}} = 3.53$; $SD_{1 \text{ degree}} = 0.94$ and $M_{2 \text{ degree}} = 3.68$; $SD_{2 \text{ degree}} = 0.97$). With an assumed significance level of $p < 0.05$, significant differences between the two groups were found, based on the results of the Mann-Whitney U-test analysis, in terms of assessing the impact of both the use of innovative energy-saving technologies in the production and delivery of products: $Z = -2.16$; $p < 0.05$; $r_g = -0.1$; as well as the development and implementation of environmentally friendly innovative production and delivery methods: $Z = -2.09$; $p < 0.05$; $r_g = -0.1$.

However, the study level of the respondents was not significant for their assessment of impact of the other process innovations in the context of creating environmental awareness. In the group of first degree students, the impact of innovations such as innovative recycling methods ($M_{1 \text{ degree}} = 3.79$; $SD_{1 \text{ degree}} = 0.93$ and $M_{2 \text{ degree}} = 3.93$; $SD_{2 \text{ degree}} = 0.82$), innovative recycling methods ($M_{1 \text{ degree}} = 3.64$; $SD_{1 \text{ degree}} = 0.94$ and $M_{2 \text{ degree}} = 3.78$; $SD_{2 \text{ degree}} = 0.93$) and innovative methods for treating wastewater and grey water ($M_{1 \text{ degree}} = 3.65$; $SD_{1 \text{ degree}} = 0.97$ and $M_{2 \text{ degree}} = 3.77$; $SD_{2 \text{ degree}} = 0.88$). On the basis of the results of the analysis with the Mann-Whitney U test, the above differences were considered statistically insignificant. This was the case when assessing the impact of innovative methods for both recycling: $Z = -1.56$; $p = 0.12$; $r_g = -0.07$; Upcycling: $Z = -1.94$; $p < 0.053$; $r_g = -0.09$; what wastewater and grey water treatment: $Z = -1.54$; $p = 0.124$; $r_g = -0.07$.

Significant differences were observed between first- and second-degree students in terms of their assessment of the impact on creating environmental awareness of two organisational innovations. The first group perceived a lower impact of remote learning organisation using innovative IT tools ($M_{1 \text{ degree}} = 3.04$; $SD_{1 \text{ degree}} = 1.15$ and $M_{2 \text{ degree}} = 3.32$; $SD_{2 \text{ degree}} = 1.1$) and pro-environmental corporate reorganisation ($M_{1 \text{ degree}} = 3.33$; $SD_{1 \text{ degree}} = 0.94$ and $M_{2 \text{ degree}} = 3.52$; $SD_{2 \text{ degree}} = 0.95$). These differences were found to be statistically significant, as shown by analysis with the Mann-Whitney U test, with regard to the assessment of the impact of both remote learning organisations using innovative IT tools: $Z = -2.88$; $p < 0.01$; $r_g = -0.13$; and pro-environmental corporate reorganisation: $Z = -2.26$; $p < 0.05$; $r_g = -0.11$.

The impact of the creation of an environmental risk department and/or cell on the creation of environmental awareness was assessed almost the same in the study groups distinguished by level of study ($M_{1 \text{ degree}} = 3.15$; $SD_{1 \text{ degree}} = 1.02$ and $M_{2 \text{ degree}} = 3.16$; $SD_{2 \text{ degree}} = 0.98$). Remote work organisation using innovative IT tools was rated slightly lower by first degree students in this respect compared to second degree students ($M_{1 \text{ degree}} = 3.14$; $SD_{1 \text{ degree}} = 1.09$ and $M_{2 \text{ degree}} = 3.31$; $SD_{2 \text{ degree}} = 1.07$); as was the introduction of new quality management systems ($M_{1 \text{ degree}} = 3.31$; $SD_{1 \text{ degree}} = 0.97$ and $M_{2 \text{ degree}} = 3.39$; $SD_{2 \text{ degree}} = 1$). However, the differences noted were not statistically significant, as indicated by the results of the analysis with the Mann-Whitney U test. This was true for both remote work organisations using innovative IT tools: $Z = -1.89$; $p < 0.059$; $r_g = -0.09$; introduction of new quality management systems: $Z = -0.93$; $p = 0.355$; $r_g = -0.04$; and the creation of an environmental risk department and/or unit: $Z = -0.03$; $p = 0.979$; $r_g = 0$ (Table 10).

Table 10.

Relationship between respondents' level of study and their assessment of the impact of particular organisational innovations on creating environmental awareness

	Level of study	Descriptive statistics					Stand error.	Mann-Whitney U test	r _g
		Mean ± Standin g dev.	Median [Q25 - Q75]	Min. - Max.	Confidence interval				
					-95.00%	+95.00%			
Remote organisation of learning using innovative IT tools	1st degree (n = 811)	3.04 ± 1.15	3 [2-4]	1-5	2.96	3.12	0.04	Z = -2.88; p < 0.01	-0.13
	2nd degree (n = 189)	3.32 ± 1.1	3 [3-4]	1-5	3.16	3.48	0.08		
Remote work using innovative IT tools	1st degree (n = 811)	3.14 ± 1.09	3 [2-4]	1-5	3.06	3.21	0.04	Z = -1.89; p < 0.059	-0.09
	2nd degree (n = 189)	3.31 ± 1.07	3 [3-4]	1-5	3.16	3.47	0.08		
Green corporate reorganisation	1st degree (n = 811)	3.33 ± 0.94	3 [3-4]	1-5	3.27	3.40	0.03	Z = -2.26; p < 0.05	-0.11
	2nd degree (n = 189)	3.52 ± 0.95	4 [3-4]	1-5	3.39	3.66	0.07		
Introduction of new quality management systems	1st degree (n = 811)	3.31 ± 0.97	3 [3-4]	1-5	3.25	3.38	0.03	Z = -0.93; p = 0.355	-0.04
	2nd degree (n = 189)	3.39 ± 1	3 [3-4]	1-5	3.25	3.54	0.07		
Creation of an environmental risk department and/or unit	1st degree (n = 811)	3.15 ± 1.02	3 [3-4]	1-5	3.08	3.22	0.04	Z = -0.03; p = 0.979	0.00
	2nd degree (n = 189)	3.16 ± 0.98	3 [3-4]	1-5	3.02	3.30	0.07		

Source: own elaboration.

In contrast, none of the marketing innovations differed between first- and second-degree students in terms of their assessment of its impact on creating environmental awareness. The former group perceived a slightly lower impact of innovative information campaigns promoting care for the environment ($M_{1 \text{ degree}} = 3.17$; $SD_{1 \text{ degree}} = 1.03$ and $M_{2 \text{ degree}} = 3.28$; $SD_{2 \text{ degree}} = 0.94$); the introduction of new sales channels based, for example, on healthy food and/or ecology ($M_{1 \text{ degree}} = 3.15$; $SD_{1 \text{ degree}} = 1.01$ and $M_{2 \text{ degree}} = 3.25$; $SD_{2 \text{ degree}} = 0.92$); changing product packaging to organic and/or biodegradable ($M_{1 \text{ degree}} = 3.69$; $SD_{1 \text{ degree}} = 1.02$ and $M_{2 \text{ degree}} = 3.77$; $SD_{2 \text{ degree}} = 0.99$); change product names to suggest that they were produced by a natural method ($M_{1 \text{ degree}} = 2.66$; $SD_{1 \text{ degree}} = 1.16$ and $M_{2 \text{ degree}} = 2.69$; $SD_{2 \text{ degree}} = 1.09$) and green marketing ($M_{1 \text{ degree}} = 3.1$; $SD_{1 \text{ degree}} = 1.11$ and $M_{2 \text{ degree}} = 3.14$; $SD_{2 \text{ degree}} = 1.06$). The above differences, as shown by the Mann-Whitney U test analysis, did not reach statistical significance. This means that the study level of the respondents did not differentiate their evaluation of the impact on creating environmental awareness of marketing innovations such as innovative information campaigns promoting care for the environment: $Z = -1.12$; $p = 0.265$; $r_g = -0.05$; introduction of new sales channels based, for example, on healthy food and/or ecology: $Z = -1.25$; $p = 0.211$; $r_g = -0.06$; change of product packaging to organic and/or biodegradable: $Z = -0.98$; $p = 0.329$; $r_g = -0.05$; changing product names to suggest they were produced by a natural method: $Z = -0.31$; $p = 0.759$; $r_g = -0.01$; and green marketing - introducing environmentally friendly marketing methods: $Z = -0.49$; $p = 0.627$; $r_g = -0.02$.

4.6. Influence of form and level of study on the assessment of the level of environmental awareness in Poland

The form of study of the respondents did not substantially affect their assessment of the level of environmental awareness in Poland. On a scale of 1-5, stationary students rated the level of the aforementioned awareness almost the same as in the group of non-stationary students ($M_{\text{Stationary}} = 2.37$; $SD_{\text{Stationary}} = 0.83$ and $M_{\text{Non-stationary}} = 2.32$; $SD_{\text{Non-stationary}} = 0.9$). Analysis with the Mann-Whitney U test did not show statistically significant differences in this respect between the two groups: $Z = 1.13$; $p = 0.26$; $r_g = 0.04$.

The assessment of the level of environmental awareness of the students surveyed in Poland was also not related to their level of study. First- and second-degree students rated the level of the above-mentioned awareness almost the same ($M_{1 \text{ degree}} = 2.36$; $SD_{1 \text{ degree}} = 0.85$ and $M_{2 \text{ degree}} = 2.34$; $SD_{2 \text{ degree}} = 0.85$). Based on the results of the analysis with the Mann-Whitney U test, it was found that there were no statistically significant differences between the two groups in terms of the assessment of the level of environmental awareness in Poland: $Z = 0.61$; $p = 0.543$; $r_g = 0.03$.

5. Conclusions

Second-cycle students are more likely to undertake any pro-environmental activities. On the contrary, the form of study is not important for tertiary students in Poland to take this type of action.

Stationary students are more likely to take environmentally friendly measures by using alternative and/or environmentally friendly forms of transport. Non-stationary students are more likely to use modern and energy-efficient lighting, respectively. In terms of degree level, first degree students are more likely to use alternative energy sources, while second degree students are more likely to take cost-saving measures, i.e. save energy and/or water resources, buy second-hand items and repair broken electronic equipment, respectively.

The form and level of study have little bearing on the rationale of tertiary students in Poland to take pro-environmental action. Non-stationary students are more likely to be persuaded to take the above-mentioned actions by potential reductions in living costs, while second-level students are more likely to be encouraged to take these actions by caring for their surroundings and the environment.

The opinions of students of higher education institutions in Poland on some of the pro-environmental actions necessary to be taken by state institutions and their home university in the near future depend on the form and level of their studies. Stationary students in the context of actions on the part of state institutions pay more attention to the necessity of extending the clean transport zone and eliminating sources of pollutant emissions, while with regard to

universities, they pay more attention to greening, respectively. On the other hand, in the case of the degree level, second-level students, in the context of actions necessary on the part of state institutions, consider the creation of new cycle paths and parking facilities for cyclists as more important, as well as an increase in the purchase of various environmentally friendly solutions and support for the implementation of eco-innovations; while with regard to universities, support for environmentally friendly projects and the inclusion of education in the area of sustainable development in all fields and levels of study, respectively.

The research presented in this article has some limitations. Firstly, it was conducted only in Poland, and secondly, only selected pro-environmental measures were taken into account. The results of the study can be used in practice as a kind of guideline for pro-environmental actions taken by students. From the point of view of scientific development, it seems interesting to compare the results obtained with other countries in the world.

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INTERNAL AUDIT AS AN ELEMENT OF THE INTERNAL AUDIT SYSTEM AND ITS DISCLOSURE IN NON-FINANCIAL REPORTSKatarzyna OLEJKO^{1*}, Izabela EMERLING²¹ University of Economics in Katowice; katarzyna.olejko@uekat.pl, ORCID: 0000-0003-2093-8269² Cracow University of Economics, izabela.emerling@uek.krakow.pl, ORCID: 0000-0002-9371-9430

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Purpose: The purpose of this article is to analyse the non-financial disclosures concerning the application of good practices in the area of internal systems and functions in WSE-listed companies and to compare the level of implementation of these practices between companies operating in different sectors. To achieve the assumed goal, research questions were asked: 1) Do WSE-listed companies provide information on the implementation of good practices for internal systems and functions? 2) What is the difference in the level of application of good internal audit practices between WSE-listed companies operating in different sectors?

Design/methodology/approach: The research methods used are based on the study of the literature on the subject and the analysis of non-financial reports of WSE-listed companies (including corporate governance statements, management reports and reports submitted to the WSE).

Findings: Analysed data on the application of BPLC 2021 principles by companies included in the ten economic sectors, i.e.: groceries, banks, automotive, media, energy, mining, chemistry, building fuel and gas telecommunications allowed to confirm that the surveyed companies report non-financial information on the application of the BPLC 2021, and including solutions for internal systems and functions. That the level of application of the rules differs. The highest level of application of the principles concerning internal systems and functions was shown by banks, while the lowest level was found in the automotive group. The highest not comply rate was shown for principle 3.6 on the positioning of internal audit in the company's structure. In the case of banks, the banking law imposes obligations on these institutions to implement appropriate solutions for internal systems and functions. Accordingly, the principles set out in the BPLC 2021 are also implemented.

Originality/value: The implementation of corporate governance is aimed at securing the interests of the owner and the capital invested in the company, as well as the interests of other stakeholders. A very important additional non-financial information from the point of view of corporate governance is information regarding the area of internal control, the reporting of which in non-financial statements is still insufficient.

Keywords: corporate governance, non-financial information, reporting, internal control, audit.

Category of the paper: general review, case study.

1. Introduction

Institutional improvement remains a key area for the smooth functioning of any entity. Internal audit is a tool that allows the search for an organisation's improvement potential. It also offers great research potential and a not fully disclosed area of practical use by management (Lisinski, 2011, p. 9). It is a tool for gaining management and customer confidence. The basic principles of audit in the private and public sectors remain unchanged, and the differences relate to the scope and purpose of the audit (Szczoł, 2014, p. 7). Internal audit seems to be an indispensable management tool, especially in decentralised entities that have complex and complicated processes. Its purpose is to provide the head of the audited entity with information on the results of an objective assessment of the compliance of the functioning of the business with the applicable internal regulations, legal regulations, as well as to provide information on the effectiveness and efficiency of control and management systems in the audited entity (Kiziukiewicz, 2009, p. 9).

The purpose of this article is to analyse the non-financial disclosures concerning the application of good practices in the area of internal systems and functions in WSE-listed companies and to compare the level of implementation of these practices between companies operating in different sectors. To achieve the assumed goal, research questions were asked:

- 1) Do WSE-listed companies provide information on the implementation of good practices for internal systems and functions?
- 2) What is the difference in the level of application of good internal audit practices between WSE-listed companies operating in different sectors?

The article is a research study. In order to better understand the value of the information presented in the non-financial reports of companies listed on the WSE, information on the application of internal audit practices was analyzed based on the WSE's published good practices scanner. This information is published by companies in their corporate governance statements, management reports and in reports sent electronically to the stock exchange.

The study is part of the authors' research interests in internal auditing, corporate governance and non-financial reporting.

2. Importance and objectives of internal audit

The term "audit" comes from the Latin word *audire*, which means to interrogate, examine, listen (Kiziukiewicz, 2009, p. 13). Internal audit is an instrument that actively assesses the efficiency and effectiveness of the internal control system and risk management processes in an active, objective and independent manner, brings added value by revealing deficiencies,

errors and weaknesses and by identifying opportunities to improve the quality of work (Saunders, 2002, p. 36).

As defined by the Institute of Internal Auditors (IIA), internal audit is an activity that provides and advises to improve the functioning of the audited organization. It helps to achieve the set goals through consistent and systematic actions that lead to the improvement of the effectiveness of risk management, organization or control system (Czerwiński, 2005, p. 10). Internal audit is a systematic examination of the correctness and effectiveness of the activities of an entity (entity) by an appropriate specialist – an auditor – over a longer period of time, usually employed full-time in a given entity.

According to the Lexicon of Human Resources Management, the term "audit" means "an in-depth and detailed analysis of the activities of a given organization, conducted by external, independent specialists in order to reveal possible problems or irregularities in its functioning" (Padzik, 2002, p. 5).

W. Lück argues that internal audit " ... It is an independent activity that checks and evaluates the structures and activities within the company. At the same time, it is an independent institution that conducts internal inspections of the company and provides thorough analyses, evaluations, recommendations and information on the structures and activities checked" (Winiarska, 2017, p. 21).

According to L.B. Sawyer, internal audit previously "focused on certifying the accuracy of financial data. Currently, it provides services that include the examination and evaluation of both inspections and the entire activities of public and private entities" (Winiarska, 2017, p. 21).

J. Jagielski believes that internal audit is "a component of the internal control system in the sense that it extends this system with a control, monitoring and advisory mechanism, serving the head of the organization, allowing for the assessment and diagnosis of all processes and states occurring in this unit, primarily in the area of financial resources management, as well as in the organizational and human resources spheres, or in relation to the functioning of internal control and procedures (Jagielski, 2003, p. 14).

According to the International Standards for the Professional Practice of Internal Auditing, "internal audit is an independent, objective assurance and advisory activity aimed at adding value and improving the operations of the organization. It helps an organization achieve its objectives by implementing a systematic, disciplined approach to assessing and improving the effectiveness of risk management controls and management processes" (International Standards for the Professional Practice of Internal Auditing 2016).

Pursuant to Article 272(1) of the Public Finance Act of 27 August 2009 (Journal of Laws of 2009, No. 157, item 1240), the internal audit of [...] is an independent and objective activity, the purpose of which is to support the minister in charge of the department or the head of the unit in the achievement of objectives and tasks through systematic assessment of management control and advisory activities".

An internal audit, which has been carried out correctly, can be an effective management tool. It serves the head of the unit to make sure that:

- The goals that the entity has set for itself are properly implemented.
- Procedures and rules introduced by the head of the unit and resulting from the provisions of applicable law are implemented and complied with,
- The adopted internal control system is effective and adequate, leading to a correct assessment of the entity's operations.

With this information, it is possible to identify irregularities and then take corrective action. The role of auditors is also to look for opportunities to optimize the processes taking place in the entity, both basic and supportive. As a result, the head of the unit minimizes the risk of irregularities and increases the probability that the company is operating properly. In audit practice, therefore, one speaks of a rational assurance. It is a satisfactory level of trust at a certain cost, level of risk and benefits (Kiziukiewicz, 2009, pp. 16-17).

In addition to assuring the head of the unit that it is functioning without major reservations, the audit will also include:

- Analysis of the risks faced by the entity, which will allow to establish an audit program and assess the effectiveness of risk management processes.
- Submission of reports on findings and presentation of conclusions and comments leading to the improvement of the current situation of the entity.
- Provide an opinion on the effectiveness of the control mechanisms in the audited System (Ministry of Finance, 2003, p. 7).

3. Brief history and development of the audit according to historians

The history of the auditor's profession is many years old and, according to historians, it is very interesting. Around 3000 BCE, writers in the Mesopotamian civilization used dots, hooks, and other stamps for an advanced system of internal control (Kiziukiewicz, 2009, p. 25). The Egyptians required grain deliveries to the granary in the presence of a witness and required a receipt for the goods. According to references from English and French, an auditor is a listener or auditor of books in the economic practice of the time. The first documents that confirm the verification of data by auditors date back to the Mesopotamian civilization. Originally focused mainly on auditing financial documents in the 1930s with the establishment of the US Stock Exchange, auditing slowly began to divide into external and internal. In the development of internal auditing, a landmark event was the establishment of The Institute of Internal Auditors (IIA) by 24 people in 1941.

Over the past few years, internal audit in Poland has changed its role from a verifier who analyses events, transactions "post factum" and reacts to reported irregularities, to an advisor in risk management processes who focuses on preventing and counteracting errors or inaccuracies. Analysing the historical evolution of internal audit in a simplified way, we can distinguish four generations of audit, following each other:

- First generation (pre-1980 events).

The internal audit conducted in the first generation was focused on the applicable processes, internal control systems, procedures and rules existing in the entity. The auditor's work focused mainly on checking the compliance of the actual state with the documented accounting state. When differences from the applicable procedures and standards were detected, they were classified as irregularities, and the people who were guilty of these differences were held accountable, and professional consequences were drawn (Banaszkiewicz et al., 2003, pp. 14-15).

- Second generation (1980-1989).

In the second generation, internal audit evolved from ex post to ex ante, with more and more reference to the concept of risk. In their work, the auditors focused on the economic risks that accompanied the entity's operations, on the key and most important issues. The verification of economic risks began with the examination of financial risks, due to the clarity of understanding of these risks. This generation, in addition to focusing on economic risks, also focused the auditor's attention on the verification of the internal control system and their procedures. After examining the internal control procedures and issuing a positive assessment, the auditor began to check their operational effectiveness (Banaszkiewicz et al., 2003, p. 15).

- Third generation (1990-1998).

Internal audit has expanded its activity of identifying the risk of financial activity areas to include the risk of operating areas (Winiarska, 2007, p. 34). Financial risks have been exceeded. The internal auditor began his or her activities by getting to know the environment in which the entity operates, its research, as well as the processes and goals that are pursued by the entity. The main focus was on the evaluation of the functioning of the internal control system. The work focused on comparing the optimal shape of the internal control system that actually functioned with the solutions that were included in the procedures.

- Fourth generation (after 1999).

Due to the dynamically changing environment of the entity, the ongoing changes in its operations and a sharp increase in risk, which threatened the continuation of the entity's operations and even its existence, they caused further changes in the conduct of internal audits. Organizations must maintain an active risk management policy in order to adapt to the changes that are taking place in the market and properly prepare for the new challenges ahead. Individuals are aware of the threat, which is why they carry out activities aimed at identifying, reducing or eliminating them completely.

4. The use of selected Best Practices of Companies Listed on the Warsaw Stock Exchange concerning internal audit

Nowadays, due to the growing information needs, there is a noticeable expansion of financial statements towards business reports, otherwise known as annual reports (Samelak, 2013, p. 115). According to the definition proposed by J. Samelak (Samelak, 2013, p. 188), an annual report is a collection of financial and non-financial statements. It is necessary to properly present, understand the context, diagnose and assess the effects of the company's operations and resources, as well as its current and future market and financial situation. Good practices, as a set of principles of corporate governance and principles defining the norms of shaping relations between listed companies and their market environment, have become an important instrument strengthening the competitiveness of the market (Dunlop quoted in: Rudolf et al., 2002, p. 32). Acting with the intention of strengthening the principles of corporate governance as an instrument increasing the competitiveness of the market (Dobija, Kołodkiewicz, 2011, p. 13), the Warsaw Stock Exchange has established the basic principles of corporate governance, taking into account the beliefs and expectations of investors associated with the WSE and issuers listed on the WSE (WSE Best Practices of Companies Listed on the Warsaw Stock – BPCL 2021).

Various events contributed to the creation of the internal audit in companies, including: scandals and bankruptcies of large companies and corporations in the United States, such as Enron and World Com. This was reflected in the Code of Good Practice prepared by GPW and adopted by the companies, and also influenced the shape of corporate governance in Poland.

Corporate governance focuses primarily on the proper functioning of the company, including its bodies, risk management processes, internal audit, as well as the promotion of ethics among both employees and managers. Corporate governance reports are also presented on the WSE website in the form of a good practice scanner.

Separate laws define the types of information obligations imposed on public companies, presented in Figure 1.

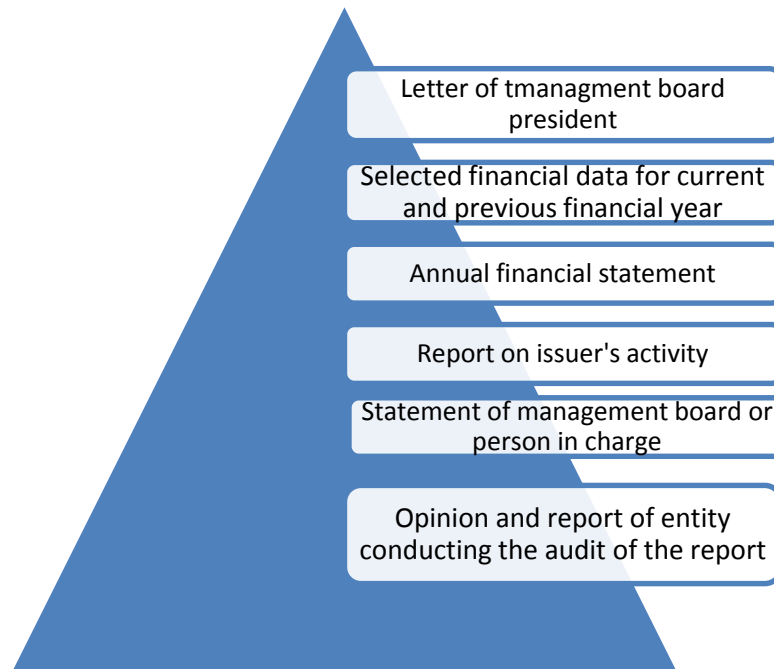


Figure 1. Elements of the public companies report.

Source: Emerling, Olejko, Kaczmarczyk-Grabowska, 2022, p. 74.

Proper fulfilment of the disclosure obligations results in:

- increase in investor confidence,
- reduction of costs related to raising capital,
- reduction of costs related to the issue of bonds,
- rating upgrades,
- reducing the costs of monitoring the broadly understood market, which results in indirectly reducing investors' expectations as to the return on investment (Zaleśkiewicz, 2015, p. 3).

Until 2014, the practice of disclosing non-financial data was a voluntary element of reporting (Krasodomska, 2014, p. 62).

The features that distinguish non-financial information from financial information include, among others:

- the relative youth of non-financial data, as it began to be disclosed less than 25 years ago, while financial data has been disclosed for 500 years,
- significant subjectivity of non-financial information caused by the lack of an obligation to verify it by statutory auditors,
- the possibility of publishing non-financial data of a prospective nature.

In Poland, according to Article 49 (1) of the Accounting Act, there is an obligation to attach to the financial statements the so-called management report on the company's activities. The management report is a mandatory element in the reporting of limited liability companies, limited joint-stock partnerships, mutual insurance companies, mutual reinsurance companies, cooperatives, as well as state-owned enterprises. The management report, prepared by the head

of the entity, is, as it were, a supplement to the financial statements. In addition, if an entity's financial statements are subject to mandatory audit by a certified public accountant, the management report is also subject to audit.

The obligation to disclose non-financial information, which arises from Directive 2014/95/EU, applies to certain large entities and capital groups, i.e. the so-called public interest entities (HUs), which meet one of two financial conditions:

- average annual employment exceeds 500 people,
- The balance sheet total at the end of the financial year exceeds PLN 85 million or the net revenues from the sale of goods and products for the financial year exceed PLN 170 million.

Public companies are also required to disclose the status of good practices in so-called Corporate Governance Statements. These statements can be presented in a separate report or in the company's management report. The new rules require larger companies in the European Union to disclose non-financial information on an annual basis on environmental, social and employee matters, respect for human rights and anti-corruption.

In order to present the non-financial information published by companies, regarding the internal audit function, companies in the food, banking, automotive, media, energy, mining, chemical, construction, fuel and telecommunications sectors were analyzed on the basis of reports on the application of good practices presented by the WSE in the good practices scanner.

Companies listed on the WSE are required to report information on the implementation of the principles indicated in the BPLC2021 document developed by the WSE (Olejko, 2023). In 2021 the Warsaw Stock Exchange made available on its website the so-called best practice scanner, i.e. a tool that enabled ongoing monitoring of the level of Company's compliance with the solutions regarded as mechanisms increasing the effectiveness of corporate governance. This report is an important element of the companies' non-financial disclosures about the company. These reports allow an analysis of the company's application of internal audit principles.

The important role of internal systems and functions, including internal audit, in reducing the risk of irregularities and increasing organisational effectiveness is confirmed by their inclusion in the BPLC2021 regulations. In Chapter 3 (Table 1) Internal Systems and Functions, recommendations are made on the use of internal audit as a function to support corporate governance.

This part of the study reviewed reports on the application of good practices of WSE-listed companies and assessed the degree of application of recommendations on the functioning of internal audit in 10 selected company sectors.

Table 1.
Structure of Best Practice for WSE Listed Companies 2021

No.	Chapter
1.	Information policy and communication with investors
2.	Management Board and Supervisory Board
3.	Internal systems and functions
4.	General meeting and relations with shareholders
5.	Conflict of interest and transactions with affiliated entities
6.	Remuneration

Source: Best Practice for WSE Listed Companies 2021.

Based on the analysis of the data provided by the WSE in the BPLC2021 scanner and the 'not comply' indicator, the level of implementation of the core principles was assessed (Fig. 2).

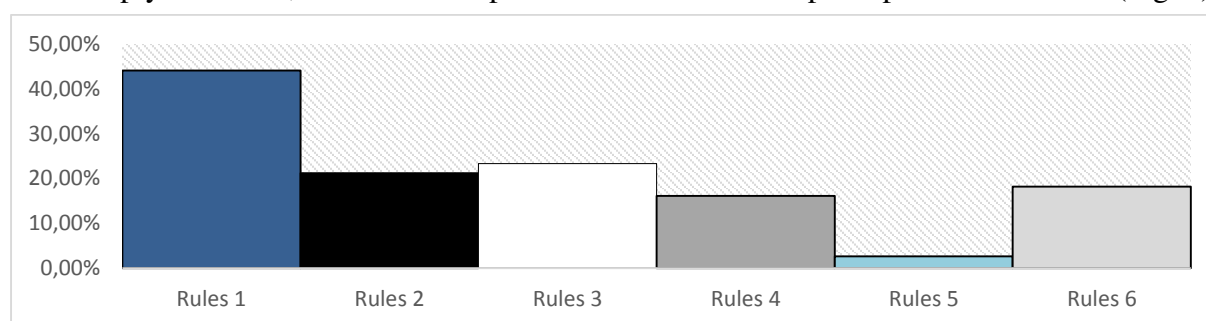


Figure 2. Average % of “not complied” – general rules (companies listed on the WSE in total).

Source: Prepared by the author based on The best practices scanner, <https://www.gpw.pl/dpsn-skaner>, 9.12.2023.

On the basis of the analysis carried out of the level of application of the basic principles, it was found that Principle 1 and Principle 3 (Table 2) showed the highest level of responses in the questionnaire 'not complied'.

Table 2.
Selected basic rules

Selected basic rules	
Rule 1	In the interest of all market participants and its own, a listed company shall ensure proper communication with its stakeholders by pursuing a transparent and reliable information policy.
Rule 3	Efficiently operating systems and internal functions are an indispensable tool for exercising supervision over the company. The systems cover the company and all areas of its group's operations that have a significant impact on the company's situation.

Source: Prepared by the author based on The best practices scanner, <https://www.gpw.pl/dpsn-skaner>, 9.12.2023.

The % 'not comply' responses rate for system and internal function specific rules, including internal audit, is presented below (Fig. 3).

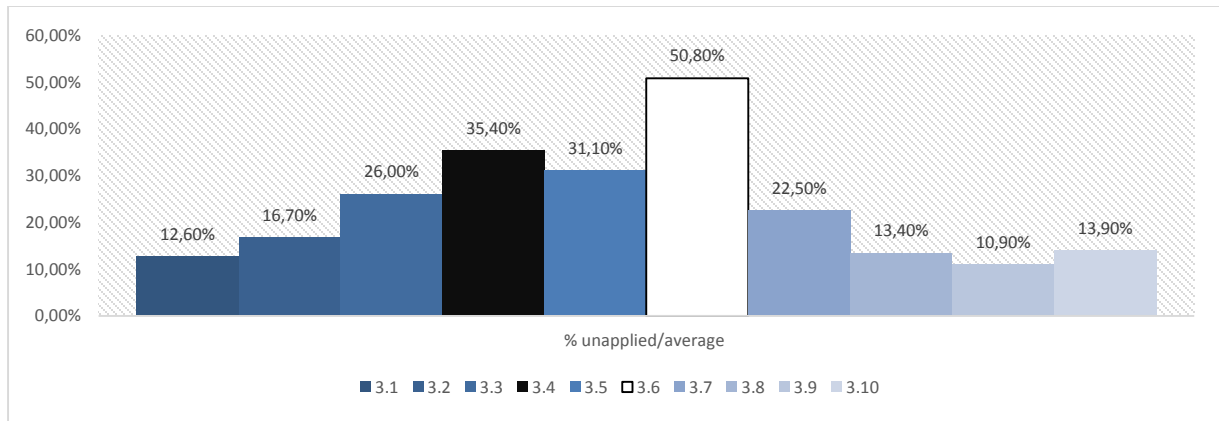


Figure 3. Average % of “not complied” rules answers – rules 3– companies listed on the WSE in total.

Source: Prepared by the author based on The best practices scanner, <https://www.gpw.pl/dpsn-skaner>, 9.12.2023.

On the basis of the analysis carried out, it can be concluded that among the detailed rules for internal systems and functions, the lowest level of application is shown for rule 3.6. according to which “The internal audit head reports organisationally to the president of the management board, and functionally - to the chairman of the audit committee or the chairman of the supervisory board, if the board performs the function of the audit committee. “

Research on the application of the principles carried out in a cross-section of companies belonging to the 10 selected sectors (fig. 4) confirmed the previous findings that the highest percentage of companies deviates from the implementation of the principles of the Information policy and communication with investors.

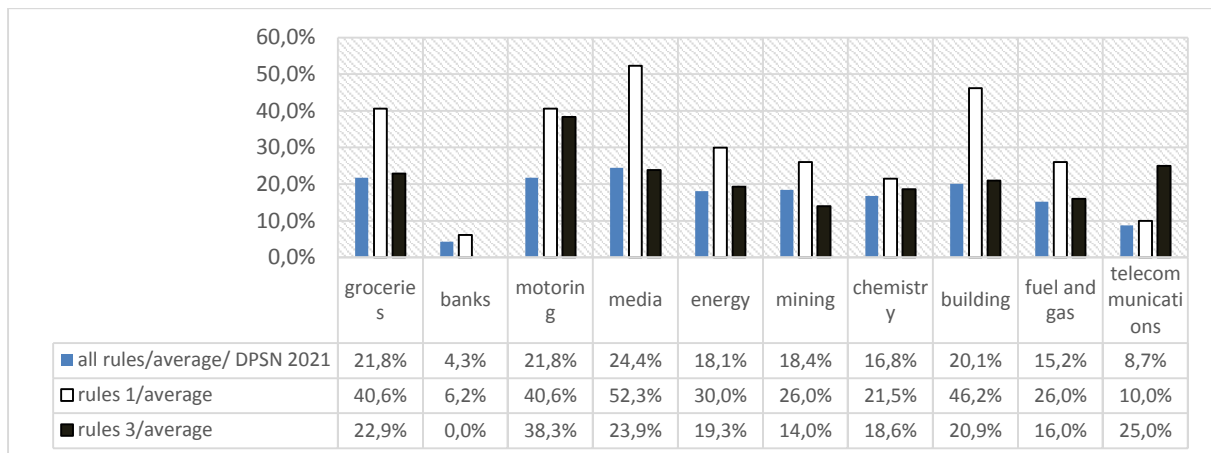


Figure 4. Average % of “not complied” rules answers – companies listed on the WSE in total.

Source: Prepared by the author based on The best practices scanner, <https://www.gpw.pl/dpsn-skaner>, 9.12.2023.

An analysis of the level of “not complied” with basic rule 3 showed that the group of companies belonging to the automotives sector showed the highest "not comply" rate (Fig. 5). The banks fully implement all principles regarding internal systems and functions.

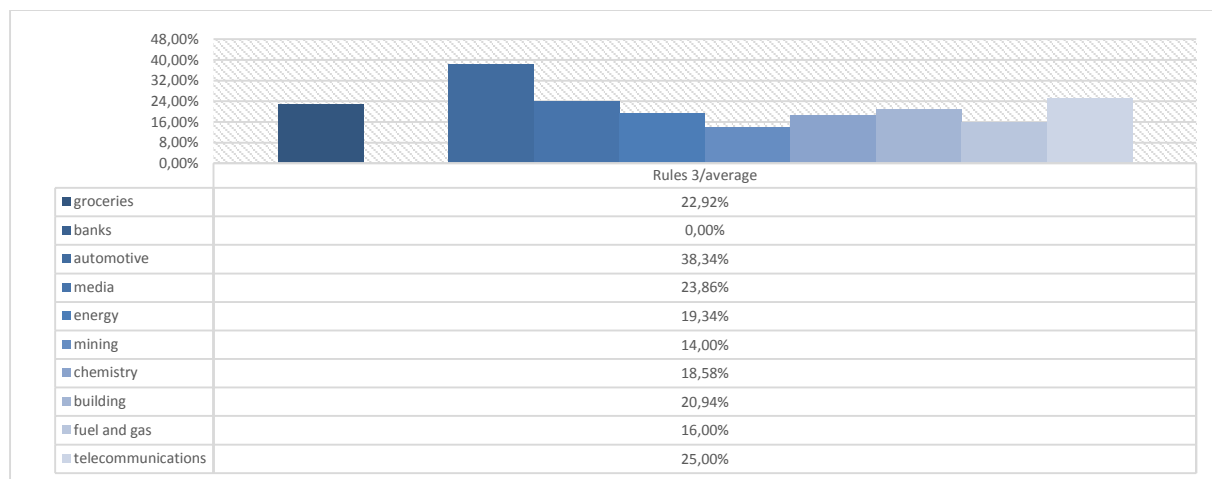


Figure 5. Rules 3 - internal systems and functions/average/"not complied" in sectors by WSE.

Source: Prepared by the author based on The best practices scanner, <https://www.gpw.pl/dpsn-skaner>, 9.12.2023.

Presented below are the results of an analysis of the application of detailed rules concerning the system and internal functions by companies across the sectors analysed. The research confirmed significant differences between groups of companies and showed that the dominant one in terms of the level of non-implementation is principle 3.6 (Fig. 6).

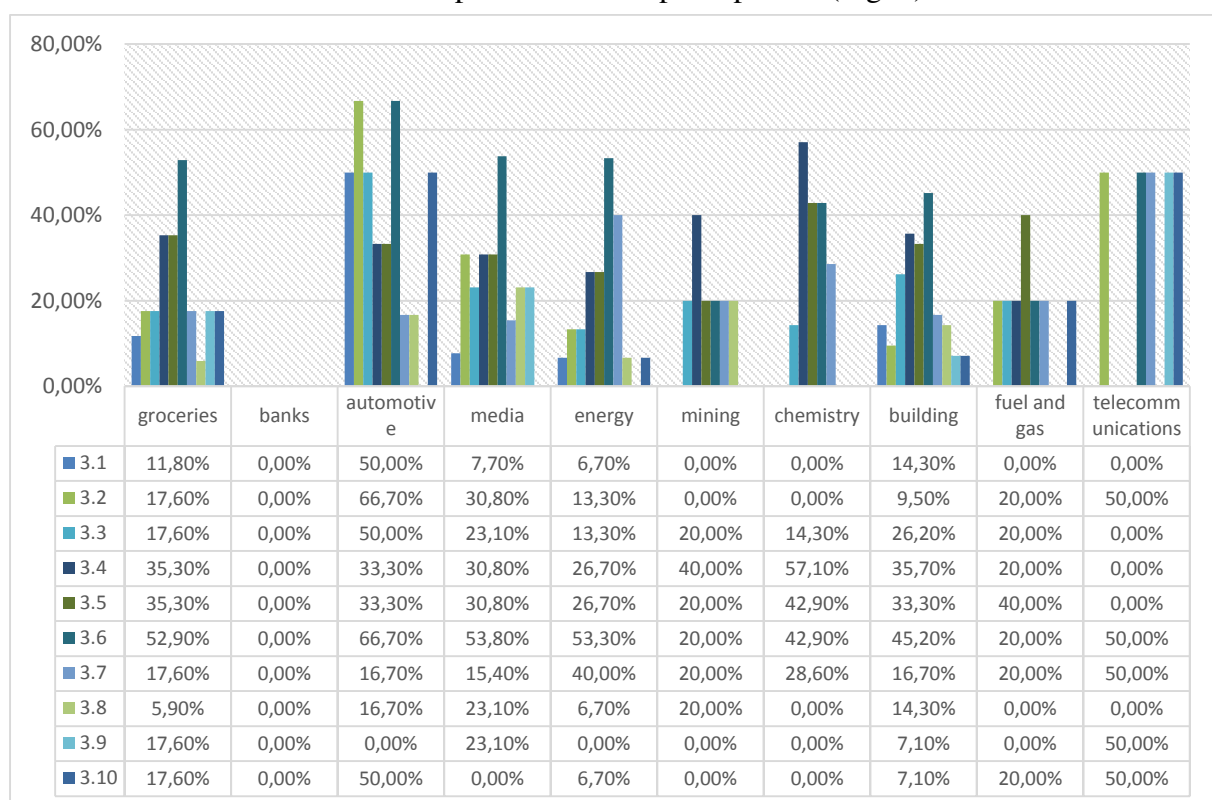


Figure 6. Average % of "not complied" rules 3 answers – companies listed on the WSE by sectors.

Source: Prepared by the author based on The best practices scanner, <https://www.gpw.pl/dpsn-skaner>, 9.12.2023.

The research carried out confirmed that reports on the application of good practices of companies listed on the WSE are an important source of non-financial information on the company and its operation. They allow for cross-sector comparisons.

The analysed data on the application of the BPLC 2021 rules by the companies included in the ten sectors, i.e.: groceries, banks, automotive, media, energy, mining, chemistry, building, fuel and gas, telecommunications, allowed us to confirm that the surveyed companies report non-financial information on the application of the BPLC2021, including solutions for internal systems and functions.

Investigations into the level of implementation of the rules on internal systems and functions described in Chapter 3 of the BPLC2021 indicate the application or non-application of best practices for internal audit. After analysing data on companies from different industries, the level of application of the principles was found to differ. Banks showed 100% application of the rules regarding internal systems and functions, while the lowest level was found in the automotive group. The highest not comply rate was shown for rule 3.6 on the location of internal audit in the company's organisational structure.

It should be emphasised that banks, in accordance with the Banking Act of 29 August 1997, are obliged to strictly comply with the regulations on internal control systems and internal audit. The statutory solutions are consistent with the rules set out in the BPLC2021 which explains the full implementation of the BPLC2021 from this area.

The highest not comply rate among the groups of companies analysed was shown for the automotive sector for:

- Rule 3.1 according to which: A listed company shall maintain effective systems of internal control, risk management and compliance and an effective internal audit function appropriate to the size of the company and the nature and scale of its business, the operation of which shall be the responsibility of the board of directors.
- Rule 3.3, the appointment of an internal auditor to head the internal audit function, operating in accordance with generally accepted international standards for the professional practice of internal auditing.
- rule 3.6, The head of internal audit reports organisationally to the chairman of the board of directors and functionally to the chairman of the audit committee, or to the chairman of the supervisory board if the board acts as an audit committee.
- rule 3.10, according to which a review of the internal audit function shall be carried out at least once every five years in a company included in the WIG20, mWIG40 or sWIG80 index by an independent auditor selected with the participation of the audit committee.

In the case of rule 3.4, according to which: the remuneration of the persons responsible for risk management and compliance and the head of internal audit should depend on the performance of the assigned tasks and not on the company's short-term results, the highest not comply rate was found in the chemicals sector.

In the case of rule 3.8, according to which, at least once a year, the person in charge of internal audit presents to the supervisory board an assessment of the effectiveness of the functioning of internal systems and functions, the highest not comply rate was found in the group of companies belonging to the media sector.

5. Summary

The considerations carried out in this article confirm the importance of non-financial information published by companies. On their basis, the stakeholder has the opportunity to assess the activities of company management boards in building effective control systems, including internal audit. In this way, it can assess the risk of possible loss of capital. It is also possible to make inter-sector and company comparisons. The analysis also confirmed that the principles are fully implemented by those entities that are obliged to apply certain solutions by law. Others, using the voluntary "comply or explain" principle, often do not apply the proposed solutions. However, this may discourage potential investors. In the case of internal audit rules, lack of application indicates an increased risk of irregularities.

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SOCIAL CAPITAL AND ITS REPORTING – CASE STUDY OF SELECTED POLISH COMPANIES LISTED ON THE WARSAW STOCK EXCHANGE

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Purpose: Drawing attention to the increasing role of non-financial information, including this referring to social capital, in the process of complex company evaluation and verifying assumptions that socially responsible companies enhance the supportive activities of their employees directed at building social capital within the organization, and present valuable information about such activity in their non-financial reports.

Design/methodology/approach: In order to verify the above assumptions, the study was conducted on a random sample of 6 companies engaged in industrial activities, companies listed on the Warsaw Stock Exchange, and included in the WIG-ESG index. An analysis and evaluation were based on the annual reports for 2022, as well as the content published on the websites.

Findings: For companies to present achievements in building social capital measures enabling comparisons would be necessary as well as tools supporting their introduction. So far such needs have not been explicitly addressed and remain unnoticed.

Research limitations/implications: Limitations refer to poorly addressed enhancement of employees' initiative to show real engagement rather than triggered by management obliged to report non-financial information. Implications involve the necessity to design measures capable of demonstrating the effectiveness of strategies employed by companies reporting numerous activities aimed at building social capital. Research would be useful to verify how the activities affect civic engagement.

Practical implications: Reports on non-financial information should include activities that are undertaken following employees' initiative. They should also show interest in proving their effectiveness and contribution to long-term core organizational values development.

Social implications: The article should impact society by addressing relevant issues of CSR (non-financial) reporting in its social dimension. It indicates gaps and deficiencies in the way of designing social policies by companies and points directions that may lead to better understanding of the role of individual employees who should be empowered and accountable in the process of building social capital. Such changes could enable authentic and long-lasting civic engagement that can benefit individuals and society as a whole.

Originality/value: The article approaches non-financial reporting from a different perspective. While presenting the advantages of the new standards visible in numerous activities undertaken by firms, it identifies areas of improvement to ensure this sort of reporting can genuinely strengthen social capital and civic engagement. It is addressed to companies and other decision-makers to indicate how reporting should evolve and what are its missing elements.

Keywords: social capital, non-financial reporting, social engagement.

Category of the paper: case study, general review.

1. Introduction

The nature of human behaviour which is at the center of attention of social sciences and today's business has been found to be driven not only by one's individual profit/benefit either based on rational premises or spontaneous psychological factors but also the values and interests of the whole community. Control over one's own resources can be forsaken for the benefit of an integrated community such as a nation or a local community. For homo sociologicus, it is the social group that dominates the individual, and evaluations are based on feelings, either positive or negative, and individual perceptions.

An opposing view of an individual as homo oeconomicus implies rational decisions – so as a professional, he should strive for maximization of profit, and as a consumer for maximization of utility. As homo sociologicus, he should ensure his actions follow common values and aim at the benefit of the group and the whole community. This approach has been addressed in company CSR activities and more specifically in the pursuit of ways to stimulate civic engagement.

However, this should not only be reflected in involvement in initiatives that benefit the environment but also such activities that result in the development and support of the community the employees form. Moreover, it should be emphasized that employees' social engagement aimed at supporting their well-being is realised within the framework of formal and informal structures. Examples of the latter are, among others, associations or other organizations, such as trade unions, whose activities are regulated in Polish law. While the study of the activity of informal labor groups is quite difficult, since there is no official information in the area, the activity of formal groups is subject to numerous information obligations. Therefore, it is possible to evaluate them, as well as to determine their impact on the creation of a community of values, and thus on the creation of social capital, understood according to the definition of E. Coks as "a set of social processes occurring between groups of individuals leading to the development of networks, norms, trust, processes, the measure of which is satisfaction".

The purpose of this article is to study the increasing role of non-financial information, including this referring to social capital, in the process of complex company evaluation. It was assumed that socially responsible companies enhance the supportive activities of their employees directed at building social capital within the organization, and present valuable information about such activity in their non-financial reports. In order to verify the assumptions, the study was conducted on a random sample of 6 companies listed on the Warsaw Stock Exchange and included in the WIG-ESG index. The selection followed the ranking of companies and resulted in focusing on companies located both highest in the index (highest weight) and lowest (lowest weight).

An analysis and evaluation were based on the annual reports for 2022, as well as the content published on the websites. The material is organized around non-financial reports of the selected companies to compare and contrast the way of presentation as well as activities within the scope of those recognized as having the potential to support social capital building in the company context. The main feature of its novel approach is addressing ways to understand the dichotomy between tangible activities and their expected profound long-term results such as building intangible social capital. It was established the focal point should be evaluating if and how the existing indices reflect the intensity of efforts made to boost civic engagement.

2. Social engagement vs. social capital

Corporate language seems to fail to distinguish the two terms: social engagement and civic engagement. While the former is widely used in the context of CSR activities and represents a commitment to socially valid issues of different nature (environmental protection, eco-friendliness, support of disadvantaged groups and individuals, demonstrating care), the latter implies empowerment of individuals as citizens, their awareness and trust in agency based on their knowledge of institutions, operations and processes. In companies, civic engagement can be strengthened by empowerment, vested decision-making, and accountability. Understood as such, civic engagement will be derivative of numerous environmental factors, including long and rich democratic traditions, strong public institutions, and specific modes of management and leadership.

The following elements comprise Civic engagement: action (active participation in activities), commitment (readiness to act) deriving from the system of values or call of duty, skills (ability to act), and social cohesion incorporated in trust, reciprocity, and bonds.

Rasborg (2017) claims long-lasting traditional dedication to family life has been transformed toward an individualized, anonymous, and mobile society. Similarly, loyalty towards an employer typical of job-for-life holders who belonged to older generations (Traditional, Boomers, or even Xers) has been replaced by combined careers, flexible

employment contracts, and career changes. Such an environment does not favour stability which is needed to develop ties and establish close relationships and constitutes the foundation for engagement and activity for the benefit of the community. Only those individuals who identify with the community will demonstrate an active stance in social structures. Through civic engagement, individuals can build strong networks based on collective, shared values, trust, and relationships. In this context, civic engagement has the potential to prevent the loss of social structures (Levine et al., 2018). Local communities and workplaces are complex systems of various functionalities, norms, and interactions as opposed to anonymous social systems created by mobile and unstable societies of today.

Only when built from the very beginning, and based on profound knowledge can such engagement be effective, intense, and ongoing. Later on in a professional career, an active stance can be naturally taken if supported by encouragement, empowerment, motivation, and role models in leadership and management.

From the company's perspective, it is particularly important to address the issue of social capital. As Z. Mockało underlines, ongoing research "points to the links between social capital and the well-being and development of societies, social groups and eventually, workplaces and employees (Mockało, 2015). The value of social capital is built by mutual social relations and the trust of individuals. This capital is a resource that enables the achievement of diverse benefits, both individual and group, in social, private, or professional life (Mockało, 2015), including benefits for the company.

R. Putnam, one of the authors of the concept of social capital, emphasizes the relationship between social capital and the organizational characteristics of society, where he includes trust, norms and ties that increase the efficiency of society while facilitating the coordination of activities. As the author comments, "spontaneous cooperation is facilitated by social capital" (Zarycki, 2004).

For P. Bordieu (1985, p. 248) and S. Coleman (1990, pp. 300-321), social capital is an important element among the intangible assets of an enterprise and a necessary complement to social networks and norms of reciprocation. Formal and informal norms and values shared by group members constitute the value that depends on members' readiness to give up the individual good for the good of the group. The elements of social capital include trust, loyalty, reciprocation, solidarity, fairness, responsibility, and reliability.

According to F. Fukuyama (1997, p. 20) obligations, expectations and trust depend on the cultural heritage of a society and as such are strictly connected and interconnected with social capital. Social relations in business are based on human capital and its elements, and social norms are needed for social interaction to take place.

J. Czapiński (2007, p. 264), who asserts that social capital is the key factor in building economic capital, sees its modern functions as much more far-reaching, i.e. as contributing to social integration and inclusion.

According to Rok (2014) approach to leadership in contemporary companies should address all staff members to integrate them around common goals and desirable values to follow the increasing expectations of all stakeholders, not only financial ones. Leadership to be sustainable demands alignment at the citizenship stage with implemented sustainability principles to business strategy, competencies of a leader boosted in the area of engaging employees to meet the abovementioned principles.

3. Social networks and their influence on engagement

On corporate grounds, human capital management is becoming increasingly important. It is commonly understood that, as a key intangible resource, it increases the chance of success. At the same time, success is currently viewed from the perspective of the role sustainable development and achievement of non-financial goals, including the widely understood social aspect play in the achievement of optimal financial results. It should be emphasized that social activity is associated with the creation of an atmosphere conducive to building a competitive advantage. Socially active companies, often taking on tasks traditionally attributed to state-owned institutions, increase confidence in their activities, not only the pro-social ones. Initiatives conducive to increasing the efficiency of the company by strengthening social involvement are therefore a tool to support the sustainable development of the organization.

As a result, the creation of a social network in an enterprise has a positive impact on its operation. Having engaged staff means a lot of considerable benefits from the corporate perspective, such as an ability to identify with the company goals, achieve better results, efficiency and loyalty that translate into improved staff retention.

The social networks that are the building blocks of social capital can be divided into bridging capital and bonding capital (Moskallo, 2015).

Bridging capital is formed by ties between individuals with 'diverse characteristics' (Moskallo 2015) while bonding capital allows for networks of ties to be formed by individuals who are 'homogeneous in terms of socioeconomic data' (Moskallo, 2015). The fundamental difference between the aforementioned capitals stems from the motives for creating networks of connections. In the case of bridging capital, it is the pursuit of excellence. The determinant for the creation of bonding capital, on the other hand, is the need for security. Ties typical for trade unions seem to be, for example, created to ensure the economic security of workers with similar socio-economic characteristics. They are formed to protect the interests of their members and so act in the interest of the group, which is often contrasted with the interests of the employer. On the other hand, it should be emphasised that these organisations care about the well-being of employees which is a key factor in ensuring the long-term development of the

organisation. It is assumed that associations, NGOs, citizens' communities, local governments, and therefore also trade unions, are the pillars of civic society (Gliński et al., 2002).

The work environment, however, is mainly the space where bridging capital is created and developed. This capital promotes the well-being of employees and thus benefits the organisation as a whole. Well-cooperating employees are a source of inspiration and active engagement for the wider society. Organisations with strong networks between people of different characteristics provide examples of a high level of engagement in actions taken for other groups. They include both ad hoc actions, employee volunteering and activities typically undertaken within the framework of permanent structures established by companies, such as foundations. It is participation in such actions and campaigns that strengthens bonds critical for boosting the social capital of the employees involved. At the same time, the literature distinguishes two forms of employee engagement - traditional and operational, which involve the employee's engagement in the socially responsible operation of the company (Mirvis, 2012).

4. Social capital in the context of non-financial reporting

Today, concepts that view and evaluate the activities of companies from the perspective of their social impact are increasingly articulated. This approach emphasises the diversity of stakeholders, thus challenging agency theory, which focuses on protecting the interests of the principal and the need to reduce the information asymmetry between him and the agent. Confirmation of the above thesis is provided by, among other things, the significant changes observed in the reporting of information on the activities of an enterprise. The form of a company's communication with its environment has been evolving over recent years, forced by significant social changes.

Until recently, periodic reports predominated whose main element was the financial statement and the management report on the company's activity allowing for the assessment of the company's efficiency from the perspective of generated profit and growth in its value. Limited interest was shown in the dependence of these values on environmental and social activities. Now, such statements need to be enriched with non-financial information that addresses the company's impact on the wider environment, both internal and external (Walińska, 2015). Thus, they are aligned with the increasingly widespread conviction that the possibility of making rational decisions, including investment decisions, is determined by the possibility of confronting financial with non-financial information (Balzinska, 2018).

Thanks to the obligations to publish non-financial information introduced into the Polish legal system, there has also been a gradual reduction of the information gap in this area (Walińska, 2015).

Thus, as a result of the transposition of Directive 2014/95/EU of the European Parliament and of the Council on the disclosure of non-financial and diversity information by certain large undertakings and groups, reporting of non-financial information has been a part of the system since the beginning of 2018 (Tylec, 2018). Following the directive, the Accounting Act in Poland was amended (Dz.U. 2017, item 61). The obligation to disclose non-financial data applied to reports prepared already for 2017 (Krasodomska, 2017, Rubik, 2018). At the same time, the issue of non-financial reporting was regulated by the Ordinance of the Minister of Finance of 25 May 2016 amending the Ordinance on current and periodic information provided by issuers of securities and the conditions to recognise the information required by the laws of a non-member state as equivalent (Dz.U. 2016, item 860).

Even before the introduction of the above-mentioned regulations, there was a need to expand reporting to include non-financial information understood as: "facts, descriptions, materials, opinions of non-monetary nature, essentially describing the entity's business model and the variables that make it up, such as the entity's policies on the environment, society, human rights, employees and corruption" (Zyznarska-Dworczak, 2016, p. 218). An important role in the development of non-financial reporting was played by the concept of corporate social responsibility, mentioned before, which originated in American business (Tylec, 2018). Some business entities were already preparing voluntary corporate social responsibility - CSR reports before the above-mentioned regulations were introduced into the Polish legal system.

The reported non-financial information had a varied form (Macuda, Matuszak, Róžańska, 2015) which significantly limited the comparability of data and contributed to the decreased value of the information in published reports. On the other hand, due to the remarkable development of the culture of social engagement, the need to verify a company's activities not only in terms of the financial result it generates but also social impact factors was becoming increasingly evident in the public debate. While upon initiation of reporting on CSR activities the legitimacy of creating reports and publishing information on such activities was often denied, currently, with the intensive development of social movements aimed at protecting the wider environment, including the working environment, such an attitude is increasingly rare.

With the introduction of successive EU regulations that affect the content of national regulations, there is a growing interest among companies in presenting information on their commitment to social projects (Rubik, 2018). When developing non-financial reports, companies use reporting standards. The most relevant ones include (Macuda et al., 2015):

- OECD guidelines aimed at multinational entities (OECD, 2011).
- ISO26000 providing guidance on how companies can act in a socially responsible manner (Discovering ISO, 2014).
- GRI standards providing guidance, formulating basic reporting principles and a set of non-financial indicators (GRI.G4, 2016).

However, "vague" regulations obliging companies to report non-financial information confused both the form and content of non-financial reports (Jelska, 2023). Their limited comparability (Szadziewska et al., 2023) and, consequently, reduced informational value provided a stimulus for the search for new solutions aimed at increasing the informational value of published communications presenting the company's role as an entity supporting and implementing social initiatives.

On 16 December 2022, the Corporate Sustainability Reporting Directive (so-called CSRD) was published in the Official Journal of the EU. It represents a further attempt to structure the regulation on non-financial reporting, making it responsive to the information needs of the market and increasing the comparability of information given by different entities (Świdorska, Krysik, 2023). According to the regulation, large companies will be obliged to prepare an ESG report according to the new standards in 2024. Implementing the provisions of the directive will be a major challenge for the companies.

5. Support of social engagement in reports of selected companies

This article attempts to evaluate companies' social capital-building activities in the employee group on the basis of published non-financial information. The research was based on non-financial information reports of selected companies listed on the Warsaw Stock Exchange, with attention focused on reports for 2022. Information published by the companies on the websites was also analyzed. Selected companies listed in the WIG-ESG* index were included in the group of entities of the study (Table 1). The characteristics of the index, which takes into account social issues, including labor issues being an element of non-financial reporting, justify the choice of the research sample listed in Table 1. The research sample was limited only to companies with manufacturing and trading activities, located both highest in the mentioned index (highest weight) and lowest (lowest weight).

Published as of September 3, 2019, the WIG-ESG Index replaced the RESPECT Index that existed since 2009, includes all companies listed on the main stock market belonging to the WIG20 and WIG40 indexes, meeting the stock exchange guidelines included in the DPSN2021 document on corporate governance, information governance and investor relations, concerning the ESG (Environmental, Social, Governance) area tab. 1. In addition to assessing the level of application of the Good Practices, the index also takes into account the performance of companies in the ESG ranking prepared by the independent research agency Sustainalytics. In addition, capitalization and share trading value are taken into account in the index. The scoring of companies here is carried out based on information posted by them on their websites. The inclusion of a company in the WIG - ESG group does not depend, as in the case of the previously functioning Respect index, on filling out an appropriate questionnaire.

Below is an evaluation of the position of the analyzed companies in the WIG-ESG index, in the ranking prepared based on the level of implementation of the DPSN 2021 and in the summary prepared according to the criterion of the level of ESG risk.

Based on the review of information provided by selected companies on their websites and in published periodic reports on social activity in 2022, an attempt was made to identify activities aimed at supporting the construction of social capital of employees. An analysis was carried out of information on sample networks in the form of support for the process of building bridging capital and bonding capital.

Table 1 presents the companies listed within the WIG-ESG index, with the order being in accordance with the weight of the respective company in the WIG-ESG index (Company 1 – the highest weight, Company 6 - the lowest weight). Also indicated is the sector to which the company is assigned by the classification used in the DPSN 2021 scanner, as well as information on the significant participation of the State Treasury (directly or indirectly) in the company's shareholding.

Table 1.

Companies included in the survey sample

	Sector (classification of DPSN2021-GPW scanner)	Significant direct or indirect State Treasury shareholding
Company 1	Energy	Yes
Company 2	Apparel and cosmetics	No
Company 3	Mining	Yes
Company 4	Energy	Yes
Company 5	Mining	Yes
Company 6	Electronics	No

Source: own study based on <https://www.gpw.pl/dpsn-skaner>.

Based on the data made available in the DPSN2021 scanner, Table 3 presents the level of good practices applied by the analyzed entities -companies listed on the WSE (comply indicator - the level of respect for the principles), the implementation of which was the primary criterion for evaluating companies in the RESPECT Index from 2009 to 2020.

Table 2.

Implementation of DPSN2021 comply rate

No.	Company	Comply ratio	Used	Not used	NA	sector (classification of DPSN2021-GPW scanner)
1	Company 2	100%	100%	0%	0%	Apparel and cosmetics
2	Company 5	94%	94%	6%	0%	Mining
3	Company 3	92%	92%	8%	0%	Mining
4	Company 4	89%	89%	11%	0%	Energy
5	Company 1	84%	84%	16%	0%	Energy
6	Company 6	68%	68%	32%	0%	Electronics

Source: own study based on <https://www.gpw.pl/dpsn-skaner>.

The analysis confirmed that the weight of companies in the WIG-ESG index is not directly dependent on the level of DPSN2021 realization. Company 1 – with the highest weight in the WIG-ESG Index - shows a relatively low DPSN2021 realization rate (84%). This is influenced by the principle introduced with the launch of the WIG-ESG Index of a broader spectrum of factors considered in assessing the social aspects of companies' performance. The realization of DPSN2021 is now only one of the criteria taken into account to determine the weight of a company in the WIG-ESG Index.

Table 3.

Level of ESG risk in selected companies

ESG risk level (1 – lowest, 6 – highest)	Company	sector (classification of DPSN2021-GPW scanner)
1	Company 2	Apparel and cosmetics
2	Company 6	Electronics
3	Company 1	Energy
4	Company 5	Mining
5	Company 3	Mining
6	Company 4	Energy

Source: own study based on <https://www.gpw.pl/dpsn-skaner> and <https://www.sustainalytics.com/esg-rating>

In Table 3, the companies are arranged according to the level of ESG risk (1 – the lowest risk, 6 – the highest risk), understood as risks related to environmental, social and organizational factors that may affect the financial situation or hinder the operation of the company. The level of risk was determined here using, among other things, information made available by the research agency Sustainalytics [www]. Based on the research, it was found that company 1 with the highest weight in the WIG-ESG index among the analyzed companies showed a relatively high level of ESG risk with a relatively low level of comply factor. On the other hand, company 6 with the lowest weight in the WIG-ESG among the analyzed companies was ranked second and shows a lower level of risk compared to companies 1, 5, 3 and 4 and at the same time, the lowest comply factor in the analyzed group.

The analysis showed that the evaluation of the social aspects of the companies studied, in addition to the WIG-ESG ranking, which, due to the capitalization criterion, favors large companies, should also be made taking into account the company's position in the rankings prepared based on the other two criteria.

A review of the information reported by the selected companies for 2022 confirmed that all of them are fulfilling their disclosure obligations to publish non-financial information, but report the information in different ways. Companies with direct or indirect participation of the State Treasury (sector: mining and energy) use similar rules for reporting non-financial information. The non-financial information they publish can be found in the company's management report in the statements on non-financial information and in the integrated report. Company 2, located in the apparel and cosmetics group – with 100% private equity participation – prepared a separate comprehensive non-financial report – the Sustainability Report and

refrained from the presentation of statements on non-financial information in the company's management report. Company 6 (also with 100% private capital participation) presented non-financial information only in the management report as part of the statements on non-financial information. All companies present either an integrated report or a separate non-financial report in accordance with GRI standards. However, the integrated reports presented by companies 1, 3, 4 and 5 are significantly different in form and use individualized graphics. The solutions and visualizations used, while interesting, can be a handicap that limits the informational value. In addition, despite the application of the same reporting standards, this diversity limits the comparability of published data. The sustainability report prepared by Company 2 is a separate element of the annual report. It is a clear source of detailed information on the social aspects of a company operating in the area of clothing and cosmetics.

Table 4.

Reporting of non-financial information - standards and form

	Non-financial reporting in management report on the company's activities 2022	Integrated report	Separate non-financial report	GRI standards	Sector (classification of DPSN2021-GPW scanner)
Company 1	yes	yes	no	yes	Energy
Company 2	no	no	yes	yes	Apparel and cosmetics
Company 3	yes	yes	no	yes	Mining
Company 4	yes	yes	no	yes	Energy
Company 5	yes	yes	no	yes	Mining
Company 6	yes	no	no	no	Electronics

Source: own study based on companies reports.

The variety of forms of non-financial data presentation described above makes it difficult to search for information on the company's activities related to building employees' social capital. The content presented here provides a broader or narrower description of the implemented activities but does not allow us to assess their impact on the real involvement and strength of social ties among employees. Based on the analysis carried out, it was found that the basic forms of building and strengthening the social attitudes of employees are employee voluntarism, various arrangements for the social environment, including NGOs, the exercise of the right of association in particular trade unions and the activities of foundations. At the same time, the so-called corporate foundations operate in all surveyed SOEs. This form of integration of employees, around activities for the benefit of society is not used by either company 6, showing a limited scope of reporting non-financial information, or company 2 reporting extensively on its social activity in a separate report and undertaking numerous activities in support of employees and the environment.

Table 5.
Selected tools for building social capital of employees

	Employee volunteering	Support for NGOs	Trade unions	Foundation
Company 1	yes	yes	yes	yes
Company 2	yes	yes	yes	no
Company 3	yes	yes	yes	yes
Company 4	yes	yes	yes	yes
Company 5	yes	yes	yes	yes
Company 6	no	yes	no	no

Source: own study based on companies reports.

Differences regarding not only the form but also the scope of the reported information can be seen even between companies operating in the same area. For example, Company 3, classified as a mining company, in its statements on non-financial information presented a broad description of activities in the area of employees' rights to associate. It included detailed information on resolving disputes with social representatives, as well as the actions taken to mitigate them. Other companies presented limited information on support for union activities. All of the SOEs, as well as Company 2, described extensively the activity in introducing and supporting employee voluntarism policies. This activity is conducive to the actions described by these companies for the benefit of other social groups. The aforementioned activities are important for both stimulating and strengthening social bridging capital and bonding capital. A kind of "nuisance" that results from unions' existence following current legal regulations in this regard, is accepted and supported in such a way as to balance the interests of employee groups with those of the employer.

However, it should be noted that the activities of the Companies within the area under consideration, have been evaluated by the authors solely based on the information they provide. This limits the possibility of verifying the compliance of the information presented by the companies against reality. To mitigate this risk, according to the new guidelines, non-financial reports will be audited by auditors starting in 2024. This will minimize the risk of presenting false information.

6. Summary

The analyses of the non-financial reports of the selected companies demonstrate activities taken to strengthen social capital. However, there are no measures or indices that could prove this capital was enhanced either by general company commitment or by a specific activity. There is a dichotomy between specific activities of tangible form, purpose and (short-term) effect undertaken and their expected profound long-term benefits such as building intangible social capital. What can be concluded from the analyses is that while the companies are determined to follow the guidelines and be compliant with (changing) regulations they do not

make efforts to see the attempts are effective and contribute to developing social capital. There are neither measures to indicate if and how the capital increased as a result of activities undertaken nor evidence proving the reason-result relationship between the scope, content and efficiency of the activities. While they are linked to specific results and a benefit desired (pro-active) stance development, it is not evaluated how effective they are in building social capital in a broad sense and how they build civic engagement. Encouragement to participate in socially-oriented activities can play a part in empowering employees and their readiness to trigger initiatives. Such bottom-up initiative is necessary to mirror authentic engagement. The reports analysed prove a top-bottom initiative is taken to comply with the regulations on the one hand and create a company image relevant for employer branding of a modern caring organisation, on the other hand.

Without creating mechanisms to provide appreciation of individual authentic commitment the development of the culture of social engagement will not be boosted. Regulations on non-financial reporting important for investors and stakeholders seem unable to play an important part in supporting civic engagement in a broad sense.

For companies to present achievements in building social capital measures enabling comparisons would be necessary as well as tools supporting their introduction. So far such needs have not been explicitly addressed and remain unnoticed. The positive influence of non-financial regulation on society is undeniable, however, it seems to lead to changes in parts of the substance rather than the core of an organization.

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Footnotes

*Published as of September 3, 2019, the WIG-ESG Index replaced the RESPECT Index that existed since 2009, includes all companies listed on the main stock market belonging to the WIG20 and WIG40 indexes, meeting the stock exchange guidelines included in the DPSN2021 document on corporate governance, information governance and investor relations, concerning the ESG (Environmental, Social, Governance) area. In addition to assessing the level of application of the Good Practices, the index also takes into account the performance of companies in the ESG ranking prepared by the independent research agency Sustainalytics. In addition, capitalization and share trading value are taken into account in the index. The scoring of companies here is carried out on the basis of information posted by them on their websites. Inclusion of a company in the WIG - ESG group does not depend, as in the case of the previously functioning Respect index, on filling out an appropriate questionnaire.

RULES OF RESTRUCTURING AND BANKRUPTCY IN POLAND AND THEIR IMPACT ON THE SITUATION OF CREDITORS AND DEBTORS

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Purpose: The aim of the publication is to analyse the solutions that are available to entrepreneurs in the event of a difficult financial situation and to assess the scope of their application in practice.

Design/methodology/approach: The conducted research used an analysis of domestic and foreign literature, given insolvency and restructuring proceedings, as well as changes in law. As part of the conducted works, the following research hypotheses were raised: implementation of legal changes increased the possibilities of functioning and the development of insolvent entities on the market; interest in restructuring proceedings is increasing, which increases the possibility of recovery for creditors.

Findings: Research would show that with changes in the law and changing conditions in the environment, the interest of entrepreneurs in restructuring procedures is increasing, while the number of bankruptcies is decreasing. An analysis of the literature and legal regulations allows us to draw the conclusion that due to the lower formalities and advantages for debtors, they most often choose the procedure for approval of the arrangement.

Originality/value: The content of the study confirms the impact of risk and changes in law on increasing the ability to protect organisations from bankruptcy. The paper is dedicated to people dealing with organisation management and the insolvent entrepreneurs and organisations.

Keywords: bankruptcy, restructuring proceedings, entrepreneur, risk.

Category of the paper: Research paper.

1. Introduction

Recent years have brought many changes in the economic life of entrepreneurs in Poland. The outbreak of the COVID pandemic, the war in Ukraine, inflation, shortage of raw materials, disruption of supply chains have led entrepreneurs to financial problems. Many entities doing business in Poland have been forced to make decisions on how to continue operating. Those who had reserves for this remained on the market, some suspended or closed their

business activities, while others took advantage of the provisions of the bankruptcy or restructuring law. In addition, at the time of the greatest threats to businesses in Poland, the legislator introduced special solutions enabling facilitated restructuring, which was actively used by entrepreneurs to protect their operations. The article discusses an important issue concerning restructuring proceedings and bankruptcy of enterprises. This is an important issue for the economy, as the effectiveness of these proceedings has not only an economic but also a social dimension. It can lead to saving the entrepreneur's situation, paying off creditors or maintaining employment.

The aim of the article is to deepen the knowledge in the field of the above-mentioned proceedings in terms of their use by Polish entrepreneurs. The analysis of changes in the field of bankruptcy and restructuring law, as well as the study of the use of their standards by entrepreneurs show a steady increase in interest in restructuring and a decrease in the number of bankruptcies. Recent years have shown that interest in restructuring proceedings is growing (435 restructurings in 2018, 2290 in 2022, 3209 by the end of September 2023) and entrepreneurs are less likely to choose bankruptcy (for example, in 2018 620 bankruptcies were announced, in 2022 – 357, by the end of September 2023 – 295). A significant increase in the number of restructurings in relation to the number of bankruptcies is caused by changes in the law, which give debtors a better chance of surviving thanks to the possibility of concluding an arrangement with creditors. This is due to the new and attractive changes in proceedings, especially for debtors, which protect the debtor's situation to a greater extent than before, giving him a chance to heal.

2. Doing business in Poland

Economic activity is understood by the Polish legislator as an organized gainful activity, carried out in one's own name and on a continuous basis (Entrepreneurs' Law, Art. 3). On the other hand, an entrepreneur is considered to be a natural person, a legal person or an organizational unit that is not a legal person, to which a separate act grants legal capacity, and which conducts business activity (the Business Law Act, Art. 4). However, the legislator does not treat as entrepreneurs natural persons who, although in subsequent months constantly generate current revenues from their individual activities, but their income does not exceed 75% of the minimum wage (Entrepreneurs' Law, Art. 5). Such persons are therefore excluded from the above definition and are not subject to official registration. These people are also not included in the official statistics on entrepreneurs kept by the Central Statistical Office in Poland. Figure 1 presents the development of entrepreneurship in Poland.

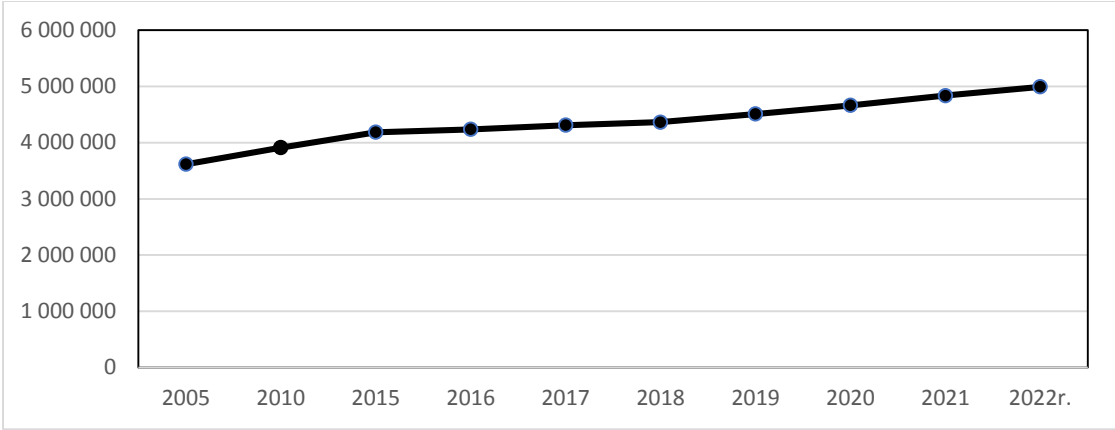


Figure 1. Number of entrepreneurs registered in REGON.

Source: Own elaboration based on the Statistical Yearbook of the Republic of Poland 2022, 2020, Small Statistical Yearbook of Polish 2023.

Figure 1 clearly shows that the number of entrepreneurs in Poland is constantly increasing from over 3.6 million registered in 2005 to over 4.9 million at the end of 2022 (Small Statistical Yearbook of Polish 2023). It should be noted that the present statistical data do not provide information on the number of entities actually conducting business activity, but only on the number of registered companies. Figure 2 presents data on entrepreneurs who have ceased their business activity as a result of liquidation or transformation, and those who have decided to suspend their activities.

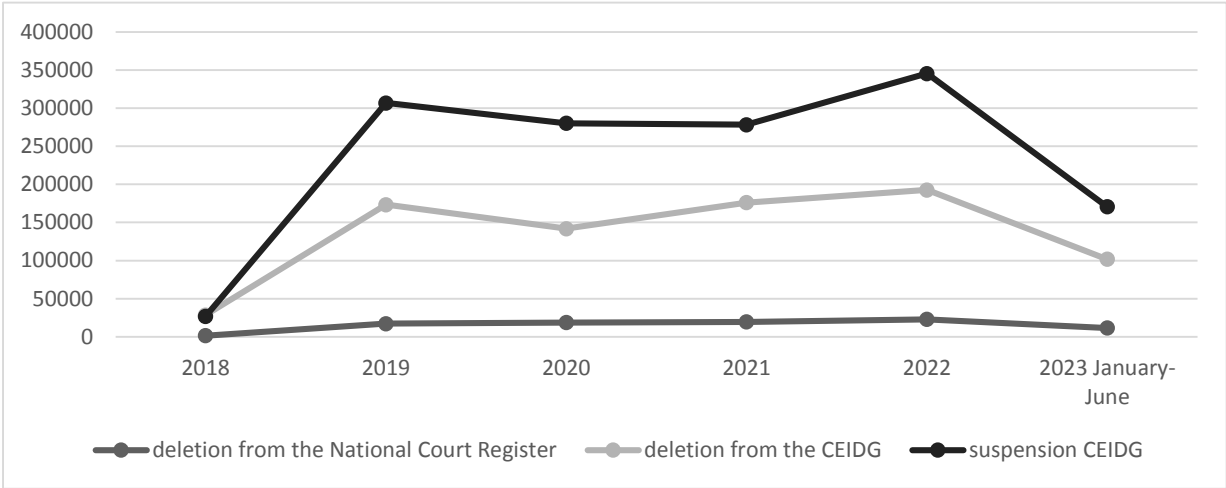


Figure 2. Number of deleted and suspended business activities in the National Court Register and CEIDG

Source: own analysis based on data from the Central Economic Data Index, Deletions of companies statistics 2023, 2022, 2021, 2020, 2019, 2018 (coig.com.pl), accessed on 12.12.2023.

Figure 2 shows that the number of entrepreneurs who are closing down is increasing. Particular changes in this regard took place in 2022. Entrepreneurs are also constantly taking advantage of the possibility of suspending business activity. This form of interruption in business activity is mainly used by natural persons, because one of the basic conditions for the suspension of activity is the lack of employment. More often, such a condition is met by natural persons.

3. Forms of business activity

The law in Poland gives many possibilities to choose the legal form of your business. However, Polish entrepreneurs most often choose:

1. individual business activity carried out by natural persons on the basis of an entry in CEiDG and the Act of 6 March 2018. Entrepreneurs' law,
2. civil partnerships operating on the basis of Articles 860-875 of the Act of 23 April 1964. Civil code,
3. commercial companies regulated in the Commercial Companies Code, where entrepreneurs can choose between a general partnership, a partnership, a limited partnership, a limited joint-stock partnership, a limited liability company, a simple joint-stock company or a joint-stock company.

In addition, it can still be carried out as a European company, a European economic interest grouping, a cooperative or as a state-owned enterprise.

The analysis of data on entities operating in Poland shows that the most common types of business activity are those run by individuals and commercial companies.

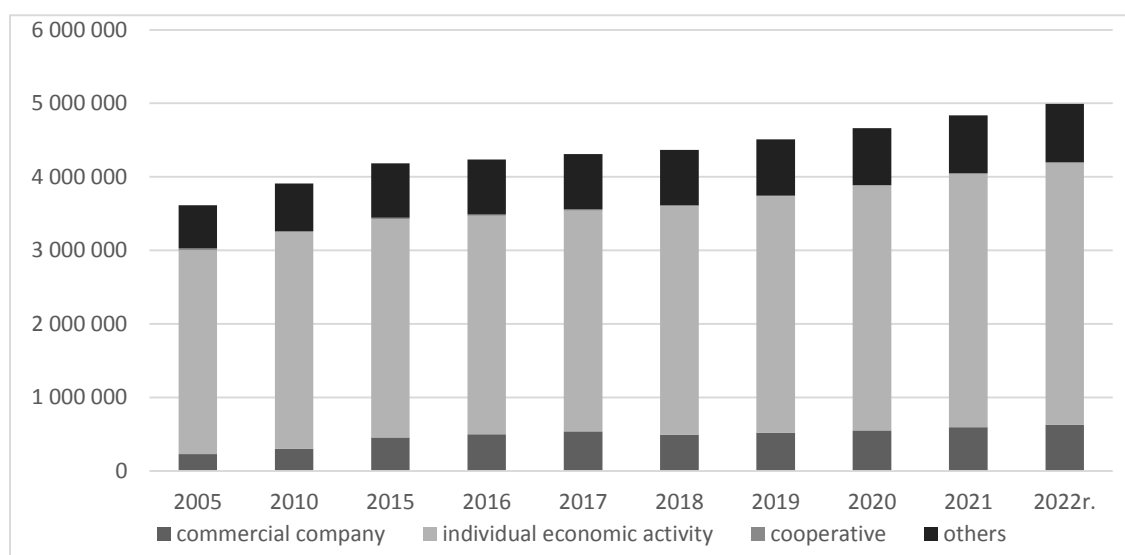


Figure 3. Number of entrepreneurs registered in Poland by legal form in the years 2005-2022.

Source: Own elaboration based on the Statistical Yearbook of the Republic of Poland 2022, 2021, Small Statistical Yearbook of Polish 2023.

Figure 3 shows that the number of registered entrepreneurs in Poland is constantly increasing. This applies to almost all legal forms in which such activities can be carried out. However, the most popular is individual self-employment. This is certainly due to the ease of creating and running a business in this way.

4. Risk in entrepreneurs' activities

Polish entrepreneurs have a wide choice in terms of forms of business activity. It is worth noting that in Poland, entrepreneurs run their business on the basis of solutions used all over the world. The above-mentioned forms (in particular individual economic activity, commercial companies) are also carried out in European and non-European countries (Nancu, Mihai, 2021; Schölna, Ohlssonb, Brooméd, 2017). It should be noted, however, that none of the available forms guarantees success in business. This means that every entrepreneur is exposed to undesirable events which, as a result of the incurred loss or increase in operating costs, will have a negative impact on its functioning.

It seems that the most important objectives of commercial companies are profitability (i.e. maximising profit or market share) and risk (i.e. 'security' or 'survival'). It will be the task of those who make decisions about the future of the company to choose an opportunity that minimizes risk for a given profit or maximizes profits for a given risk. In both cases, the goal is the same – maximizing the value of the company (Fig. 4).

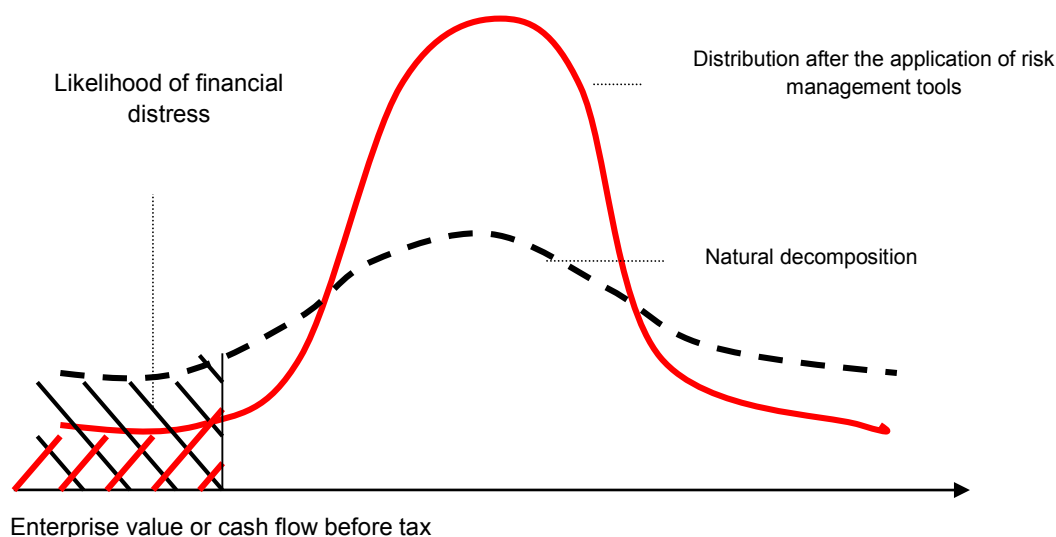


Figure 4. Relationship between risk and enterprise value.

Source: Smithson, Smith, Sykes, Wilford, 2000, p. 134.

Figure 4 allows us to draw the conclusion that an entrepreneur who is aware of the risk and knows the instruments for reducing it will have a chance to operate more safely and increase the value of his company.

Risk is an inherent part of every decision made by entrepreneurs, but it has not yet been clearly defined. Differences in the interpretation of this term are manifested in such issues as the relationship between risk and uncertainty, the types of deviations that arise – unidirectional, multidirectional, the subject of reference, the possibility of measuring by applying the theory of probability. The first definitions of the concepts of risk and uncertainty were found in the work of F.H. Knight (Gup, 1992). According to this author, risk means the possibility of

deviation from the expected or planned state, which can be calculated using the theory of probability, while uncertainty occurs when such an eventuality cannot be assessed more precisely, because it is not possible to use the theory of probability. Representatives of the **defensive trend** treat risk as a negative phenomenon – a source of losses that should be taken into account in the company's operations (Brühwiler, 1980), the danger of a negative deviation from the goal (Sahl, 1996), and the threat of a decrease in profit.

The theory of decision-making under conditions of uncertainty and risk is based on the assumption of quantification. R.D. Luce and H. Raiffy distinguish three types of decisions that can be made (Jędralska, 1992):

1. under conditions of certainty - if it is known that a particular action leads to a certain result,
2. under risk conditions – when an action leads to some outcome from a certain set of possible outcomes, each of which has a probability of occurrence known to the decision-maker,
3. Under conditions of uncertainty, we do not know the probability distribution of the goal being achieved.

A similar concept of risk and uncertainty is presented by R.L. Ackoff, who distinguishes areas of certainty, risk and uncertainty in the decision-making space.

The presented concepts show that risk is on the one hand the result of the uncertainty experienced by the decision-making entity and, on the other hand, depends on the amount of capital involved in the implementation of the decision. Risk is a function of uncertainty, and this function is a simple relationship: the greater the range of uncertainty, the greater the risk, and vice versa – as unspecified and uncertain factors decrease, so does the risk. It follows that there is no risk where there is no uncertainty and where some capital has not been committed. It is obvious that **the risk increases with the amount of capital employed**. It should also be noted that since the main attribute of risk is uncertainty, the value of risk will also be fundamentally influenced by time. This means that **as the time horizon of predictions is extended, their uncertainty will increase**. Over time, the expected rate of return decreases, while the probability that the achieved rate of return will deviate significantly from the expected value increases. As a result, the risk increases over time.

In the literature, there is a broader and narrower understanding of risk. The authors emphasize, for example, the high impact of personnel risk on the company's operations and results. However, from the point of view of the commercial activity of companies, the following interpretation of financial risk seems to be the most appropriate.

Financial risk in trading is the possibility of unforeseen events beyond the control of the entity related to:

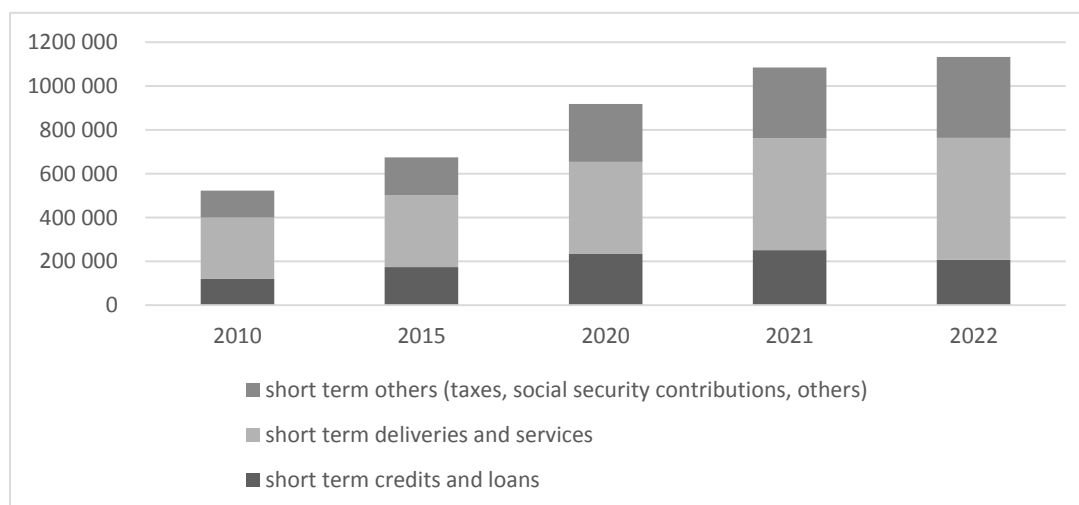
- concluded commercial transaction (*transaction risk*),
- changes in the company's market environment (*market risk*),

- products or goods that the entity sells (*commodity risk*),
- economic and political activities of the countries in which the company operates (*country risk*)

which cannot be fully prevented, and which, by increasing operating costs or causing a loss, have a negative impact on the financial situation of the company (Olkiewicz, 2005).

One of the most important risks in business activity is transaction risk. It means that the contractor may not fulfill the contract for various reasons. Therefore, the contractor may commit in particular: delay in payment, fail to pay for the goods at all, fail to undertake the transaction or fail. Each of these situations has negative consequences for the entrepreneur. In Polish and foreign legislation, there are many legal instruments aimed at reducing transaction risk and protecting entrepreneurs. An example of such tools are the regulations on the insolvency of entrepreneurs and consumers, which on the one hand are designed to secure the interests of creditors in the best possible way and, on the other hand, if possible, to enable the debtor to continue to function in economic life.

One of the counterparty risks is the risk of non-payment. Statistical data on enterprises in Poland show a steady increase in the debt of companies in the private sector (Polish Statistical Yearbook, 2022). This creates a risk for their counterparties. On the one hand, they have to credit the activities of their partners and usually incur debt themselves, and on the other hand, they may not pay at all. Figure 1 presents the current liabilities of Polish entrepreneurs, including trade and service liabilities.



Rysunek 5. Short term liabilities of enterprises in private sector in Poland in mln PLN.

Source: own study based on the Small Statistical Yearbook of Polish 2023.

The data presented in the figure shows that the short-term debt of entrepreneurs in Poland is constantly growing. The increase is recorded mainly in the group of payables resulting from supplies and services. In this category, liabilities have increased by more than 70% since 2010. This means that Polish entrepreneurs are constantly using loans from their business partners. This, in turn, gives rise to a risk related to the counterparty's situation. Particularly large

increases in this area were observed in 2020-2021, which was undoubtedly influenced by the situation caused by the COVID-19 epidemic and the outbreak of the war in Ukraine.

Data on the increase in liabilities in the private sector indicate that procedures that enable either the improvement of the financial condition through debt relief and restructuring or those that ensure that creditors recover at least part of the receivables through the debtor's bankruptcy are becoming of great importance for entrepreneurs.

5. Rules of bankruptcy and restructuring of entrepreneurs in Poland

The statistical data presented in parts 2 and 3 of the article show that the number of entities registered in official registers of entrepreneurs in Poland is constantly increasing. The value of companies' debts is also increasing, as is the number of those who suspend their activities and remove themselves from the registers. Recent years, and in particular economic, political and global events have led to a significant interest in restructuring and insolvency procedures. This is mainly due to the growing indebtedness of entities. Indebtedness, on the other hand, often leads to enforcement and compulsory exercise of rights by creditors through enforcement proceedings. This, in turn, makes it virtually impossible to conduct business activity as a result of, for example, the seizure of bank accounts or the forced sale of assets needed to verify this activity

Such threats cause entrepreneurs to look for solutions to save their business and get out of a difficult situation, or to end it without the risk of criminal or civil liability. A good solution is to rely on the provisions of the Bankruptcy Law or the Restructuring Law. Both laws currently cover insolvent entrepreneurs. On the other hand, the Restructuring Law may also be applied to entrepreneurs threatened with insolvency (Restructuring Law, Art. 1). It should be noted that solutions similar to those in Poland are regulated by the legislator of European countries and the law in force in the United States of America (Renssen, 2017, p. 20).

Act of 15 May 2015 The Restructuring Law came into force on 1 January 2016 and replaced the previously applicable Bankruptcy and Reorganization Law in terms of bankruptcy protection. Although the act has been in force since 2016, it has been amended many times. An analysis of the amendments to the Restructuring Law allows us to conclude that these changes were made in accordance with changes in the socio-economic environment. At the same time, the legislator reacted to extraordinary phenomena such as the COVID epidemic or the war in Ukraine. Some of the changes were related to the need to implement Directive (EU) 2019/1023 of the European Parliament and of the Council of 20 June 2019 on a framework for preventive restructuring, discharge of debts and prohibitions on conducting activities and on measures to increase the efficiency of restructuring, insolvency and discharge proceedings, as well as amending Directive (EU) 2017/1132 (Resolution and Insolvency Directive). Since its entry into force, the Act has been amended in more than thirty ways.

The Bankruptcy Law, on the other hand, regulates the bankruptcy of an entrepreneur and its liquidation by a receiver under the control of the court. It has been in force since October 1, 2023 and has also undergone many legislative changes since then.

Gradually, the changes introduced by the legislator have led to the establishment of rules of conduct in the case of insolvent entrepreneurs or those who are at risk of such insolvency. Currently, every insolvent entrepreneur has a choice, i.e. They can file for bankruptcy or try to save their business by restructuring. In addition, it should be pointed out that any of the entrepreneur's creditors may initiate bankruptcy. On the other hand, entrepreneurs threatened with insolvency may take advantage of one of the restructuring proceedings.

Table 1 presents the basic concepts common to bankruptcy and restructuring regulations.

Table 1.

Basic definitions of the Bankruptcy and Restructuring Law

Concept	Definition
Entrepreneur insolvent	<ul style="list-style-type: none"> – A debtor who has lost the ability to pay his monetary obligations. – A debtor is presumed to have lost the ability to meet its monetary obligations due if the delay in payment exceeds three months. – A debtor who is a legal person or an organizational unit without legal personality, which is granted legal capacity by a separate statute, is also insolvent if its financial liabilities exceed the value of its assets, and this state of affairs persists for a period exceeding twenty-four months
Entrepreneur threatened with insolvency	A debtor whose economic situation indicates that he may soon become insolvent.

Source: In-house analysis pursuant to Article 11 of the Bankruptcy Law and Article 6 of the Restructuring Law; Janda, 2023, p. 11.

The primary purpose of insolvency proceedings is to satisfy the claims of creditors as much as possible, and if reasonable considerations allow it, the debtor's existing business has been preserved. On the other hand, in restructuring proceedings, the primary objective of the Act is to avoid the debtor's bankruptcy by enabling the debtor to restructure by concluding an arrangement with creditors, and in the case of sanation proceedings – also by carrying out remedial actions, while securing legitimate rights Creditors. The legislator indicated that this objective is to be achieved in the course of the proceedings by enabling the debtor to restructure, which takes place by concluding an arrangement with creditors. In sanation proceedings, the purpose of the proceeding may additionally be achieved by carrying out remedial actions while securing the legitimate rights of creditors (Filipiak, Hrycaj, 2023; Janda, 2023; Witosz 2021).

Table 2 presents legal possibilities that can be used by entrepreneurs in the event of losing the ability to settle due liabilities or when there is a threat of such difficulties.

Table 2.*Types and objectives of proceedings concerning insolvent entrepreneurs*

Bankruptcy proceedings	
May be carried out by insolvent entrepreneurs	Objectives of the procedure
	The proceedings should be conducted in such a way that the claims of creditors can be satisfied to the greatest extent possible and, if reasonable considerations allow, the debtor's existing business is preserved.
Restructuring proceedings	
May be carried out by entrepreneurs: – Insolvent, – threatened with insolvency.	General Purpose
	Avoiding the debtor's bankruptcy by: 1. allowing it to restructure by concluding an arrangement with creditors, 2. and, in the case of sanation proceedings, also by carrying out remedial actions, securing the legitimate rights of creditors.
Types of restructuring proceedings	
Procedure for approval of the arrangement	1) enables the conclusion of an arrangement as a result of the debtor's own collection of creditors' votes without the participation of the court; 2) may be conducted if the sum of disputed claims entitling to vote on the arrangement does not exceed 15% of the sum of claims entitling to vote on the arrangement.
Accelerated arrangement proceedings	1) enables the debtor to conclude an arrangement after the list of claims has been drawn up and approved in a simplified manner; 2) may be conducted if the sum of disputed claims entitling to vote on the arrangement does not exceed 15% of the sum of claims entitling to vote on the arrangement.
Arrangement proceedings	1) enables the debtor to conclude an arrangement after the list of claims has been drawn up and approved; 2) may be conducted if the sum of disputed claims entitling to vote on the arrangement exceeds 15% of the total amount of claims entitling to vote on the arrangement.
Remedial proceedings	It enables the debtor to carry out remedial actions and conclude an arrangement after the list of receivables has been prepared and approved. Remedial actions are legal and factual actions, which aim to improve the economic situation of the debtor and are aimed at restoring the debtor's ability to perform its obligations, while protecting it from enforcement.

Source: In-house analysis based on the Bankruptcy Law and the Restructuring Law.

Table 2 shows that currently entrepreneurs threatened with insolvency or insolvent have a wide range of choices as to whether or not to continue to operate or liquidate their business. Theoretically, each of the proceedings is intended to protect the legal and financial situation of creditors. However, the consequences of opening these proceedings may also be unfavourable for creditors. The purpose of bankruptcy proceedings is to liquidate an entrepreneur. The Act provides for the possibility of changing these proceedings to restructuring proceedings if they would lead to better protection of the interests of creditors and provided that an arrangement was concluded with the creditors on the repayment of the receivables. On the other hand, the primary purpose of restructuring proceedings is to avoid the debtor's bankruptcy. However, if this proves impossible during the proceedings, it may be converted into bankruptcy proceedings. Therefore, it seems that the procedures provided for in the Restructuring Law and the Bankruptcy Law now provide for better instruments for debtors than was the case under the previous regulations. At the same time, the primacy of restructuring proceedings has been adopted in the acts. This means that even if, for example, two applications concerning the same entrepreneur are filed at the same time – one for bankruptcy and the other for restructuring, the court is obliged to consider the restructuring application in the first place and give the entrepreneur a chance to repair its business by using restructuring instruments.

It is worth noting that the opening of both restructuring and bankruptcy proceedings has far-reaching consequences for creditors. These effects are presented in Table 3.

Table 3.

Consequences of opening bankruptcy and restructuring proceedings

Effects of the opening of proceedings Insolvency	Consequences of opening restructuring proceedings
<ol style="list-style-type: none"> 1. The bankrupt's assets become the bankruptcy estate. 2. The bankruptcy estate is taken over by a receiver who, under the supervision of the bankruptcy judge, will liquidate it. 3. Enforcement proceedings concerning claims from the bankruptcy estate are suspended by operation of law. 4. The trustee makes an inventory and designs a list of receivables, which will be the basis for possible repayments. 5. Creditors are repaid in the order defined by the following categories: <ol style="list-style-type: none"> a) The first one includes, for example: receivables from the employment relationship for the time before the declaration of bankruptcy, maintenance receivables, receivables arising in restructuring proceedings, b) the second - other receivables, if they are not subject to satisfaction in other categories, c) the third, interest on receivables included in the higher categories in the order in which the principal is to be satisfied, as well as judicial and administrative fines and receivables in respect of donations and bequests, d) the fourth - receivables of partners or shareholders under a loan made to a bankrupt company in the period of five years prior to the declaration of bankruptcy, together with interest. 	<ol style="list-style-type: none"> 1. By operation of law, enforcement proceedings are suspended with respect to receivables covered by the arrangement by operation of law, i.e. personal receivables arising before the date of opening the proceedings, with the exception of receivables: *maintenance, *pensions for damages, *social security contributions, *from an employment relationship, *secured on the debtor's property by mortgage, pledge and other property rights. 2. The entrepreneur's assets are left in his management, under the supervision of a supervisor, or the management of the property is taken away and given to the administrator. 3. The debtor prepares arrangement proposals, which usually include: *reduction of liabilities, *distribution of liabilities into installments, *reduction of interest, *restructuring of the debtor's assets. 4. Arrangement proposals may provide for the division of creditors into groups comprising particular categories of interests. 5. The terms of the restructuring of the debtor's liabilities are the same for all creditors and, if the voting on the arrangement is carried out in groups of creditors, the same for creditors included in the same group, unless the creditor expressly agrees to less favourable terms. 6. The arrangement is binding on creditors whose claims are covered by the arrangement according to the Act, even if they are not included in the list of claims. 7. A resolution of the creditors' meeting on the acceptance of the arrangement is adopted if it is supported by a majority of the voting creditors who cast a valid vote and who have a total of at least two-thirds of the total claims of the voting creditors.

Source: own analysis based on the Bankruptcy Law and Restructuring Law.

Table 3 shows that by initiating bankruptcy or restructuring proceedings, the debtor obtains a stay of enforcement with respect to his assets. Creditors, on the other hand, even those who have already successfully carried out such enforcement, unfortunately have to take into account other creditors and the decisions of the receiver, supervisor or administrator. In these proceedings, creditors are treated according to the same rules. Only creditors who have tangible collateral on the debtor's assets have a good position in both proceedings. They can recover the sum specified in the collateral from the subject of that collateral.

The analysis of statistical data on ongoing and initiated bankruptcy and restructuring proceedings in Poland shows the growing interest of entrepreneurs in these procedures. The number of bankruptcy and restructuring proceedings initiated and conducted in recent years allows us to assume that they are particularly appreciated by debtors.

Table 4.

Number of bankruptcies in Poland 2018-2023

	2018	2019	2020	2021	2022	I-IX 2023
Number of bankruptcies in Poland, in which:	620	614	549	400	357	295
– natural persons conducting business activity % of total bankruptcies	141 23%	149 24%	120 22%	82 21%	37 10%	40 14%
– limited liability companies % of total bankruptcies	335 54%	332 54%	308 56%	229 57%	245 69%	197 67%

Source: own analysis based on data: KRZ, MSIG, www.coig.pl, 12.12.2023.

Table 4 shows that the interest in bankruptcies among Polish entrepreneurs is gradually decreasing. On the other hand, if it is chosen for this procedure, it is most often by limited liability companies and natural persons conducting business activity. Presumably, this is due to the fact that under Polish commercial law, members of the management board of limited liability companies are liable for their liabilities if they fail to file for bankruptcy within the required time limit (Article 299 of the Commercial Companies Code). Filing such a request within the statutory time limit relieves them of this responsibility. The bankruptcy of individual entrepreneurs is also of great interest. They are responsible for their liabilities with all their assets. In the case of this group of entities, bankruptcy may lead to their debt relief and the beginning of business life anew without the burden of liabilities incurred.

In contrast to bankruptcy proceedings, restructuring proceedings are becoming more and more popular. Recent years have shown a steady increase in the number of proceedings initiated. This trend is presented in Table 5.

Table 5.

Number of restructuring procedures opened in Poland 2018-2023

	2018	2019	2020	2021	2022	I-IX 2023
Number of restructuring procedures opened	435	436	755	1848	2290	3210

Source: In-house analysis based on data from KRZ, MSIG, MGBI Report Warsaw 2023, www.coig.com.pl, 12.12.2023.

Table 5 and Figure 6 clearly show that, in contrast to the decrease in the number of insolvency proceedings, the number of restructurings is increasing from 245 in 2018 to over three thousand in the first three quarters of 2023, i.e. more than sevenfold.

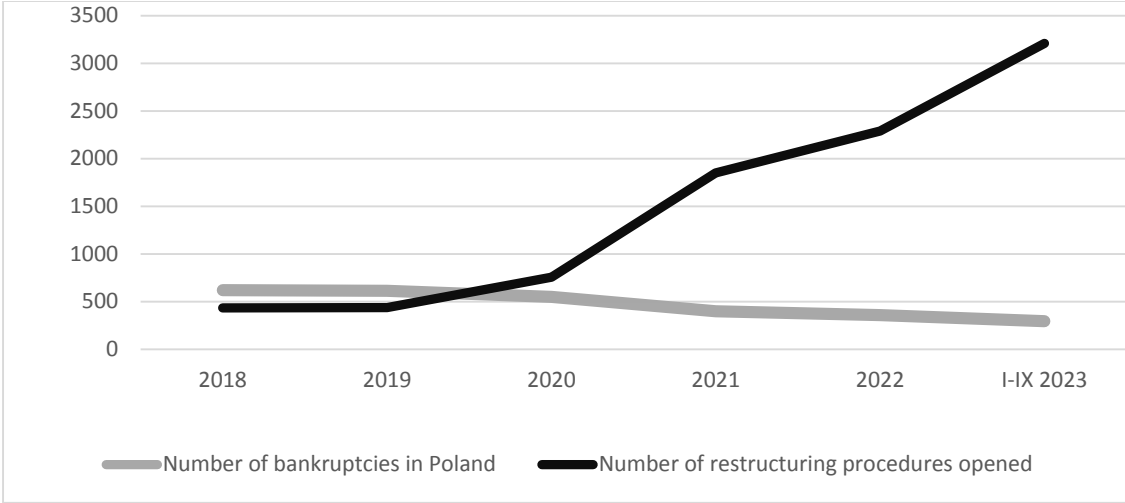


Figure 6. Number of insolvency and restructuring proceedings initiated in Poland in 2018-2023.

Source: In-house analysis based on data from KRZ, MSiG, MGBI Report Warsaw 2023, www.coig.com.pl, 12.12.2023.

Among the restructuring proceedings in recent years, the most popular have been the arrangement approval procedure and the special arrangement approval procedure introduced temporarily in connection with the COVID-19 outbreak, as shown in Figure 7.

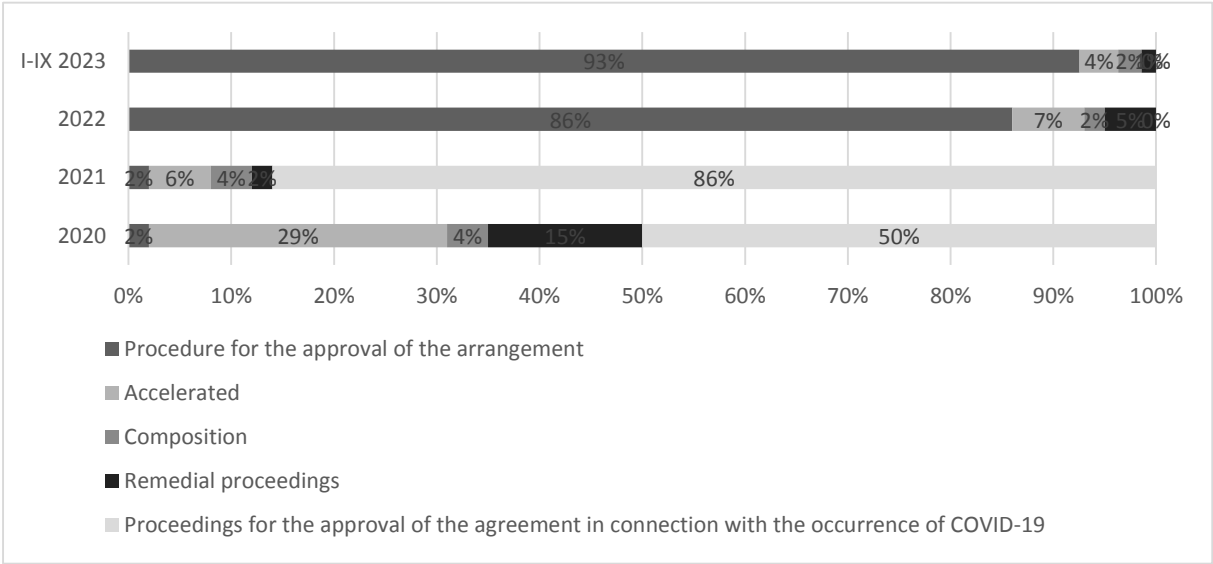


Figure 7 The use of types of restructuring proceedings by Polish entrepreneurs in 2020-2023.

Source: own analysis based on data from MSiG, MGBI Warsaw 2023 Report, www.coig.com.pl, 12.12.2023.

The data presented in the figure clearly shows that the most popular were the arrangement approval proceedings provided for in the regulations introduced to protect entrepreneurs against the effects of the COVID epidemic, and now the arrangement approval procedure (over 92% of all proceedings initiated). On the other hand, arrangement proceedings (1.4% in 2023) and remedial proceedings (2.4% in 2023) are the lowest initiated.

An unquestionable advantage of the arrangement approval procedure is the fact that it is initiated at the initiative of the debtor by concluding an agreement with a restructuring advisor

selected by the debtor. Then, the advisor makes an announcement on the arrangement date in the Court and Economic Monitor. From that moment on, the debtor and the supervisor have three months to convince the creditors to conclude an arrangement with the debtor, which usually includes partial discharge of liabilities, cancellation of incidental receivables (interest, compensation), and payment of liabilities in instalments. The attractiveness of this procedure and its frequent use is due to the benefits it gives the debtor in terms of protection against enforcement. The determination of the arrangement date means that, by operation of law, enforcement proceedings addressed to the arrangement estate are suspended, and new proceedings cannot be initiated. This procedure is usually chosen by those entities against whom enforcement is already being carried out, or by those who have knowledge that enforcement will soon be commenced. The debtor continues to run his business under the supervision of the arrangement supervisor and the court. After the lapse of three months from the date of the arrangement date, the effects of the announcement cease to exist. A debtor who has not been able to conclude an arrangement with creditors continues to run a business, and has the option of taking advantage of other restructuring proceedings or filing for bankruptcy.

Other restructuring proceedings are less frequently chosen by debtors, as they are associated with a greater limitation of the debtor's activities in relation to his assets. In sanation proceedings, the debtor loses the management of his assets, while in arrangement proceedings or accelerated arrangement proceedings, the management may be taken away from the debtor. For debtors, there is a risk that they will be deprived of the ability to decide about their assets. In this case, a court-appointed administrator will take care of it.

6. Summary

From the considerations presented in the article and the statistical data, it is clear that the proceedings related to restructuring are silent about the growing interest of entrepreneurs. In recent years, there has been a marked increase in the number of restructuring proceedings initiated. This trend is facilitated by the amended law on restructuring procedures. The Polish legislator recognizes the need to protect existing entities, while maintaining the protection of the legitimate interests of creditors. The procedures assume that existing business activities are rescued in the first place, while bankruptcy seems to be the last resort, which is not a procedure desired by the entrepreneurs themselves and their creditors. This is because it means the liquidation of the entity. On the other hand, restructuring proceedings are aimed at the continued functioning of the entrepreneur, which in turn gives a chance to meet at least some of the debts incurred in the course of operations. Such an approach to the recovery of entrepreneurs can have many positive effects, in particular the preservation of jobs, the maintenance of existing relations between entities, and the fulfilment of public law obligations by entrepreneurs.

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THE IMPACT OF ECONOMIC MACROENVIRONMENT ON SHAPING FOREIGN TRADE DURING THE COVID-19 PANDEMIC IN POLAND

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Purpose: The purpose of this article is to demonstrate how changes in economic indicators affect foreign trade in Poland during the COVID-19 pandemic.

Design/methodology/approach: The research problem is: what impact did economic indicators have on imports and exports in Poland during the COVID-19 pandemic? Main hypothesis: the COVID-19 pandemic had a negative impact on economic indicators, which directly had a negative impact on the export and import from Poland. The conducted research used an analysis of domestic and foreign literature and method of a document examination.

Findings: Research has shown that the emergence of the COVID-19 pandemic in 2020 had a significant impact on the development of several indicators of the economic macroenvironment, in particular GDP, inflation and the unemployment rate. Indicators identifying foreign trade did not show significant dependencies on the number of infections, but on phenomena shaping sensitive indicators.

Originality/value: The content of the study confirms the impact of the COVID-19 pandemic on changes in most indicators of the economic macroenvironment. Additionally, it shows the phenomenon and the scale of impact, which may be important in the event of new cases of epidemiological threats or crisis situations (e.g. geopolitical).

Keywords: pandemic COVID-19; index; trend.

Category of the paper: Case study.

1. Introduction

The proper functioning of entrepreneurship is determined, among others, by the economic situation of a given country, the potential of the organization, the socio-economic and geopolitical situation of neighboring countries or countries potential for cooperation. Analysis of opportunities and threats gives companies the opportunity to implement customer-oriented changes, meeting their changing expectations and requirements while increasing their

satisfaction. Continuous analysis of macroeconomic market variables through appropriate identification and evaluation of data allows you to minimize the risk of running a business in such volatile times through flexible and responsible management. The literature on the subject indicates that much attention is paid to the appropriate identification and assessment of various phenomena relating to investment, social, sociological aspects, etc. in terms of business cycles (Taylor, McNabb, 2007; Klein, Ozmucur, 2010). Such studies of the economic macro-environment are intended, firstly, to give a hint as to what factors are (can be) the main determinants of economic success, and, on the other hand, how to manage an organization or a country to achieve stability (functioning, development, macroeconomic) by undertaking various types of activities aimed at a specific goal (Kozioł, 2010).

A query of the most important databases revealed that there are few publications that focus on the analysis of the impact of the COVID-19 pandemic on foreign trade in Poland. It can therefore be assumed that this issue is relatively rarely researched in the literature and the literature on this subject is limited. Therefore, with this publication I would like to fill this research gap.

The aim of the publication is to demonstrate how changes in economic indicators affect foreign trade in Poland during the COVID-19 pandemic. The study poses a research question: what impact did economic indicators have on imports and exports in Poland during the COVID-19 pandemic? and a hypothesis was put forward: the COVID-19 pandemic had a negative impact on economic indicators, which directly had a negative impact on the export and import from Polish.

2. Literature review

The Social, economic, political and cultural changes force organizations to make changes and decisions quickly, which involves the need to verify the goals of action and sometimes the implemented strategies. The early years of the 21st century were perceived very positively, as they indicated a significant acceleration of the processes of internationalization of the economy and globalization processes, resulting from, among others, trade liberalization, technology development, global dissemination of logistics systems and global development (investment) activities undertaken by international corporations. The growing expectations of market stakeholders cause constant changes in the market(s), shaping trends and the economic situation (Kozioł, 2010; Wang, Zeng, 2020). Therefore, ensuring the stable operation and development of enterprises in the global economy is becoming more and more difficult. Organizations began adapting to new conditions resulting from, among others, digitalization, the development of automation and intelligent technologies, as well as changing laws (legislation) in the second half of the 20th century. This was particularly important for achieving

the set goals in specific socio-economic conditions (dimension of the economic macro-environment), where economic acceleration required reliability, standardization and appropriate information management (big data) from enterprises (Inekwe, 2020; Ghosh, 2021).

Responsible management, based, among others, on corporate social responsibility, is important from the point of view of the economic functioning and development of the organization. There is always a possibility of a recession or other threats, e.g. pandemic, war, which may limit the proper functioning of the organization and force business entities to analyze the causes and mechanisms causing them. This will allow you to focus on anticipating market opportunities and threats resulting from, for example, government actions, e.g. lowering taxes, lowering interest rates, supporting strategic investments for the country, etc., which may have a positive or negative effect on the economic activity of enterprises (Bodo et al., 2000; Narayanan, Unni, 2017; Oi, Cheun, 2020; Konstantinou, Tagkalakis, 2011).

It becomes particularly important during the emergence and development of the COVID-19 pandemic. There was a significant threat to the implementation of current activities of business entities (various industries), investment and development activities (Ainsworth, McKenzie, 2020; Yu, 2020; Wang, Zeng, 2020).

This was confirmed by the effects of the spread of various pathogens and viruses in the past. Various threats caused by viruses have always appeared in the world on a mass scale. Examples include SARS in 2002-2003, bird flu in 2003-2006, swine flu in 2009-2010, Ebola in 2013-2016, and measles in 2019 and now. However, the range and power of destruction were much less noticeable (Długosz, 2021) than in the case of SARS-CoV-2, also known as the COVID-19 pandemic.

The economic development of the country has an important impact on the activities of economic entities and households, and the emergence and development of the COVID-19 pandemic around the world, including in Poland, has influenced changes in the conditions of the country's economic macroenvironment. In such urgent crisis situations, epidemiological restrictions are introduced, e.g. maintaining social distance, the obligation to wear masks or partial closure of activities in some sectors (Anderson et al., 2020; Lewnard, Lo, 2020; Musselwhite et al., 2020; Moreno et al., 2021), determined running a business, forcing actions to guarantee social security. (Camargo, 2021; Anderson, 2020; Khan, Upadhayaya, 2020; Olkiewicz, Wolniak 2018; Wolniak et al., 2021; Wyszomirski, Olkiewicz, 2020).

3. Materials and methods

The aim of the publication is to demonstrate how changes in indicators affect foreign trade in Poland during the COVID-19 pandemic. This is especially important in terms of running a business and, above all, shaping its development. The study attempts to show how the

COVID-19 pandemic affected basic economic indicators that could influence decision-making regarding international trade. In the study, the most important parameters (indicators) influencing international aspects were adopted in the identification of the economic macroenvironment according to Pizło and Mazurkiewicz-Pizło: GDP, inflation, unemployment level, income level.

The study asked research questions: what impact did economic indicators have on imports and exports in Poland during the COVID-19 pandemic? The analysis of the literature and observations of the effects caused by the COVID-19 pandemic led to the development of a "negative" hypothesis: the COVID-19 pandemic had a negative impact on economic indicators, which had a direct negative impact on the export and import from Polish.

The research was carried out as follows:

1. The changes in individual indicators in the years 2016-2020 were analyzed in the analysis of quarterly series.
2. The data were subjected to regression analysis and correlation between variables.
3. The data were subjected to comparative analysis to demonstrate relationships.
4. The final result of the study was to demonstrate the development of foreign trade in the analyzed period.

The study analyzes domestic and foreign literature on the subject. Quantitative research was based on secondary data from the following databases: EUROSTAT, NBP, TRADING ECONOMICS Central Statistical Office covering the period 2016-2020. The values of the analyzed indicators were calculated in Microsoft Excel, and the research results were presented in the form of Microsoft Excel charts.

4. Results

The effects of the COVID-19 pandemic were visible throughout the global economy. Literature analysis shows that the first series of infections quickly caused a global pandemic, which continues to this day, as well as its effects. The WHO announced the COVID-19 pandemic on March 11, 2020, because the phenomena occurring in various parts of the globe indicated a mortality rate of 3.4% globally, and for Poland 2.29% (Olkiewicz, 2022). Figure 1 shows the increase in infections during the analyzed period.

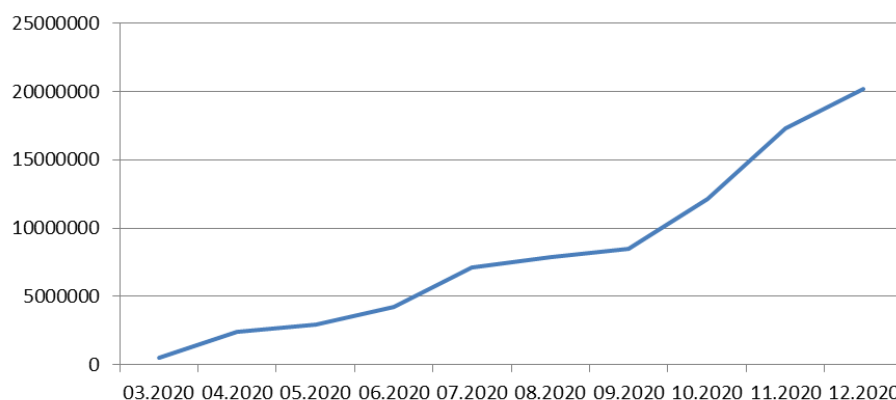


Figure 1. The scale of COVID-19 infections in the world.

It is worth recalling that all sectors of the economy had to undergo rapid, radical changes. Not all enterprises have passed the test of their ability to adapt to sudden, unforeseen crisis situations. It should be noted that the rapidly progressing COVID-19 pandemic changes resulted in socio-economic changes, which resulted in the introduction of epidemiological restrictions. On the one hand, the restrictions influenced the conduct of business activities, increasing and guaranteeing the safety or sense of security of employees, and on the other hand, they changed the habits, habits and expectations of customers and also caused the emergence of new needs. Such changes were reflected in the development of Gross Domestic Product. The data presented in Figure 2 indicate that despite the emergence of the pandemic, the analysis of the GDP indicator at current prices does not show any downward trends. There is minimal increase from year to year.

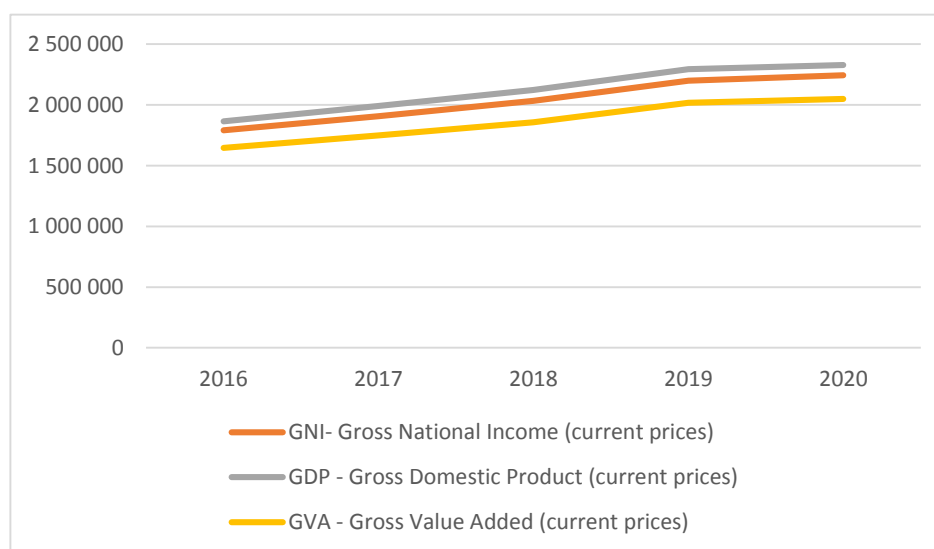


Figure 2. Changes in the GDP index.

The data in Fig. 3. looks different. Changes in the method of data identification, i.e. comparative analysis year to date (at constant prices) and the value of the previous year = 100, allow us to conclude that the GDP indicator shows negative variability during the emergence of the COVID-19 pandemic.

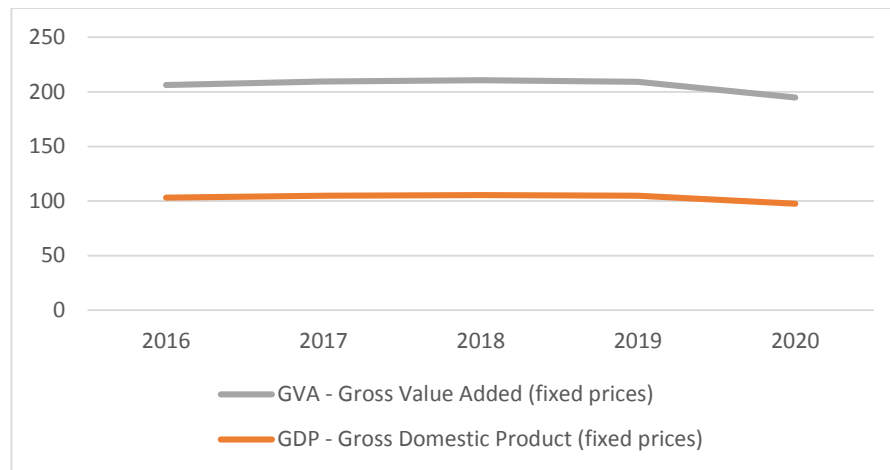


Figure 3. Changes in the GDP index.

The analysis of figure 3 indicates a significant impact of the COVID-19 pandemic on the development of the GDP indicator (changes in the GDP indicator compared to the same period of the previous year), as there is a breakdown in the tendency of the indicator's distribution. For a better presentation of the interaction of both phenomena, Figure 4 is presented. The data in Figure 4 show how the number of infections directly affects changes in GDP, i.e. the number of infections increases and the GDP indicator decreases.

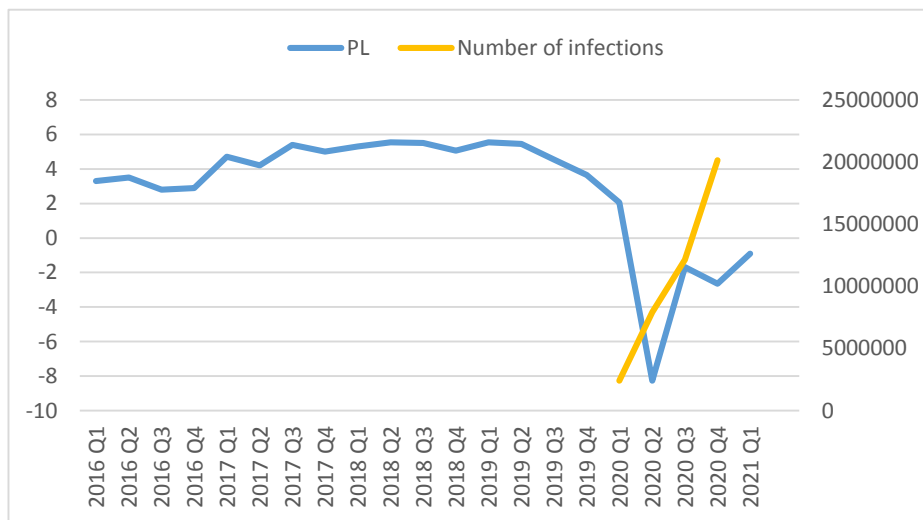


Figure 4. Changes in the GDP index in quarters and the number of infections.

Changes resulting from the introduction of restrictions and restrictions, e.g. related to maintaining distance, have largely influenced the demand and supply of products and services. Fears of infection and disease have resulted in restrictions on movement and direct consumption. This, in turn, (sales restrictions) resulted in the increase in inflation presented in Figure 5.

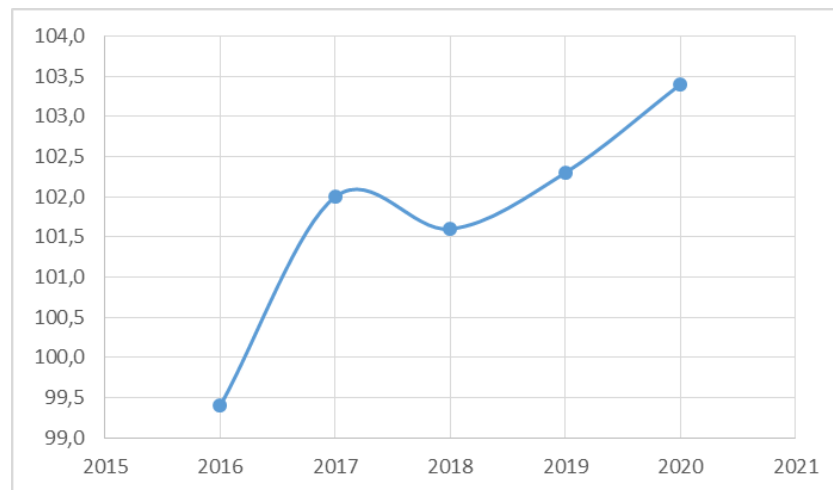


Figure 5. Changes in the inflation rate.

The analysis of the phenomenon of change in the inflation rate (year to year) from Figure 5 indicates a significant increase, which resulted in an increase in the prices of raw materials, which in turn, together with the limited access of employees to work (epidemiological restrictions), resulted in higher production costs, forcing entrepreneurs to raise prices products. It should be noted that actions limiting the possibility of stable operation of enterprises, due to restrictions and bans implemented by the government, forced employers to change the organization of work, including sending employees on forced leaves. Ultimately, employees made decisions to lay off employees or even suspend or close their operations. Such radical changes had their consequences in terms of changes in the unemployment rate. Figures 6 and 7 indicate that in the case of Poland, the COVID-19 pandemic also had a negative impact on the development of this parameter.

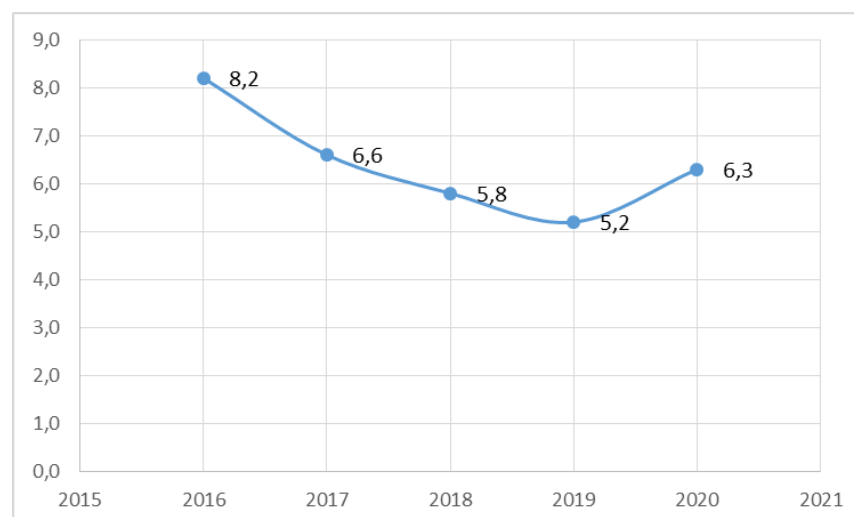


Figure 6. Changes in the unemployment rate (in %).

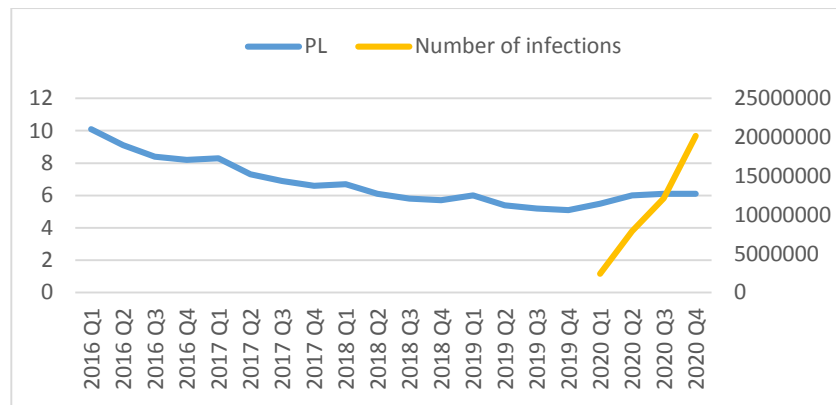


Figure 7. Changes in the unemployment rate in quarters and the number of infections.

The change in the unemployment rate (Fig. 6, 7) in the analyzed period indicates that there was a reduction in jobs due to the liquidation of entities and the difficult socio-economic situation. Particularly visible is the relationship between the distributions of the unemployment rate, which begins to increase when COVID-19 cases increase.

It is worth noting that the growing unemployment rate as well as reduced demand should be reflected in the development of the international trade index, in particular foreign imports and exports. The analysis of the export and import index (on a year-to-year basis) in the analyzed period had a very similar distribution to changes in GDP (Fig. 8), but in terms of value it was slightly different (Fig. 9).

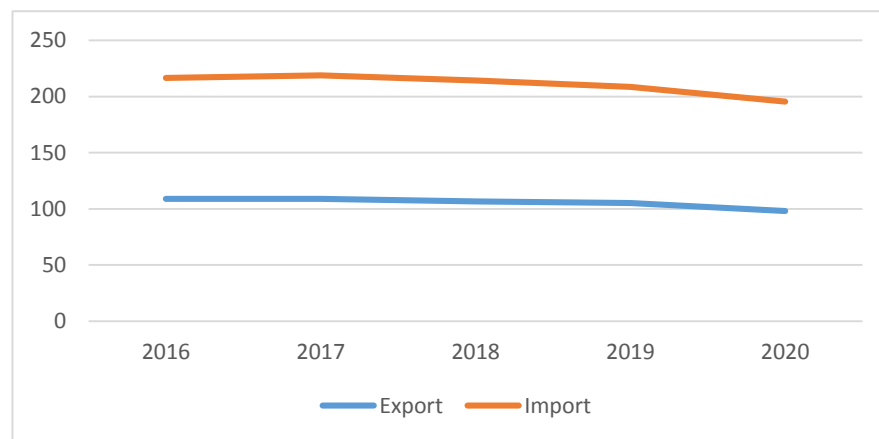


Figure 8. Changes in the export and import index.

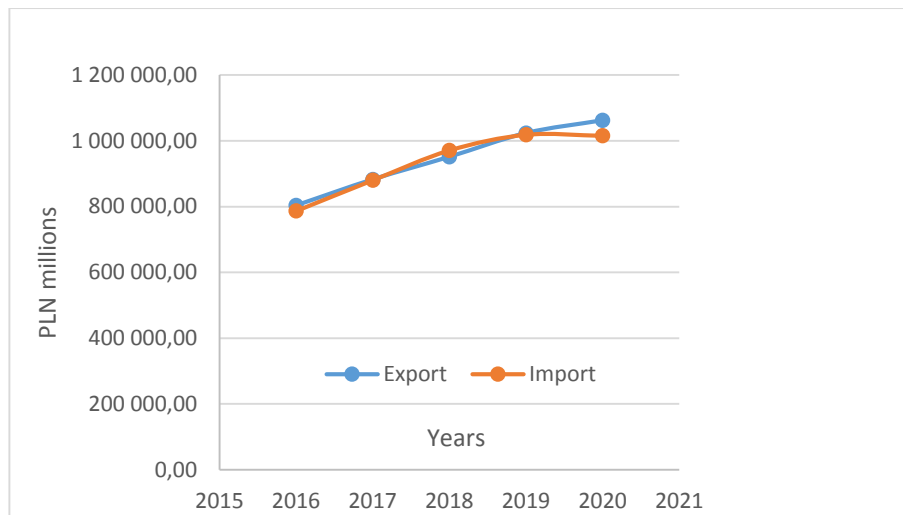


Figure 9. Changes in the international trade.

The analysis of Figures 8 and 9, despite a different approach to assessing the distribution, indicates downward trends (imports) and slowing growth (exports) during the COVID-19 pandemic. For a better presentation of the studied phenomenon, the export index and the number of cases were identified on a quarterly basis (Figure 10).

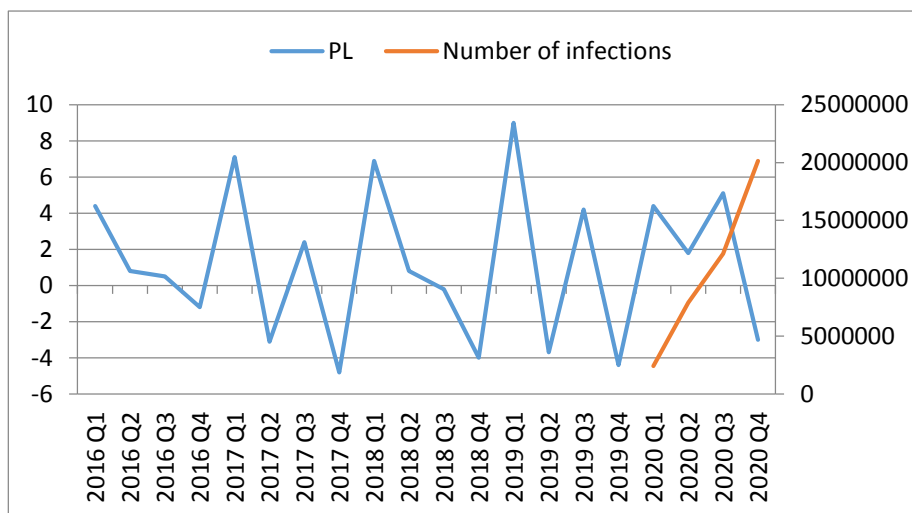


Figure 10. Changes in the export index in quarters and the number of infections.

Analysis of Fig.10. indicates that the initial wave of illnesses had a positive impact on export volumes. This may be the result of the disease being detected later than in other countries, thanks to which the organization's current production and resources could be sold abroad. However, as infections increased, the trend of foreign trade (export) began to decline. This may mean, on the one hand, limited sales opportunities and, on the other hand, interrupted supply chains of raw materials necessary for the production of goods. This distribution may mean that there is a small correlation in the short term but a significant one in the long term. However, the lack of correlation both in the long and short term is visible in the identification of the import index and the number of cases (Fig. 11).

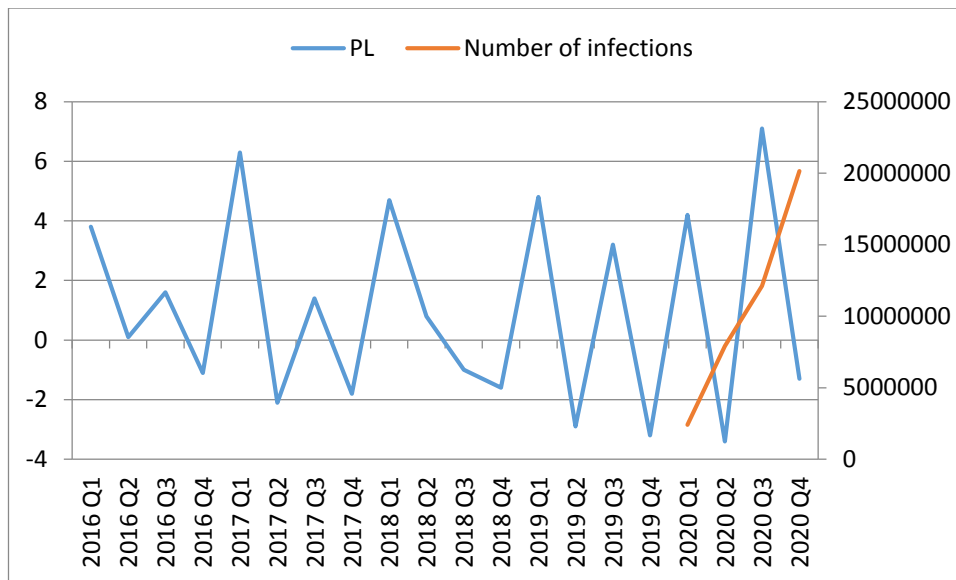


Figure 11. Changes in the import index in quarters and the number of infections.

This means that the COVID-19 pandemic is the main determinant of the import rate from abroad. In other words, the import rate is influenced by the demand situation in the country for given goods or services, as well as their availability, consumption possibilities (wealth of the inhabitants), etc. The analysis of Figure 11 only confirms these statements, as a very low relationship between these features is visible. To confirm the previous conclusions, Figure 12 presents the level of foreign trade between Poland and Ukraine.

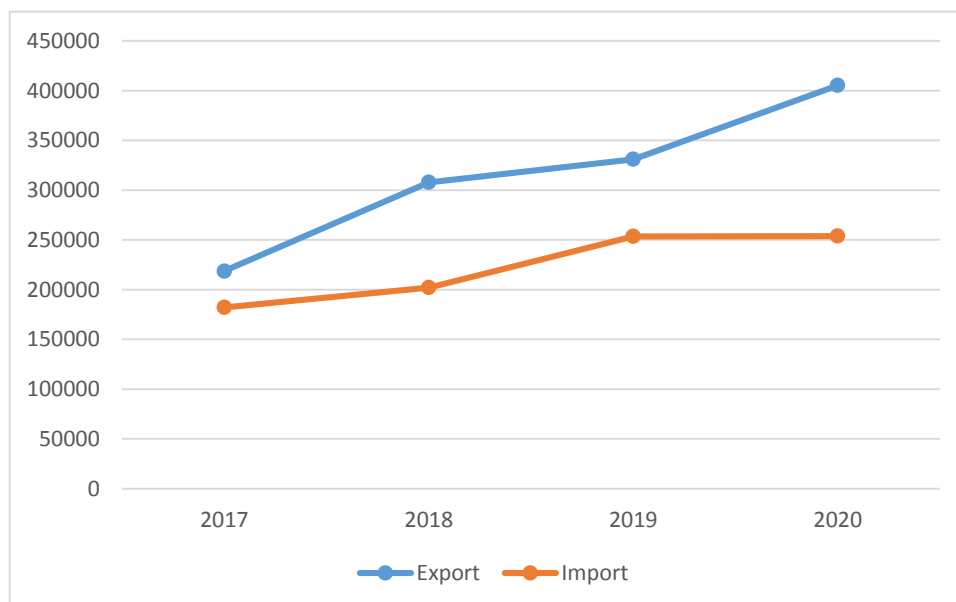


Figure 12. Polish imports from Ukraine and Polish exports to Ukraine in thousands of dollars.

The presented data confirm that in the initial phase of the COVID-19 pandemic, the growing trend in exports was maintained, while imports were already disrupted. The presentation of economic macro-environment indicators identifying the impact on foreign trade during the pandemic is presented in Fig. 13.

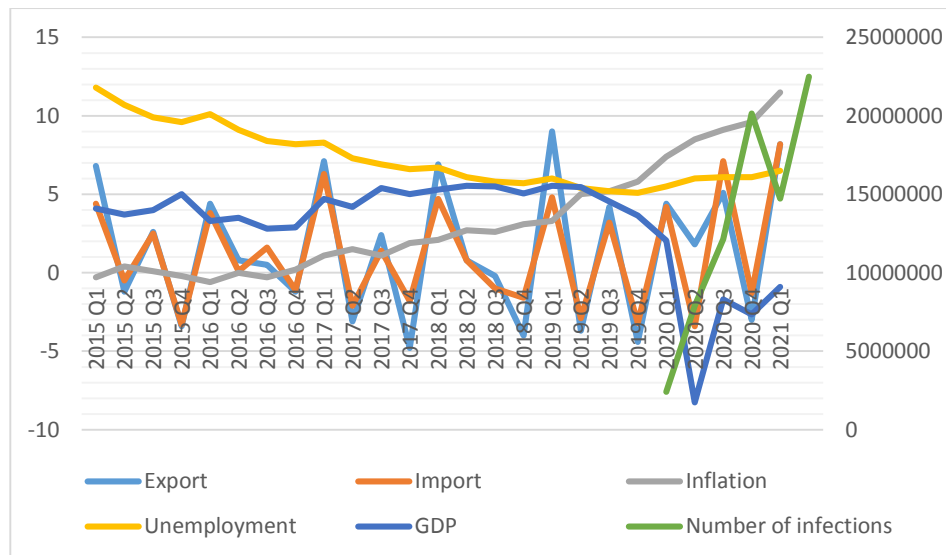


Figure 13. Indicators of the economic macro environment in quarters in 2016-2020.

5. Conclusions

The analysis of socio-economic phenomena indicates that the emergence of the COVID-19 pandemic in 2020 had a significant impact on the development of few indicators of the economic macro-environment. The presented statistical data show that most economic entities in Poland and the government took quick actions to minimize radical changes in the development of basic economic (macroeconomic) indicators. Significant changes were visible in GDP, inflation and unemployment rates. Such rapid changes had direct economic significance. It is worth noting that indicators identifying foreign trade did not show significant dependencies on the number of infections. It seems that the most sensitive indicators could have an impact on foreign imports, as many entities struggled with difficulties in organizing work and with the labor force. A similar situation was with exports, which could be limited by the same phenomena (as in Poland) in other countries, as well as logistic difficulties. The conducted research proves that the research hypothesis was correct, as the COVID-19 pandemic had a negative impact on economic indicators, which directly had a significant negative impact on the export and import of Polish products.

The research results indicate that the research area should be deepened and the research period should be extended. It is worth noting that during the research, limitations or difficulties were encountered resulting, for example, from the availability of data in the Central Statistical Office and EUROSTAT databases and various types of measurement methodologies used.

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BASIC ETHICAL PROBLEMS RELATED TO THE DEVELOPMENT OF ARTIFICIAL INTELLIGENCE AS A MANAGEMENT TOOL

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Purpose: The aim of this article is to show the most important ethical problems related to the development of artificial intelligence as a tool used to an increasing extent in the management process.

Design/methodology/approach: The article analyzes selected available literature on artificial intelligence. The authors are particularly interested in the ethical aspect of the use of artificial intelligence as a tool in the management process. In addition to the literature review, the authors use the method of analysis and logical construction.

Findings: The article presents the issue of artificial intelligence as a technological project that is becoming an increasingly important tool used in a manager's work. The use of AI is also an effective means of improving business operations. However, this raises a number of ethical problems and they are the main subject of the analyzes undertaken in this article.

Research limitations/implications: The text refers to a limited number of studies. Further research should be conducted to verify the real impact of AI application in management processes, especially when it comes to the human-machine relationship.

Originality/value: The article points to the main ethical problems emerging from the use of AI-based technologies in management processes. The analyzes mainly refer to the latest literature in this field and focus on those ethical difficulties that most disturb human-AI interaction.

Keywords: Artificial intelligence (AI), ethics, ethics of AI, machine Ethics.

Category of the paper: Conceptual paper.

1. Introduction

Artificial intelligence (AI) is currently the most discussed technological project in scientific literature. It is also becoming an increasingly important tool in supporting business operations. Recent advances in this field make it possible to support managerial tasks and functions such

as strategy planning, marketing and customer service. AI is also becoming an effective tool for business performance and an effective tool for its improvement (Gil et al., 2020). Due to the great impact of AI on various areas of social life and technological progress, its development has sparked a broad debate on the principles and values that should guide its development and applications (Kazim, Koshiyama, 2021; Vayena et al., 2018).

The growing possibilities of using AI in the management process have attracted enormous attention of scientists, business managers, entrepreneurs and politicians. Despite the fact that AI is one of the main sources of innovation, so valuable in business, it also poses a threat because, for example, it can deprive people of their jobs (Huang, Rust, 2018). AI is a tool increasingly used in management practice. Due to the ongoing AI-human interactions and emerging real or anticipated ethical problems, these processes require deeper ethical reflection (Heyder et al., 2023).

AI systems are used, for example, in the area of human resources management (HRM). In the process of the so-called "algorithmic management" AI technology is used to evaluate and select candidates (Marr, 2018), recruitment and selection process (Guenole, Feinzig, 2018) and the end of employment (Kellogg et al., 2020). The use of AI in the HRM process raises ethical questions. One of them is the issue of justice arising in the context of decision-making.

Deep ethical consideration becomes all the more necessary because AI-based technologies are no longer always subordinated to people (Baird, Maruping, 2021). They take over responsibility for the tasks performed. A question arises: are technologies managed by AI and AI itself also burdened with moral responsibility? The most important ethical challenges related to the use of AI in management processes include, for example: the issue of distributive justice, discrimination and exclusion, or transparency resulting from people's helplessness in the face of the growing capabilities of AI.

AI-based technologies seem to lead to the disappearance of traditional forms of work, giving rise to its hybrid form in the human-machine system. To avoid unintended negative ethical consequences resulting from the changing nature of human-AI interactions and the increasing importance of AI in management processes, it is necessary to re-examine how we manage human-AI interactions in organizations (Rai et al., 2019).

The analysis of ethical problems related to the use of AI in management processes requires as stated above, first of all, the development of the issue of ethical management of human-AI interaction based on the principles of ethics (Alsheibani et al., 2020; Han et al., 2020). The condition for ethical behavior when designing and implementing AI into company management processes is the actions of employees based on ethical values (Flathmann et al., 2021).

The emergence and development of AI opens a new era in various areas of life. This also applies to management. At the same time, it also poses numerous challenges, including those of an ethical nature. Understanding them and being able to counteract possible negative ethical effects becomes a necessity. This is an interdisciplinary challenge. Meeting this challenge is only possible with the cooperation of representatives of various scientific disciplines.

2. Methodology

To achieve the research objectives of this article, the study used techniques such as literature review to collect, analyze and synthesize relevant information from a wide range of sources. The databases were searched based on the following keywords: artificial intelligence, ethics, AI ethics, AI tools in management. The literature review was performed using Google Scholar and Scopus browsers.

The aim was to conduct a theoretical review based on an extensive literature search and qualitative content analysis of relevant articles to develop and expand knowledge on the ethical management of human-AI interaction. The article attempts to answer the question about the main ethical problems emerging with the development of AI. Then, attempts are made to identify those problems that are characteristic of the use of AI-based tools in management processes.

3. Literature review

The development of AI-based technologies now allows to perform cognitive functions that characterize the human mind (Rai et al., 2019). These technologies differ from previous ones in their ability to operate (semi-)autonomously (Rieder et al., 2020). There is a problem resulting from the fact that technologies based on AI are no longer always subordinated to the human factor (Baird, Maruping, 2021). Does this mean that they become responsible for the actions they take? It seems that the answer to this question is still negative.

Starting in the early 1960s, thanks to the development of experimental social psychology, considerations on the nature of justice and other ethical concepts ceased to be purely theoretical (Reis, 1984). This allowed later for example to understand how people respond to being paid higher or lower than the going rate and what mechanisms govern the allocation of group rewards. However, this did not lead to the elimination of conflicts, especially regarding distributive justice. Some researchers also point to AI failures leading to customer dissatisfaction (Castillo et al., 2021).

In order to avoid potential negative ethical consequences resulting from the changing nature of human-AI interactions taking place in organizations, the way in which it is managed should be analyzed (Rai et al., 2019). This assumes the need to indicate the most important ethical threats related to the above-mentioned interaction. Ethical requirements for AI systems are requirements derived from ethical principles, norms and codes (Guizzardi et al., 2020). However, it is worth remembering that modern technologies also affect ethics (Orbik, 2023). We are therefore dealing with a feedback relationship.

The implementation of ethical principles in strategic management requires two perspectives. First, the management of human-AI interaction must incorporate ethics by establishing guidelines and developing policies that recommend appropriate ethical behavior understood as an obligation for employees and artificial intelligence (Alsheibani et al., 2020; Han et al., 2020). Second, organizational leadership must consider employee virtue ethics based on moral values that guide individuals' intrinsic motivation to behave ethically when implementing, designing, and using artificial intelligence (Flathmann et al., 2021). Therefore, in order to implement the ethical management of human-artificial intelligence interaction, it is important to combine both outlined ethical perspectives (Eitel-Porter, 2021).

Attempts to ethically organize the development and use of AI should seem to aim at creating a universal machine ethics. The basic principles of this ethics should, of course, be written into the algorithms that guide their operations. Decisions about which principles to choose should not be left solely to ethicists or engineers (Shariff et al., 2017). The morality accepted in a given culture should also be taken into account. Ethical principles that are not accepted in a given community become dead. If AI is applied to management processes, it may lead to various types of conflicts within the organization resulting from employees' lack of acceptance of these principles. This becomes particularly important when various types of moral dilemmas arise.

Analyzing the literature on AI ethics, it can be noticed that the debate is mainly conducted around five ethical issues: transparency, non-maleficence, justice and honesty, responsibility and privacy (Jobin et al., 2019). Ethical topics related to AI, manifested in the publication of guidelines and rules related to its development, occur on a global scale. Companies such as Google and SAP can be mentioned here. Various recommendations regarding the use of AI are also issued by non-profit organizations and professional associations such as the Association of Computing Machinery (ACM), Access Now and Amnesty International. The scale of this phenomenon indicates the importance of ethical issues related to the increasingly widespread use of AI technologies. Some of the most important concerns regarding AI are the threat to employees' jobs, its misuse by dishonest entities and undermining the principle of justice (Zou, Schiebinger, 2018).

The thesis that the rapid development of AI-based technologies is accompanied by the increasing interest in emerging ethical problems seems to be justified. Research shows that the vast majority (Jobin et al., 2019) of all ethical AI principles are issued in economically highly developed countries. It results, among other things, from social moods, which are caused in many cases by incorrect understanding of the principles of AI operation and the possibilities of its use. We can therefore say that the revolution caused by the emergence of AI is transforming both science and society (Etzioni, Etzioni, 2016).

In the context of decisions made in the management process using AI, the question of their fairness and justice becomes crucial. They can be assessed through the prism of organizational justice, which can be understood in a utilitarian way as a principle occurring in decision-making contexts (Colquitt, Rodell, 2015). There are many works that address the issue of justice in

companies. They can be divided into two categories: (1) regarding the answer to the question why justice is so important to employees (Folger, 2001; Lind, 2001; Tyler, Lind, 1992); (2) analyzing how the perception of justice influences the adopted attitudes and behaviors (Lind, 2001; Tyler, Blader, 2003).

One of the basic problems is measuring the degree of justice in an organization. However, this became necessary when the investigation on the concept of justice lost the status of only a philosophical reflection. Several stages of development of the methodology of research on the concept of justice in organizations can be distinguished. The former mainly used an ad hoc scale with a few items (e.g., Earley, Lind, 1987; Folger et al., 1979; Tyler et al., 1985). As research has developed, more comprehensive measures have been introduced (Moorman, 1991; Sweeney, McFarlin, 1993). As research progressed, scientists introduced additional scales, the use of which became necessary due to the development of theoretical concepts and related trends in the scientific literature (Ambrose, Schminke, 2009; Blader, Tyler, 2003; Colquitt, 2001; Rupp, Cropanzano, 2002).

Attempts to scientifically measure justice in organizations obviously encounter various difficulties. One of them is to properly construct the definition in such a way that there is correspondence between the definition and the measure (Schwab, 1980). It is also important that the definition of the concept can constitute a methodologically correct basis for the survey questionnaires (Hinkin, 1998).

In the scientific literature devoted to the issue of AI ethics, there is a noticeable tendency in the understanding of general ethical concepts in the context of their application in specific social situations. An example can be again the concept of justice, most often understood as the fairness of decision-making situations (Colquitt, 2012; Cropanzano, Greenberg, 1997; Greenberg, 2010). The consequence is, on the one hand, the possibility of quantitatively approaching moral phenomena, and, on the other hand, the blurring of the boundaries between closely related ethical concepts. For example, the terms "justice" and "fairness" are used interchangeably. Consequently, the same measure may refer to a measure that is intended to induce fairness (e.g., consistency, equality, respect, truthfulness), while another refers to the perception of fairness itself (Colquitt, Shaw, 2005). It is true that the interchangeability of some ethical concepts is not inappropriate due to their almost synonymous meaning, but more and more researchers point out that, for example, justice and honesty are completely separate concepts in meaning and distinguishing them affects the obtained research results (Choi, 2008; Kim, Leung, 2007; Rodell, Colquitt, 2009).

A certain degree of interchangeability of ethical concepts is even immutable (Greenberg, 2010). This enables to combine the measure and the research question with the operational theoretical perspective. Some researchers indicate that ethical concepts such as justice, fairness, trust, duty, commitment may refer both to people performing various functions in the organization, and to the organization itself (Blader, Tyler, 2003; Colquitt, 2001; Rupp, Cropanzano, 2002). It follows that organization-centered justice reflects the degree to which

a company or its management is perceived to act in a consistent, fair, respectful, and truthful, or, briefly, ethical manner in the context of decision-making. In contrast, fairness attributed to a manager reflects the degree to which the manager is perceived as honest.

The concept of justice is one of the most important ethical concepts analyzed since ancient times by such thinkers and advocates as Hammurabi, Moses, Aristotle and many others. Of course, our perception of justice has changed significantly since ancient times. For many centuries, the concept of justice was related to the concept of reciprocity. A significant change in the perception of justice occurred when the idea emerged that people are capable of shaping the social world so that it achieves their goals. This happened in ancient Greece thanks to the sophists. The second breakthrough idea was the thesis of the equality of all people in the light of the law of nature, proclaimed a little later by the Stoics (Johnston, 2011). It was not until the twentieth century that the concept of organizational justice emerged. "At its most general level, organizational justice is an area of psychological inquiry that focuses on perceptions of fairness in the workplace. It is the psychology of justice applied to organizational settings (Byrne, Cropanzano, 2001, p. 4). This approach points to the eclectic nature of justice as a research area. Most researchers agree that when it comes to justice understood as fairness, its two types can be distinguished: (1) distributive justice or the fairness of the outcomes received in a certain transaction, and (2) procedural justice understood as the fairness of the process leading to these outcomes (Törnblom, Vermunt, 1999).

Research on specific types of fairness in the context of machine learning programming seems particularly interesting. This is currently the fastest growing area of AI in which statistical methods allow the system to learn from data and make decisions without the need for direct programming. The ethical issue that arises here is the possibility of eliminating unfairness from algorithmic decision-making. The usefulness of machine learning for organizations is due to the fact that it reduces the errors potentially made by humans when making decisions (Pezzo, Beckstead, 2020). That is why currently, more and more managers are using machine learning in decision-making processes. The use of these methods brings new ethical challenges for society and organizations (Grenwood et al., 2020; Martin, 2019).

The desire to make AI tools fair has led to the development of various statistical techniques. They are referred to as fairness criteria and take the concept of fairness into account in the design of algorithms. The problem that arises here is not only the technical side of designing such algorithms but also the understanding of the concept of fairness. It should be consistent with people's feelings. This is a necessary condition for people working in the organization to recognize the actions of AI tools as fair (Newman et al., 2020). Unfortunately, the above-mentioned ethical issues have not yet been properly addressed by researchers.

In computer science, fairness is understood as the absence of "any prejudice or favoritism toward an individual or group based on their inherent or acquired characteristics" (Mehrabi et al., 2019, p. 1). Correctly determining the criteria of algorithmic fairness is of both theoretical and practical importance. In addition to the above-mentioned difficulties in defining ethical

concepts such as fairness, there are also practical problems. The main such problem is the lack of guidance for organizations that want to implement algorithmic criteria. This can lead to tensions between employees, customers and the business environment (Lee, 2018; Newman et al., 2020). The theory of justice in organizations mainly concerns the perception of distributive and procedural fairness by employees and customers (Goldman, Cropanzano, 2015; Khan et al., 2015). The emerging task for ethicists, managers and programmers alike would be to examine the importance of distributive and procedural fairness for algorithmic criteria.

The growing impact of AI technology on various areas of activity, including management processes, requires engineers and managers to be more committed and to incorporate knowledge of ethical principles into their managerial practice (Agbese et al., 2023). When attempting to assess the importance of ethics in management processes, including those based on AI tools, it should be stated that research indicates that ethical requirements are still rarely considered a priority at middle and higher management levels. This is due to the conviction that this type of research has little impact on human life and that it does not translate into financial value (Brendel et al., 2021).

Summarizing the development of literature on AI ethics, it can be said that to some extent a common terminology regarding this issue has been developed. Summarizing the development of literature on AI ethics, it can be said that to some extent a common terminology regarding this issue has been developed. Terms such as trust, transparency and privacy appear in various studies. Similar solutions to emerging problems are also often proposed (such as appropriate legislation). Similar main problems are identified, such as exploitation, disinformation and various types of prejudice. However, it is difficult to talk about an established, uniform canon of literature. There is also often a lack of a philosophical foundation.

All the above-mentioned ethical problems related to the development of AI also apply to its use in management practice. The digital era poses new challenges for business at all stages of its operation (Rustholkarhu et al., 2021). AI technologies are expected to transform and improve especially marketing and sales processes (Davenport et al., 2020; Iansiti, Lakhani, 2020). AI in management literature is most often described through its management applications (Rustholkarhu et al., 2022). All these areas require ethical considerations.

The literature analysis shows how complex and still only partially developed the topic of AI ethics as a management tool is (Baker-Brunnbauer, 2021). However, due to the fact that the development and use of AI-based technology is the future of management, both in-depth reflection on its ethical consequences and the implementation of solutions that eliminate potential threats, including those of an ethical nature, are necessary.

4. Discussion

Although some scientists and practitioners claim that AI is still far from achieving consciousness and therefore there is no need to consider ethical issues in its context, when combined with other technologies its potential in areas such as business, medicine or transport is evident. The numerous applications of AI-based technologies are having an increasing impact on humans, which raises ethical questions.

A distinction must be made within AI ethics, which is part of the ethics of advanced technology that focuses on robots and other artificially intelligent agents, roboethics (robot ethics) and machine ethics (Siau, Wang, 2020). Robot ethics deals with the moral behavior of humans during their interactions with AI and the related impact of robots on individuals and social groups. In other words, AI ethics are the ethical principles arising from the development and implementation of artificial intelligence.

Since there are different models of human-AI interaction (Rai et al., 2019), it is important to remember that ethical management of human-AI interaction cannot be limited to a specific task and, therefore, to a specific type of interaction. It is important to divide tasks between humans and AI (Fügener et al., 2021). The idea is for humans and AI to form a team in which there would be a chance to correct each other's mistakes (Bansal et al., 2021).

Organizations must take ethics into account when making decisions regarding the implementation and use of the latest AI-based technologies to achieve their strategic goals (Berente et al., 2021, Dwivedi et al., 2023, Marabelli et al., 2021). Therefore, in the development of AI-based tools, cooperation between managers, computer system specialists and ethicists seems to be very important.

Research conducted so far on the human-AI relationship has focused primarily on the ethical or unethical actions of humans or AI-based technologies (Hamilton et al., 2021; O'Sullivan et al., 2019). What is missing here is an analysis of the impact on ethical behavior of the moral values accepted by individuals as the main motivators of these actions. An important change that has taken place in recent years is the growing awareness of the existence and importance of ethical issues related to AI in the institutional dimension, the scientific community and society in general (Boddington, 2017).

Based on the analyzed literature, the following fundamental problems can be identified in research on the use of AI in the management process in the context of human-AI interaction:

1. the lack of a general ethical theory discussing the basic principles of conduct in the human-AI relationship (Mirbabaie et al., 2022),
2. the lack of integration between the algorithms on which AI operates and people's understanding of basic ethical concepts (Morse et al., 2021),
3. the fact that ethical issues emerging with the use of AI-based tools in management processes are part of a previously unknown interaction between humans and machines, in which so far only humans are the subject of ethical activities,

4. the lack of a global approach to the ethical aspects of AI can also be indicated as of the ethical problem (Carillo, 2020).

One of the most serious problems is the methodological difficulty manifested in the correct construction of definitions of ethical concepts (e.g. justice) in such a way that quantitative analyzes are possible. In this way, ethics as part of philosophy can become a part of scientific discourse. his scientific approach is necessary when trying to evaluate technology.

Difficulties in appropriately regulating ethical issues arising with the development of AI also result from methodological differences characterizing ethics and computer sciences (Orbik, 2016). The problem becomes even greater when we realize that the development of AI brings with it challenges requiring cooperation of such diverse disciplines as communication, business, management, media studies, law, political science, philosophy and other fields of science and engineering (Bakiner, 2023).

Several theoretical implications emerge from the literature analysis that suggest future directions of action that should be taken. First, this article highlights the potential of behavioral ethics research to enrich our knowledge of the tools used in AI-based management processes. It would be a task for both ethicists and management specialists to examine the importance of distributive and procedural fairness for algorithmic criteria. Second, we need to ensure greater integration of ethics into organizations. It cannot be treated only as a kind of extravagance or an "add-on" to technical problems (Hagendorff, 2020). Third, software developers should possess a sense of moral responsibility for the systems they design and a conviction about the moral significance of their work. In other words, AI systems should be developed and used in accordance with social and moral values such as justice, beneficence and non-maleficence (Taddeo, Floridi, 2018; Pekka et al., 2018). Fourth, it is necessary to take into account, in addition to deontological ethics based on universal ethical principles and norms, also ethics that takes into account the specific situation and the problem to be solved (Mittelstadt, 2019). Such ethics should, while remaining consistent with fundamental moral principles, refer primarily to the sense of responsibility for the undertaken actions.

The problem of the ethics of AI-based tools used both in management processes and in various other areas of life remains open. According to some researchers, there is no point in teaching a machine ethics even if it could be done (Etzioni, 2017). This view is justified by the fact that only humans are capable of making ethical choices, and machines, even those to which we are inclined to attribute intelligence, are only tools and not ethical entities. The key to resolving the dispute here is the vision of future human-intelligent machine relations. It seems that the ideal solution to this relationship would be a model that integrates the speed and capabilities of intelligent machines with the innate talents of people, where what is important is not competition but a specific type of cooperation (Shaw, 2019). In the light of the interdisciplinary nature of research on the development and application of AI, the analysis and solution of ethical challenges becomes one of its most important elements.

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THE NEED AND PROCESS OF GENERATING INNOVATIONS BY CORPORATE MUSEUMS – CULTURAL EXHIBITION UNITS OF ORGANIZATIONS

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Purpose: Corporate museums are something more than traditional ones. As unusual means of promotion, apart from disseminating the values of history and culture, they become their founders' brand and prestige manifestation. The aim of the article is to emphasize that in order to fulfill this task effectively, corporate museums must be innovative. On an empirical level, the aim is to evaluate a set of guidelines which implementation can help corporate museums meet the goals for which they have been established.

Design/methodology/approach: Theoretical part of the article has been prepared based on desk research analysis of available source data. In the preparation of the empirical part of the work (evaluation of the model for creating innovations in corporate museums), the results of the review of social profiles and websites of corporate museums were taken into account. The results of a personal (unformalized) interview with employees of corporate museums were also helpful, primarily of the Mladá Boleslav automotive museum and Waław Sakwa Foundry Art Gallery - an exhibition unit operating at the author's workplace.

Findings: In modern, complex conditions of turbulent environment it is impossible to imagine functioning of corporate museums without undertaking by them continuous creative changes. However, the mere awareness that innovations constitute an impetus for the success is insufficient from the point of view of corporate museums considering the possibility of introducing new solutions. Therefore, they have to consider particular suggestions on the practice of generating innovations which should be followed in order to improve the process of creating new solutions.

Research limitations/implications: This study focused on analyzing literature data and checking the perspective of employees of sample facilities, which may narrowed the perception of innovation in corporate museums phenomenon. A way to verify and deepen the received conclusions may be further examination from the perspective of a larger number of employees as well as to compare the obtained results with museums located in distant countries. Recommended direction for further research would be broadening perspective and conclusions.

Originality/value: The topic of corporate museums is not widely considered in the literature and this thesis offers a systematic attempt to apply general innovation theory in a exhibition unit context in order to advance knowledge on innovation in corporate museums, conceptually and empirically.

Key words: innovations, corporate museums, new solutions, culture.

Category of the paper: conceptual, research.

1. Introduction

With the advent of the new millennium, the world entered a time of increasingly faster and more unpredictable changes. Life and the conditions for performing any activity on the market are currently shaped by variability and unpredictability - turbulence (Lane, Down, 2010). Researchers are even of the opinion that turbulent times are not an aberration, but a new face of normality (Kotler, Caslione, 2009). All entities present on the modern market must operate in increasingly complex conditions, in a world of uncertainty, an abundance of data and information, unpredictability of phenomena (as demonstrated, for example, by the Covid-19 pandemic), as well as the dynamism of socio-economic processes and strong competition. The sources of these conditions should be sought in social, demographic and political changes, in the development of modern technologies and, finally, in the ongoing processes of globalization.

The increasing pace of changes taking place in the environment constitutes a challenge for science and is of key importance from the point of view of the practice of managing organizations. Both scientists and managers are increasingly consider how to effectively manage an organization in the dynamic conditions of the modern economy. It seems that one of the clear answers was given by A. Wyroba and J. Tkaczyk, who claimed that "the globalization of business activity, the development of new technologies, the increasing importance of competitiveness and cooperation result in the need to place greater emphasis on innovation" (Wyroba, Tkaczyk, 2015, p. 5). In this context, it is not surprising that in recent years this relatively new category has been included not only in the subject of scientific research, but also in practical initiatives and programs of the European Union. Already in the European Union's Europe 2020 strategy, which is a continuation of the Lisbon Strategy, fulfilling the need for the so-called: intelligent development was underlined, which should be identified with taking actions aimed at increasing the role of knowledge and innovation as the driving force of future development (Markowska, 2014).

According to this doctrine, it is impossible to imagine the survival of modern organization without undertaking continuous creative changes in order to keep up with changing environment. In an economic situation characterized by strong competition and permanent and dynamic changes in the market situation, organizational development strategies must be based to a greater extent on the introduction of innovations. Obtaining and then maintaining a competitive advantage and the development of entities in turbulent realities is conditioned by the creation of new solutions in the form of products and processes, as well as the development and implementation of previously unprecedented business models (Porter, 2001). This approach is consistent with the words of H. Ford, who at the beginning of the last century, already, expressed belief that companies grow thanks to development and improvements.

“But when an organization stops being creative, when it thinks it has achieved perfection and now only needs to produce, it is doomed to failure” (Joseph, Rodenberg, 2007, p. 234).

It may seem, however, that the need to generate innovations does not apply to museums. These are, nevertheless, organizational units that do not operate on the market based on traditional, commercial principles. Their leading mission is not to make a profit but to preserve the achievements of humanity and broadcast them to future generations. This is to be done by „collecting and protecting the natural and cultural heritage of humanity of a tangible and intangible nature, providing information about the values and contents of the collected items, disseminating the basic values of history, science and culture, shaping cognitive and aesthetic sensitivity, and by enabling the usage of collected stuff” (Žuk, 2011, p. 173). Due to this, museums traditionally occupy a special place in the system of development and distribution of socially oriented values. They retain status of a synthetic and prestigious cultural institution in modern society. They „unites the progressive and innovative areas of architecture and design, research results, fundamental and applied sciences, achievements in engineering and cutting-edge technologies” (Maystrovskaya, 1997, p. 7).

As X. Castañer and L. Campos emphasize, it is understandable to believe that entities described in such categories do not have to follow news at all costs and be very creative in their activities. These are rather the areas of economy and technology that known solutions quickly become obsolete, while in art and culture, earlier forms and works do not lose their importance and can still be used (Castaner, Campos, 2002). In reality, however, it is different because nowadays museums also have to meet the growing demands of both their organizers and recipients (Della Corte et al., 2017). At the same time, as mentioned previously, achieving a competitive advantage and meeting the addressed requirements becomes possible only thanks to innovations (Crossan, Apaydin, 2010). Hence, creative activities, e.g. in the form of creating a diversified offer or using a wide range of forms of communication, also become a necessity for museums.

At the same time, the so-called corporate museums are in a particularly demanding situation. This is due to the fact that these are special cultural exhibition units. The corporate museums are thematic, commercial buildings, owned by a particular organization, where the history of the brand and products development is presented (Piatkowska, 2014). They not only satisfy the visitors’ desire to receive new information, but also realise the business goals of brand representation, both increasing loyalty to it, and developing corporate culture (Bondarenko et al., 2020). In the article, the author explains the concept of these specific cultural units in more detail and explains the need to generate innovations by them. Above all, however, he focuses on attempting to define a set of specific guidelines, how to generate new solutions in corporate museums so that their operations can keep up with the requirements arising from modern times.

2. Corporate museum as a specific type of exhibition unit

Among the various museum facilities, there are also, so-called: corporate museums which are of interest for this study. Despite their long pedigree, corporate museums constitute a field of study that has been little explored and that occupies a particular position, at the intersection of the cultural realm of public museums and the world of business, and is characterized by a managerial vision. Corporate museums should be considered in terms of physical structures in which the history and the memory of an organization are told (Bonti, 2014). These are exhibition complexes devoted to the history, present and future of the organizations that sponsor them. Any object can be considered as such, which:

- is only an additional, side establishment for the organization by which it was created, it is maintained and managed,
- is a cultural institution established to collect, store and preserve objects of historical or artistic value,
- all or part of these objects are made available to the public in the form of permanent or temporary exhibitions (the rest are stored in specially adapted warehouses),
- very often presents the achievements of the organization to which it belongs, e.g. it displays the results of production processes that have taken place over the years (e.g. a vehicle manufacturer may display old car models of its brand),
- must have financial background and human resources ensuring the durability of its activities (one-off and ephemeral activities will not meet the durability requirement, even if they consist in activities typical for a museum, e.g. presenting an exhibition) (Barbasiewicz, 2021).

Many organizations (including enterprises, universities and even public institutions), both in Poland and abroad, have decided to create their own corporate museum. It seems that companies operating in the automotive industry are, among others, very active in this field. It turns out that some of the private museums of automotive companies are located even quite close to Poland. An example is the Škoda automotive museum (Figure 1), located in the center of Mladá Boleslav (a statutory city located in the Central Bohemian region, north of Prague), opposite the Bondy shopping center and Škoda Auto factory. It was once the building where the company's founders - V. Laurin and V. Klement - started their work in 1895.

The Škoda Museum was opened in 1995 on the occasion of the 100th anniversary of the company's establishment. In this facility, on an area of over 1800 m², the history of the Škoda Auto a.s. company is presented (as well as its predecessor Laurin & Klement). It is a modernly designed facility, established in accordance with the provisions of Art. 2, Par. 4, Act No. 122/2000 Coll, on the protection of collections of museums and amending certain other laws. As a part of a diversified, engaging, interactive and multimedial walk in the Skoda museum, visitors can get acquainted with both the oldest models produced by the company

(the company's first product was the "Slavia" bicycle) as well as contemporary, modern cars (Vojtechovsky, 2005).



Figure 1. Corporate museum of Skoda Auto in Mladá Boleslav.

Source: author, 5.07.2023.

It should be emphasized that the above-mentioned and similar, own exhibition facilities are usually not aimed at making a profit (as it may be to some extent, in the case of museums established not by organizations, but by private individuals - enthusiasts/collectors who, at some point decide to make money from their hobby by making their collected items available for viewing by outsiders for a fee). Corporate museums are rather intended to promote the organization of which they are a part and this is the justification for their existence (for example, on the website of the Czech Skoda museum, they are referred to as: the brand's showcase). Corporate museums can, of course, derive certain financial benefits from the sale of admission tickets (and they usually do), but their basic function is to achieve the appreciation of the favorable attitude of stakeholders. It is assumed that visitors will subconsciously transfer positive feelings about what they see in the organization's museum to the organization itself.

Such an approach seems to be justified. First of all, the creation of own exhibition facility can be a very eloquent signal that the organization is not only convinced of the need to protect artifacts constituting national treasure, but also that it is actively involved in this work (although it does not have to be formally). Hence, by opening its own museum or gallery, institution proves that it takes special care of the heritage of the past, and thus further strengthens the belief in its social responsibility among members of its surrounding: in this way, the parent entity is perceived "not only as a selfish entity, caring only for its own benefits, but as a socially sensitive organization that gives something particular to society" (Pabian, 2008). Further benefits are related to:

- Image building. Part or even the entire exhibition in ones own exhibition facility may be devoted to the achievements of the organization or its outstanding employees. This increases trust in the organization. People visiting its museum can be convinced of the rich achievements, competences and experience of the organization.

- **Recognition strengthening.** An exhibition facility makes the organization known to an even wider public (also to people who, for example, do not buy its products on a daily basis). Visitors also remember the name of the organization that deals with a given facility.

In this case a multiplier effect appears. Visitors are often eager to share their impressions of the visit with family members, beloved ones and friends. In addition, a corporate museum or gallery may also become the object of media interest. Articles, reports or broadcasts can significantly contribute to increase the general recognition of a given organization. In this context, a corporate museum becomes an excellent public relations tool, contributing to the possibility of achieving the goals of integrated marketing communication.

3. The need for innovations in corporate museums

In order for the exhibition units described in the above categories to bring image benefits to their parent entities (for which they were mainly created), first of all they have to be attractive from the point of view of potential visitors. This is why museums' ability to attract people is drawing the increasing interest of both scholars as well as practitioners (Manna, Palumbo, 2018). First of all, they must move away from informational to performative museology, i.e. from strictly controlled narratives defining the path through the exhibition towards more flexible compositions encouraging viewers to follow their interests and to create their own paths through the exhibition (Ziębińska-Witek, 2014). Dynamically progressing digitalization also means that they must increasingly focus on the wider use of interactive technologies in order to attract the attention of visitors by providing them with new impressions and experiences.

However, to meet such requirements, corporate museums must be innovative. In the modern, globalizing world, there are changes in the functioning of all structures and transformations in ways of thinking. Therefore, all existing elements must adapt to the turbulent environment, including corporate museums. Only new solutions can provide the foundation for making museums' offer more attractive to visitors (Kalinowski, 2010). Nowadays, innovations are necessary in all phases of a corporate museum's existence, starting from the creation of the idea, through the phase of establishing and starting the facility, existing and success, development, maturity, up to the phase of decline and extinction, when they may become the beginning of a new cycle of life. Those museums that cannot adapt to the requirement of innovation will not be attractive to visitors and thus must accept failure or the need to drift in stagnant marasmus. Those that want to be successful or exist must create new solutions and be open to new things.

In terms of benefits from implementing innovation, in addition to the social area (an attractive museum will become a more frequently visited place), there is also the economic area, which is its derivative (Pop, Brzoza, 2016). Innovations can also increase the prestige and reputation of the entire institution. As a result, in turn, ticket sales will increase and, ultimately, the company's own sources of money will increase (Camarero, Garrido, 2012). While the possibility of obtaining such benefits cannot be underestimated, the ability to create or develop novelties is still one of the greatest challenges for contemporary organizations, and this also applies to not-for-profit, permanent institutions in the service of society that exhibits tangible and intangible heritage. Despite the necessity and benefits of pro-innovation initiatives, projects and policies, many corporate museums are still insufficiently active in developing new ideas.

This attitude may seem understandable under some circumstances. Generating new ideas is a difficult task, requiring time, personnel and conceptual investment. At the same time, many corporate museums have already achieved a satisfactory status quo. The traditional type of activity continued by these entities brings them the expected results, and current operational needs use most of their creative reserves. From this point of view, additional involvement in innovative activities may seem unnecessary or unprofitable to such museums. By contrast, there are of course, also corporate museums that base their activities on the belief in the need to create and implement certain new solutions. However, regardless of the degree of interest or willingness to create innovations in museums, it is possible to distinguish a certain universal set of recommendations and tips that can help develop their innovative abilities. The mere awareness that innovations constitute an impetus for the success is insufficient from the point of view of corporate museums considering the possibility of introducing new solutions. Therefore, it is necessary to consider suggestions on the practice of generating innovations, which should be followed in order to improve the process of creating innovations in a corporate museums. The next chapter of the work will be devoted to this topic.

4. Results – the practice of generating innovations. Indications for corporate museums

The results of studies indicate that corporate museums need to demonstrate a more open attitude towards non-identical sources of inspiration. It turns out from they employees that one of the basic sources of new ideas for corporate museums is still their own interior - in practice, many of the new solutions still have this independent character. This means that new ideas are created only within a single entity, without external interaction, as a result of the individual ingenuity of its employees and using its own (and parent organization's) competence base. However, it is not without reason that in today's practice a much larger group are progressive innovations, which are the result of interactions taking place between organizations and the

environment in which these units operate. This is due to the fact that changes taking place in the environment force the need to constantly adapt to them. This always happens in the case of a dynamic environment which is usually complex and subject to frequent changes resulting from, among others, the rapid progress of knowledge or the development of new technologies (Davis, 2007). Also, cultural exhibition units which, as if by their statute, are created with the environment in mind, should be more open to external sources of inspiration for new ideas. They have many alternatives possible - exogenous sources of new ideas include: consultants, universities and research centers, fairs, exhibitions, meetings, innovation support programs, etc. (Moszyński, 1994).

Managers of corporate museums must also remember that, according to research on change management, the benefits associated with implementing gradual, slow innovation often exceed those that can be brought by a one-time breakthrough (This fact is, for example, confirmed by S. Hollander's research carried out at DuPont plants) (Hollander, 1965). Therefore, the sought novelty does not have to be radical and far-reaching. Innovations may not go beyond making minor changes in the museum. Researchers even encourage to use the small-step method when creating innovations - do better what we are already good at. They suggest focusing on making small changes from day to day. A simple improvement within the company museum may, in consequence, still result in achieving specific benefits. For example, museum can consider to introduce corrective innovations, i.e. those aimed at improving the already existing, but imperfect elements that create the functional system of the exhibition facility. "Such innovations are usually quick and easy to implement" (Kaplan, 2017, p. 20). An example may include introducing more visually attractive ways of displaying exhibits (modern showcases) or enabling visitors to interact more deeply (in the way of touching) with the elements of the exhibition.

It is also important for corporate museums to go beyond their traditional areas of activity (their interviewed employees indicated five main ones, i.e.: making research, collecting, preserving, interpreting and exhibiting), and focus more on other directions, to look for new development opportunities and encourage people to make visit. This is due to the fact that innovations that may initially seem not directly related to exhibition (and therefore little needed), may bring tangible benefits in the long run. For example, in the already mentioned Skoda museum in Mladá Boleslav, an innovation was introduced by opening additional (non-typically exhibitional) facilities. That is why nowadays tourists visit this museum not only because of the history of the automotive industry. The facility also decided to provide a modern space for organizing events (the museum boasts a new multi-functional room: "Laurin & Klement Forum"), which is being used more and more often every day. The premises host congresses, conferences, meetings, workshops and various socio-cultural events (including lectures on the design of L&K and Skoda cars, workshops for children and even concerts). Visitors to the Skoda Museum are also attracted by the souvenir shop and the modern Vaclav café/restaurant.

The management of BMW Welt (the exhibition facility of the German car and motorcycle manufacturer) has gone even further in terms of innovations that go much beyond changes within the museum itself. The focus was not on changes within the exhibition, but it was decided to offer a completely new value - the opportunity to additionally visit the factory where are produced cars (corporate museum is located next to the factory where the brand products are manufactured). This allows to take a look behind the scenes of car manufacturing, observe specific production steps up close and get to know BMW in a whole new way. BMW Anyone interested can visit Plant Munich after declaring his intentions (via internet or by phone). The Bavarian plant can be visited on working days only, in groups of up to 30 people, under the care of a guide speaking English or German language. The tour around the halls takes about 2.5 hours. During it, visitors have opportunity to see how engines are assembled and sheet metal is stamped to form body parts. They are also allowed to learn about all subsequent stages of the final assembly of the car, from the moment of inserting the engine into the body, to the final quality tests of the finished vehicle (BMW Welt, 2022). Opening the possibility of visiting the factory seems appropriate and justified. This can be used as a benchmark and inspiration for change and innovation within another museums. Innovative approach of BMW has actually brought tangible benefits to its traditional museum too. Many visitors who would not normally visit it decide to do so by the way, when visiting the factory.

Some recommendations can also be made regarding the technical side of generating new ideas by corporate museums. This process should take an organized form, the course of which is determined by specific stages. They together create a sequence of appropriate procedures. In general terms, the innovation process should constitute "a sequence of activities carried out over the time which are necessary to implement a specific innovative concept and to transform it into a new state of affairs" (Baruk, 2002, p. 76). It is true that history knows cases in which previously unseen solutions were created unintentionally or even spontaneously, as a result of a sudden flash of creativity of a single individual. However, have to be aware that most of the new solutions introduced by modern organizations are not the result of a sudden, unexpected epiphany, but they are rather the result of an intentional and organized creative process. In the same way, innovations in corporate museums should appear as a result of the innovation process, i.e. specific activities that create a series of logically consecutive stages, the implementation of which measurably increases the chances of achieving success understood in terms of the dissemination of new ideas (Harvard Business School, 2005).

The first of these activities should be identifying needs. It involves identifying all factors that highlight the need to introduce a new solution. Motives for undertaking innovative activities by a corporate museum may be very different. For example, the inspiration for innovation may be deteriorating financial situation of the facility, the desire to make the exhibition more attractive or, for example, the falling number of visitors. It is very important to prepare a comprehensive description of the problem prompting innovative activities, i.e. to carry out a thorough diagnosis of the sources and causes of individual problems.

In other words, museum cannot stop at just identifying the symptoms of a specific phenomenon, but also outline its causes. It is worth noting that a comprehensive understanding of the situation in which the institution finds itself, as well as finding circumstances in which it operates, already constitutes half the way to achieve success in terms of innovation (Murray et al., 2010).

After the recognition stage, museum's management can move to the next phase, i.e. generating and developing ideas that respond to the observed issues. Ideas for dealing with identified problems may come from various sources. A corporate museum can tap into the intellectual potential of its own employees or look for solutions outside the organization (external consultations often enable acquiring new knowledge and skills, better understanding the environment, determining the quality of work of one's own facility compared to the others, better coordinating activities at all levels of management, etc.) (Głowacka, 2005). An important role in stimulating the ability of a corporate museum to generate innovations is played by the environment in which it operates, especially the attitude of the superior entity managing it and the policy and initiative of public authorities. The adopted system solutions that define the general framework for the operation of such facilities are also important.

Once it has been managed to generate a new idea, it should always be assessed whether its implementation will be beneficial. At first glance, some innovative projects may seem very promising and ideally suited to the specific profile of the museum's activities, and still end up in failure. To avoid this type of problems, the next step should be a phase that involves testing the innovation in practice. New solution should be checked (e.g. entry ticket prices can be lowered, but only temporarily), so that it can be assessed whether the innovative idea can be considered functional. In practice, this phase means pilot implementation of the innovative idea, evaluating it and introducing possible improvements. However, conducting such an initial, common-sense assessment is usually not an easy task. Fortunately, corporate museums have specific instruments that can be successfully used to improve the evaluation stage. To evaluate innovative projects, one or several of the methods grouped within the four basic sets of methods for assessing innovative projects can be used (Szatkowski, 2016). These are: profitability assessment methods (static and dynamic), multi-criteria methods (including additive, of analytical hierarchization and the usage of reference points), mathematical ones (not very widespread - they are used for quantitative assessment and selection of innovative projects). Particularly useful may be also subjective evaluation methods, which use the knowledge and experience of opinion makers who are not normally associated with the museum and who, in accordance with the adopted work schedule and specific methodology, make a qualitative assessment of the ideas presented to them for review (Trzaskalik, 2014).

The last stage, called maintenance, means the implementation and popularization of an innovation that has successfully passed the testing phase. For such an innovation, a model for running the facility should be developed that will ensure its financial success and stability (Wronka-Pośpiech, 2015). It should be emphasized that the implementation by a corporate museum stages of the sequence of innovations' creation proces significantly increases the

chance, but never guarantees hundred per cent, the ultimate success of the new solution. History knows as many examples of successful innovations as there are unnecessary ones, i.e. those that did not catch on in the long run (Glinka, Gudkova, 2011). An example from the sphere of museology is the Museum of Opole Silesia, for which the innovative idea of selecting a director through a competition did not turn out to be successful (none of the contest participants met the detailed evaluation criteria) (Portal Wyborcza.pl, 2023).

5. Conclusion

Sometimes the terms innovation and invention are considered in almost synonymous categories and translated in a similar way. In reality, however, innovation is a broader concept. Researchers explain this by emphasizing that an invention is a new solution to a specific issue, but only one that is of a technical nature. Meanwhile, innovation is defined as newness that is intentionally introduced not only in technology, but also in organization, business activity or in any sphere of human life. „Innovation may also involve transforming an invention into a marketable product or process” (Adamczyk, Gędłek, 2009, p. 5).

Innovations are important not only for companies operating on core market principles. The need for active development in line with contemporary changes also applies to non-profit organizations such as museums. In their context, innovation should be understood as novelty or change that is put into practice and replicated with the intention to bring benefit to the organization that developed it and/or to some of its stakeholders (e.g. audience). Like the entire cultural sector, museums are currently faced with the need to overcome various, complex, and sometimes previously unknown and newly added challenges. The society in which they operate is in a process of constant change, which means that the complexity of the conditions for cultural activities is constantly increasing. In response to these great changes museums must undertake innovations. In order to successfully face challenges, they need new ideas and self-critical reflection on current approaches. Traditional core activities, such as collecting, preservation, research, exhibition, and education have to be supplemented by new issues and fields.

Corporate museums are in a particularly demanding situation. This is due to the fact that the scope of their tasks goes beyond collecting and storing monuments, disseminating the values of history and culture, providing information about the contents of the collected items, shaping cognitive sensitivity, and enabling contact with the collections. Above all, for their founding organizations they are sites of organizational memory relationship to the development of organizational identity. In this context corporate museums are a favored tool for preserving and disseminating a company's culture. Although it is true that, taking into account creativity, like all other museum organizations, they do not traditionally constitute a highly innovative

environment (their tradition and orientation towards the logic of science is the first obstacle), by following the sequence of actions presented in the article, they increase the chances of achieving success in their activities and fulfilling the goals for which they have been established.

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THE MANAGEMENT OF THE GLOBAL VILLAGE IN DUBAI AS A SHOPPING TOURISM ATTRACTION

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Purpose: The aim of this paper is to identify and characterize the Dubai Global Village as a shopping tourism attraction. The paper attempts to identify the main determinants affecting the tourist attractiveness of that destination.

Design/methodology/approach: The study used quantitative and qualitative research methods such as a literature search, website analysis, including reviews on the TripAdvisor tourism portal. Mixed quantitative (Text Mining, co-occurrence network analysis) and qualitative (narrative research) methods were used.

Findings: The majority of tourists' opinions about the Dubai Global Village left on the travel portal are positive. The analysis of tourists' opinions regarding the described place left on the TripAdvisor tourism portal shows that the key determinants of the attractiveness of the Dubai Global Village are the additional attractions, the experience and the cultural diversity that runs through the village's various attractions, not only shopping.

Research limitations/implications: Further research in the area of this issue should focus on the use of modern technology in both the demand and supply areas, methods of cooperation with all relevant stakeholders influencing the site's operations and its success or promotional tools.

Practical implications: The found determinants can provide guidance both for tourist destinations and for companies that want to create similar tourist attractions.

Social implications: One of the most attractive places within shopping tourism is the Dubai Global Village. It not only provides a place dedicated to purchasing but is also an important part of the integration of different cultures.

Originality/value: The topic of the Shopping Village has so far been addressed in the foreign literature by Alzoubi et al. (2022) in exploring marketing strategies for the introduction of Beacons (BLE) technology in businesses and how it can generate satisfaction and loyalty in potential customers, or A. Krieger (2023) - pseudo-cosmopolitanism and hyper-reality in the Dubai Global Village. However, the determinants of its attractiveness have not been investigated, which means that the presented research results are a complete novelty in that field.

Keywords: shopping tourism, buyer behavior, tourists attraction.

Category of the paper: Research paper.

1. Introduction

Shopping tourism is one form of the concept of tourism in cities. Urban tourism includes such types of tourism as leisure, business, cultural, religious, sport or just shopping tourism (Kowalczyk, 2005, pp. 157-158). In the context of the latter, it is important that it is polymotivational in nature. This means that a trip is often undertaken for the sake of more than one motive (Niemczyk, 2012, pp. 104-105). A tourist trip is usually accompanied by additional motives, such as the desire to shop, entertainment and the desire to have a good time (Kachniewska et al., 2012, p. 43). Tourist activity clearly stimulates tourists' spending on shopping (Oh, 2007, 122). Importantly, they are a key element of the tourist experience (Correia, Kozak, 2016, p. 85). Tourists shop in a variety of places including shopping malls, souvenir shops, markets or other often unique locations i.e. the Global Village in Dubai. All shopping venues form the core of the shopping tourism product (Paliś, 2022, pp. 133-134). This kind of tourism can develop precisely because of the various shopping facilities, which constitute often a very important tourist attraction for visitors (Paliś, 2022, p. 141). Dubai is one of the world's top shopping tourism destinations. The city has developed a number of attractive shopping facilities. These determine the potential of this city for the development of shopping tourism. One such venue is the Global Village. It is a remarkable facility because of its unique character, which is determined by a number of factors.

The purpose of this paper is to identify and characterise the Dubai Global Village as a shopping attraction. The paper attempts to identify the main determinants influencing the tourist attractiveness of the Global Village. The study employed qualitative research methods such as a literature search and website analysis, including reviews on a tourism portal. It was hypothesised that the key determinant of the attractiveness of the place is its cross-cultural character. The topic of the Shopping Village has so far been addressed in the foreign literature by Alzoubi et al. (2022) in exploring marketing strategies for the introduction of Beacons (BLE) technology in businesses and how it can generate satisfaction and loyalty in potential customers, or A. Krieger (2023) - pseudo-cosmopolitanism and hyper-reality in the Dubai Global Village. However, the determinants of its attractiveness have not been investigated, which means that the presented research results are a complete novelty in that field.

2. The core of shopping tourism and its product

Shopping tourism is defined in various ways in the literature. The World Tourism Organisation defines it as a contemporary form of tourism undertaken by people for whom the purchase of goods outside their usual environment is a determining factor in their decision to travel (UNWTO, 2014, p. 13). According to the Institute of Tourism, this phenomenon includes all kinds of shopping trips outside the place of residence concerning purchases for personal needs excluding those related to the satisfaction of a tourist stay (Holderna-Mielcarek, Majchrzak, 2007, p. 178). Shopping tourism is also often defined as a form of tourism service that enables tourists to purchase goods and services not commonly available in their environment (Timothy, 2005).

According to A. Niemczyk, shopping tourism is related to tourists' desire to make purchases for their own use (Niemczyk, 2015, pp. 174-184). In recent years, some definitions of shopping tourism consider it as a form of leisure. Leisure time has always been one of the main motivations for travelling, as tourists seek enjoyable activities outside the home. According to D. Timothy (2005), consumption is not only about products. It is also about consuming places, space and time. This fact has implications for the growing importance of shopping in the management space of a tourist destination, especially a city (UNWTO, 2014, p. 13). Tourists have the opportunity to obtain products outside their place of residence because of the availability, exclusivity and price of the goods (EY Centro de Estudio, 2015, p. 9, cf. Paliś, 2022, p. 120).

Shopping for personal enjoyment and use (e.g. souvenirs, clothing or cosmetics) is one of the most important activities that tourists undertake during their trip (Roy, Chandra Kuri, 2015, p. 27). These are done at a variety of shopping venues, which are often a tourist attraction for visitors. B. Paliś (2023) pointed out the following distinguishing features of shopping tourism, i.e.: visiting shopping venues or other shopping places, shopping while travelling for the pleasure of oneself and/or loved ones, shopping for souvenirs for oneself and/or loved ones, shopping for unique goods while travelling, local products, branded products at lower prices, motivation of tourists to shop, motivation to travel for shopping purposes. Local products can be an important distinguishing feature of shopping tourism, especially those products that represent the cultural identity of a place and region.

One factor in the development of shopping tourism in a market is the creation of a suitable product in its reception area. The businesses and revenues generated by such a tourism product have the potential to help develop the local economy through better employment opportunities (Wong et al., 2022, p. 1). According to A. Niemczyk (2012, p. 42), the product is a set of utilities that form a package of goods and services to make a shopping trip a reality. It encompasses everything a shopping tourist uses or encounters during a stay in a particular city. It can be referred to as an 'integrated experience' (Zdoń-Korzeniowska, 2009, p. 20). On the other hand,

according to author B. Paliś (2022, p. 132) and A. Niemczyk (2012, p. 44) it consists of a core, a real product and an extended product.

At the core of this product are the physical places of sale, i.e. the locations and their shopping offer, i.e. large-scale shopping facilities: shopping malls, retail parks, outlet centres; occasional shopping centres: Christmas markets and fairs; bazaars/tradeshows; airport shops; department stores and other facilities, i.e. local small shops or vintage shops, as well as shopping festivals, which can take place in a variety of locations (Paliś, 2022, pp. 133-153).

The actual product of shopping tourism includes price, meals, accommodation, travel, shopping excursions (Paliś, 2022, pp. 133-134), tourist information, leisure services in the shopping sphere, cultural events and activities, promotional actions offering goods at lower prices, etc. Within the augmented product, we can distinguish additional benefits consisting of: the atmosphere and image of the place, infrastructure and leisure services outside the shopping sphere and around tourism, additional excursions, product sales advice and after-sales service, tourist attractions of the city (monuments, museums) (Paliś, 2022, p. 133). Shopping facilities are what often encourage shopping trips (Paliś, 2022, pp. 134-143).

The purchase assumption is primarily based on the utilitarian benefits of owning the goods (Wong et al., 2022, p. 4). Low price, durability and reliability of the product are some of the attributes tourists look out for (Sharma et al., 2018; Sheth et al., 1991). Favourable prices along with the greater range and authenticity of products available in other markets may explain why tourists flock to shopping destinations such as Hong Kong, Paris and Milan or similar (Jin et al., 2017). However, it is important to note that the tourist evaluation of shopping often goes beyond its functional qualities, as this tourism activity also includes hedonic values, such as emotional valence and pleasure during the shopping process (Sandström et al., 2008).

For the development of shopping tourism in the world, shopping destinations that offer a combination of the above-mentioned elements are especially crucial (cf. Paliś, Przenzak, 2022, pp. 28-29). One such specific shopping destination is Dubai.

3. Dubai as a destination for shopping tourism

Dubai in the United Arab Emirates has a population of 3.34 million and boasts as many as 65 shopping malls, with another 10 under construction. As a result of the oppressive climate, these places have become community hubs and public squares where Dubai residents and tourists alike can congregate, socialise and attend various events. Dubai is the world's first literal 'shopping hub'. A 2015 study conducted in various shopping destinations in Dubai found that it has particular advantages that make it a leading luxury destination of this kind (Zaidan, 2015, pp. 3 and 10). This research found that a trip to Dubai is not seen by tourists as just a shopping trip, but rather as a place to have an exciting experience in a combination of buying and

entertainment and other attractions in the area. The survey results also show that purchasing in Dubai is a desirable activity for most visitors. Festival shopping tourism has proven to be a success for the city, as it offers exciting opportunities for tourists who want a successful shopping experience in Dubai. The results of this research addressed perceptions of the importance of luxury purchasing destinations and products as relevant to tourists. It was pointed out that more luxury buying opportunities should be offered to tourists as the demand for luxury products is increasing. It was pointed out that it is important to locate shopping centres close to major tourist attractions and hotels. Retailers should take into account that such features of luxury products, i.e. price, quality and uniqueness, are perceived as important to consumers (Zaidan, 2015, pp. 3 and 10).

The 'Dubai' brand has taken shape over a dozen years. It is a symbol not only of progress, innovation, excellence and wealth, but also of the preservation of immense cultural diversity. It has been created through products such as: Emirates, Burj Khalifa, Burjal-Arab, Palm Jumeirah (Palm Jamira), or events: Dubai Shopping Festival, Dubai Property Show, Global Village, Dubai Food Festival and many others (Podobas, Matysk, 2019, p. 34). Today, the city is the fourth most visited in the world, with 16.7 million visitors per year (Ahmed, 2020). The Dubai authorities, through their efforts, aim to make the city the world's most popular tourist destination by 2025 (Lee, 2015; Langton, 2018). According to EMAAR statistics (Zaidan, 2016), Dubai Mall, which has averaged 20 million visitors per year for the past four years, is the most visited shopping mall in the world (Jung, Mahmoud, 2013). It is not only Dubai Mall that represents one of the biggest shopping attractions in Dubai. A unique attraction is another place such as the Global Village.

4. Characteristics of the Global Village in Dubai

Dubai Global Villige (Figure 1) is considered one of the world's largest tourism, leisure and entertainment destinations and a major shopping destination in Dubai, United Arab Emirates. Not only are there shopping outlets within this location, but also many restaurants. Numerous cultural events also take place there. The company is committed to the representation of the world's cultures and symbolises the city's confident view of the world and Dubai's place within it (Krieger, 2023, pp. 31-32). The Global Village is a unique multicultural space, especially for families, created in 1997. This park is home to some of the best entertainment, shopping, restaurants and attractions in the region. The facility operates on the belief that the diversity and creativity of the world is an unlimited source of excitement and that human connections should have no boundaries. Global Village brings people together to create great experiences for tourists from around the world (<https://www-globalvillage-ae.translate.goog>; <https://www.visitdubai.com>, 17.09.2023).



Figure 1. Print screen of the Dubai Global Village.

Source: <https://mediaoffice.ae/en/news/2023/May/01-05/Global-Village-sets-new-audience-record-with-9-million-guest-visits-during-Season-27>, 29.09.2023.

Since its opening, on 25 October 2022, the Global Village has represented more than 90 cultures in 27 pavilions and hosted 40,000 performances, featuring 400 artists from more than 40 different nationalities. Visitors were also able to enjoy more than 175 rides and attractions, shop and dine at more than 3250 outlets and enjoy 77 unique fireworks displays. As many as 9 million visitors visited the Global Village during the 2023 season (<https://mediaoffice.ae>, 17.09.2023).

Fernando Eiroa, CEO of Dubai Holding Entertainment, said: ‘This new record achieved in 188 days firmly positions Global Village as not only the largest entertainment attraction in the region, but also one of the most popular entertainment destinations in the world. As we continue to play our part in building Dubai’s position as the world’s entertainment and tourism hub, we look forward to the future and thank our invaluable partners and the Global Village team whose contributions made Season 27 our most successful ever’ (<https://mediaoffice.ae>, 17.09.2023).

The attractiveness of the Global Village is determined primarily by its determinants, which the next section of the article seeks to describe.

5. Material and methods

The main objective of the paper is to identify and characterize the Dubai Global Village as a shopping tourism development attraction. The paper attempts to identify the main determinants influencing the tourist attractiveness of that destination. In this paper, mixed

quantitative (Text Mining, co-occurrence network analysis) and qualitative (narrative research) methods were used. The following research questions were formulated: What characteristics determine the attractiveness of the Dubai Global Village?; Does cultural identity matter for the attractiveness of the Dubai Global Village?; What are the behaviours of tourists visiting the Dubai Global Village?; Are the additional attractions and events organised in the Global Village relevant to its attractiveness in the eyes of tourists?; What products are sold and purchased in the Global Village?

The research aimed to confirm the thesis that the Dubai Global Village can be a shopping tourism attraction and means to contribute to its development. In undertaking the analysis, it was assumed that the main determinant of the tourist attractiveness of the shopping village is the cultural diversity that runs through the area of the various attractions of the village, not only shopping. It stems from the cultural identity of the countries representing the supply side of the site. Websites presenting information about the Global Village in Dubai were selected to investigate the determinants of its attractiveness for tourists. The research was conducted by analysing information contained on websites, while the study of the determinants influencing the attractiveness of the village to tourists was conducted by analysing reviews contained on TripAdvisor (Tripadvisor.co.uk, 2023), the English-language service of the world's largest aggregator of reviews of tourism products (UK Press Center, 2023). The sampling was network-based, which is a non-random sampling technique involving the selection of respondents from among the customers of a specific service network, in this case the Global Village (Sagan, 2018). The study had a pilot. A total of 187 reviews of Dubai's Global Village left by tourists were collected, between August-September 2023. The average rating of the opinions was approximately 4.24 on a 5-point scale, with a median of 5. Figure 2 shows the distribution of tourist ratings.

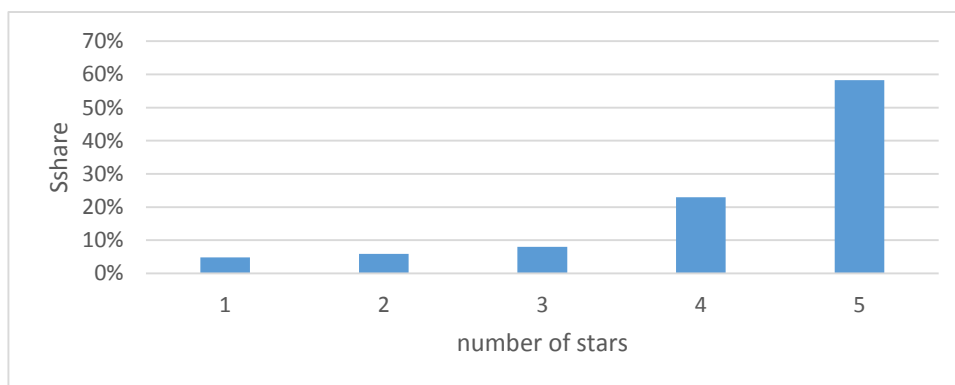


Figure 2. Distribution of tourists' ratings in reviews on TripAdvisor of the Dubai Global Village.

Source: own compilation based on content analysis.

R software (in the Text Mining procedure) and KH Coder (for co-occurrence analysis) were used to analyse the data. The following section presents the results of the research (Lander, 2014; Gatnar, Walesiak, 2009).

6. Results

Identification of keywords in tourists' reviews of the Dubai Global Village on the TripAdvisor tourism portal

In the first stage of the analysis, a Text Mining procedure was carried out to identify the most frequent words in the opinions. 175 English punctuation words were excluded from the analysis. A total of 130 words that appeared in at least 10 tourist opinions were obtained. Figure 3 illustrates these in the form of a tag cloud.



Figure 3. Words in the opinion of tourists of the Dubai Global Village on TripAdvisor tourism portal.

Source: own elaboration based on content analysis.

The selected words that are most frequently repeated in the reviews, and which may be determinants of the attractiveness of the Dubai Global Village are: place, village, global, food, visit, countries. These words are the largest, which means they are repeated the most often. Opinions refer to the size, experience, shopping, diversity, world, entertainment, fun, children, parking facilities, products, prices, opportunity to spend time with friends, uniqueness, diversity and culture (It is possible to see the positive adjectives as e.g. unique, recommend, interesting, amazing, great, good i.e.). There are some negative opinion, i.e. congestion, expensive can also be discerned among the repeated words. In the next step of the content analysis, the most frequent recurring themes were identified.

Identifying the most common issues in tourist reviews of the Dubai Global Village on TripAdvisor - a qualitative analysis

A co-occurrence network created using the KH Coder package was used to identify the most frequently occurring issues in tourists' opinions in relation to the Dubai Global Village (Figure 4). In this analysis, 130 words appearing in at least 10 opinions were considered. The co-occurrence network combines words with a high degree of co-occurrence and is created according to a method developed by Thomas Fruchterman and Edward Reingold (Fruchterman, Reingold, 1991).

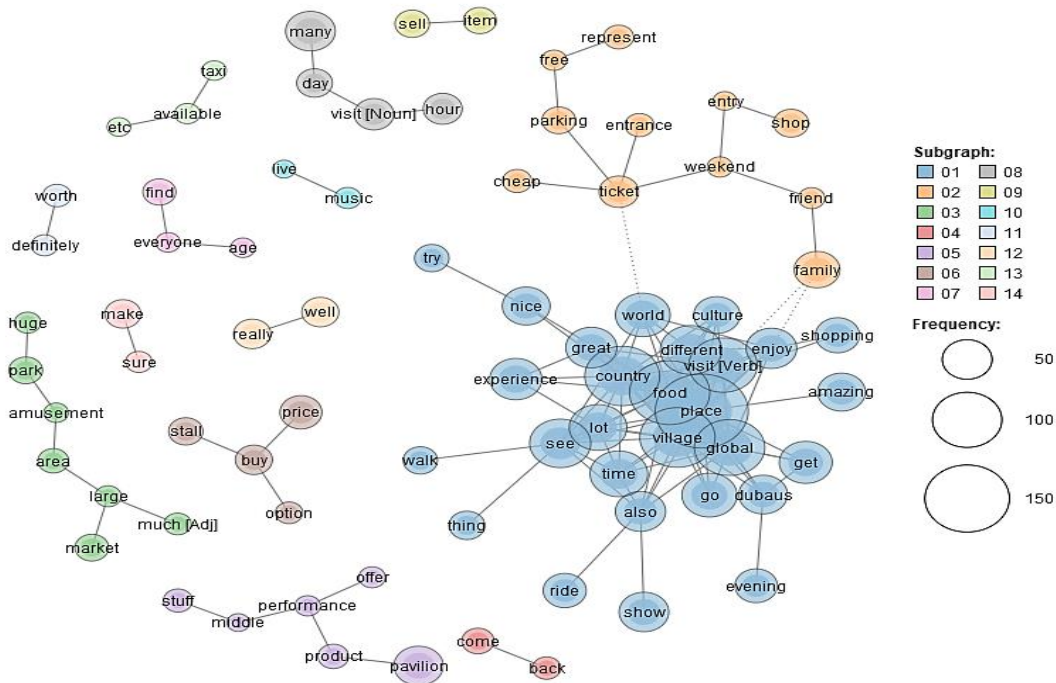


Figure 4. Issues in tourists' opinions of the Dubai Global Village on the TripAdvisor tourism portal
 Source: own compilation based on content analysis

The analysis identified 14 groups of words. The most recurring themes in the first group of words were those relating to the place, e.g. food, experience, culture, variety of shopping, global, diversity, multiplicity and world dimension, as well as fun and the possibility of visiting the venue in the evening. Another group of words related to the issue of a family-friendly place, the possibility to visit it at the weekend, cheap entrance tickets, and large free parking. Other groups of words related to the opinions about the venue, informing that it is worth visiting or returning to, as well as that it is a place for people of all ages. Opinions were grouped into 10 categories based on the content (Tab. 1).

Table 1.
Categories of tourist reviews of the Dubai Global Village on the TripAdvisor tourism portal

1. Additional attractions (entertainment, food, amusement park, fireworks, dance shows, stunt shows, funfair)
2. Great experience (walking around, time with friends, family)
3. Cultural diversity (Intercultural integration, the opportunity to learn about other cultures)
4. Different cultural merchandise
5. Diversity of products
6. Family-friendly place
7. Friendly prices/entrance tickets
8. Good communication infrastructure (parking, transport)
9. Fake/commercial (Hectic touristic market)
10. Negative experience

Source: own elaboration.

The categories refer to the attractiveness determinants that were identified. Codes for negative opinions were also extracted. Figure 5 shows the share of each category in the total sample.

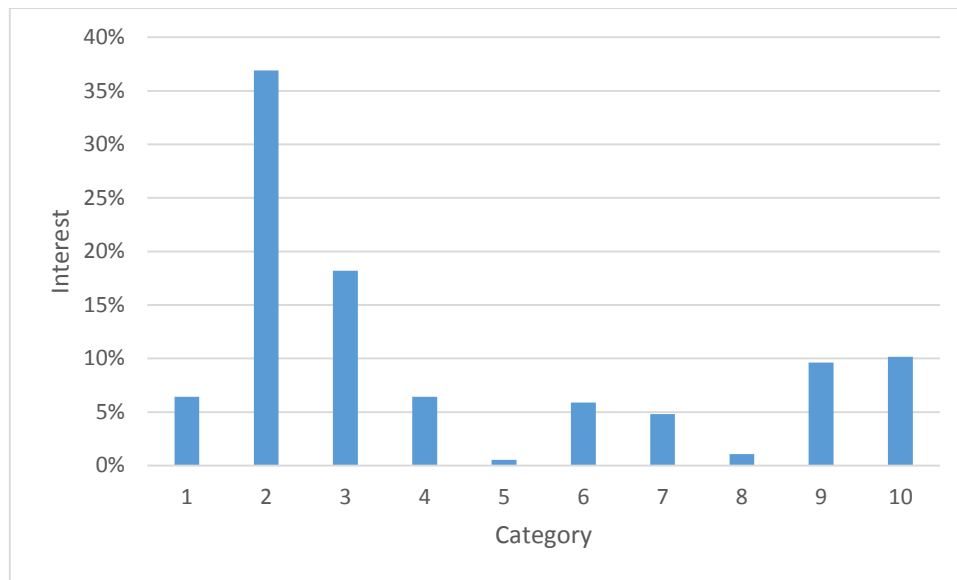


Figure 5. Distribution of tourists' opinions of the Dubai Global Village on the TripAdvisor Tourism Portal in the identified categories.

Source: own compilation based on content analysis.

As it shows, the largest percentage are additional attractions and experiences which confirms the Global Village's stature as a significant tourist attraction and a destination worth visiting. Table 2 presents the distribution of the number of opinions by category and grade.

Table 2.

Distribution of the number of tourist reviews of the Dubai Global Village on the TripAdvisor tourism portal

		Evaluation				
		1	2	3	4	5
Category	1	0	0	0	3	9
	2	0	0	0	16	53
	3	0	0	0	10	24
	4	0	1	1	1	9
	5	0	0	0	1	0
	6	0	0	1	4	6
	7	0	0	0	3	6
	8	0	0	0	0	2
	9	3	6	7	2	0
	10	6	4	6	3	0

Source: own compilation based on content analysis.

The analysis of the data in Table 2 shows that positive opinions prevail - 'great experience' and 'cultural diversity'. Additional attractions and cultural diversity of the products are also highly rated. Of all the opinions, a very small percentage were negative ones.

7. Discussion

The article seeks to demonstrate that large shopping malls, which are also entertainment centres and cultural parks like the Global Village in Dubai, can be an attraction for shopping tourism, while offering opportunities for a variety of purchasing, providing a memorable experience, entertainment, as well as an opportunity to interact with a diverse culture. A content analysis of the Global Village visitors' reviews on TripAdvisor identified the most recurring words in the visitors' reviews. They prove that, for visitors to the Global Village, it is not only the determinants of shopping tourism such as good price, high quality, variety of goods that are important, but to a greater extent the place itself, its atmosphere, the facilities and attractions it offers. It is these factors that can determine the choice of the Dubai Global Village as a tourist destination. The issue of place identity and its attractiveness in the context of large shopping malls was also addressed by Shim & Santos (2014), arguing that such places can have an identity that is an attraction in its own right. Jung & Mahmoud's (2023) research also confirms that large shopping centres become arenas for socialising and multicultural exchange, and that shared spaces play a major role in this process.

A study by B. Paliś (2022, p. 372) in the area of determinants of urban shopping tourism development shows that for typical shopping tourists the most important factors motivating them to make shopping trips were sales promotion, good quality goods at a promotional price and the unavailability of a given good in their place of residence. The surveyed opinions of the Global Village visitors indicate that they pay attention to the above factors, but above all, the decision to choose this place is influenced by its uniqueness and the possibility of encountering different cultures and thus purchasing goods specific to particular countries. Culture in its broadest sense, related to the tradition, history and heritage of a place, is increasingly becoming a factor that attracts tourists to a destination, increasing its value. Tour operators, local entrepreneurs and residents, as well as visitors themselves, are aware of this fact. Not only tangible culture, but also intangible, spiritual culture can provide a great boost to the development of a tourism product, which translates into economic benefits (Zhang et al., 2020).

The choice of products that customers buy is influenced the features directly related to the product, such as price, quality, price-quality relation, or the degree of satisfaction of customer needs. Customers are not only interested in the product itself and its functionality and usability. The customers first of all should be seen as one of the key stakeholders (Kiliańska, Pajęcki, 2022, p. 294).

8. Conclusions

The analysis shows that the Dubai Global Village is a significant attraction and one of the key products in terms of developing a shopping tourism offer in Dubai. It can be a major contributor to the development of this type of tourism. Particularly important, however, are determinants such as the additional attractions (i.e. entertainment, food, amusement park, fireworks, dance shows, stunt shows, funfair), the cultural diversity that results from the premise of an attraction such as the Global Village, as well as the great experience that is formed in the area of the various attractions offered. Analysing tourists' opinions, cultural identity was found to be important to the attractiveness of the Dubai Global Village. However, tourists do not perceive the place only as a shopping attraction, but enjoy the many ancillary attractions that the place offers i.e. cultural events, dining facilities, attractions for children. The village is a huge amusement park. A wide variety of products are bought there, especially those that represent the cultural identity of the country. Tourists appreciate the large assortment of goods on sale, as well as their diversity. The size of the attraction, the favourable admission prices and the fact that the place is both family-friendly and can also be an attraction for people of all ages are also important. The parking infrastructure is also crucial and the fact that the facility has a large car park is appreciated. Furthermore, the fact that the object can be visited late into the evening is also of significance.

The found determinants can provide guidance both for tourist destinations and for companies that want to create similar tourist attractions.

Further research in the area of this issue should focus on the use of modern technology in both the demand and supply areas, methods of cooperation with all relevant stakeholders influencing the site's operations and its success or promotional tools.

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THE IMPACT OF IMPLEMENTING SELECTED LEAN MANUFACTURING TOOLS ON THE FAILURE RATE OF MACHINES – CASE STUDY

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Purpose: The aim of the research was to present the impact of the use of selected Lean Manufacturing tools on the failure rate of production machines and devices on the analyzed production line. The research was carried out on the basis of data from an electrical industry production plant.

Design/methodology/approach: The article presents a statistical analysis of the impact of the implementation of Total Productive Maintenance on the production process - a case study.

Findings: The obtained results allowed to present the scale of changes taking place in the production process, confirming at the same time the positive impact of the implementation of the TPM tool on the duration of failure and indicators (Mean time to Repair - MTTR and Mean time to Failure - MTTF).

Social implications: The analysis carried out can increase awareness of the importance of the impact of Lean Manufacturing on the production process.

Originality/value: The article contains an original statistical analysis, which indicates a reduction in the failure rate of production machines and devices as a result of the implementation of selected Lean Manufacturing tools.

Keywords: Lean Manufacturing, Total Productive Maintenance, Machine failure rate.

Category of the paper: Case study.

1. Introduction

The progress of civilization, growing expectations and requirements of consumers, as well as the specificity of the market economy mean that one of the main factors determining the effective and efficient functioning of an enterprise is the correct anticipation of the consequences related to decisions made and planning strategy. The ability to plan the production process directly affects the level of organization and the effectiveness of the services provided.

Nowadays, companies strive to develop effective methods of managing and planning production processes, the use of which is intended to shorten the implementation time of individual operations and, consequently, reduce the costs of producing the offered products. One of the most frequently used methods to improve the organization of production processes is Lean Manufacturing (Ghobadian et al., 2020).

In the literature on the subject, Lean Manufacturing is defined as a technique for eliminating waste in production processes (Palange, Dhattrak, 2021). The Lean philosophy distinguishes seven basic types of waste, which include: overproduction, inventories, transport, shortages, unnecessary processing and unnecessary movement.

Proper implementation of the LM philosophy allows to increase the chances of competition in a dynamically developing market (Abreu-Ledon et al., 2018; Galeazzo, Furlan, 2018). The LM philosophy is universal, which means that it can be implemented in many industries, both manufacturing and service (Hopp, 2018), regardless of their size (Hu et al., 2015). The studies described in (Bayou, de Korvin, 2008) and (Narasimhan et al. 2006) present a relationship indicating that lean management enables the reduction of input resources in order to achieve better results expected by organizations. Improving the results achieved concerns many levels, including the quality of manufactured products or services provided and customer satisfaction (Natasya Abdul Wahab, 2013).

In many cases, one of the key tasks of implementing selected Lean Manufacturing tools, in addition to eliminating errors, is to increase the company's productivity while maintaining the quality of manufactured products (Nguyen et al., 2022).

Issues related to lean management have been a frequently discussed topic for many years in the context of improving selected parameters of production processes. It should be noted, however, that in many cases there are still problems related to the correct implementation of the Lean Manufacturing philosophy in production plants (Alefari et al., 2017). Research conducted at production plants in Great Britain (Baker, 2002) and in automotive companies in the United States and India indicate a low level of effectiveness of the results achieved despite the implementation of the Lean concept (Mohanty et al., 2007). However, in the article (Venkat, 2020), based on the analysis of the impact of LM on production efficiency on the assembly line process in the electrical industry, a productivity increase of as much as 23% was found. Also in the article (Samuel, 2021) conclusions are presented indicating the improvement of the obtained parameters as a consequence of the implementation of LM tools. The reason for different results in impact effectiveness depends, among others, on the type of production process, level of automation and correct implementation of LM tools.

2. Total Productive Maintenance

As mentioned in the introduction, dynamic changes on the market and intense competition force producers to introduce actions aimed at preventing situations that destabilize the production process. Therefore, in many cases, the decisive factor in implementing the production process according to the schedule is avoiding failures of machines and production equipment by implementing tools aimed at their correct and systematic maintenance (Adhiutama et al., 2020). One of the Lean Manufacturing tools used to supervise and properly maintain machines and devices is TPM (Total Productive Maintenance).

The TPM tool is defined in the literature on the subject as a concept of maintaining appropriate productivity of the production process by eliminating failures, aimed at achieving comprehensive system effectiveness as a result of the involvement of all people in the organization (Bhasin, Burcher, 2006). The work (Singh et al., 2022) highlights the important role of humans as a factor necessary for the proper functioning of the TPM tool.

In the above-mentioned article, TPM is defined as a strategy aimed at improving production that takes into account the integrity of the company's infrastructure and the efficient operation of human resources through the continuous participation of employees and their empowerment in production, maintenance and industrial efficiency.

The TPM tool includes a number of activities necessary to organize the environment in such a way that it fulfills its purpose, Figure 1. These activities are usually presented in the form of pillars which include, among others: autonomous maintenance, continuous improvement, maintenance planning, quality control planning, interdepartmental communication, staff development and training, safety and environment. However, the 5S tool is considered to be the basis of the TPM tool.

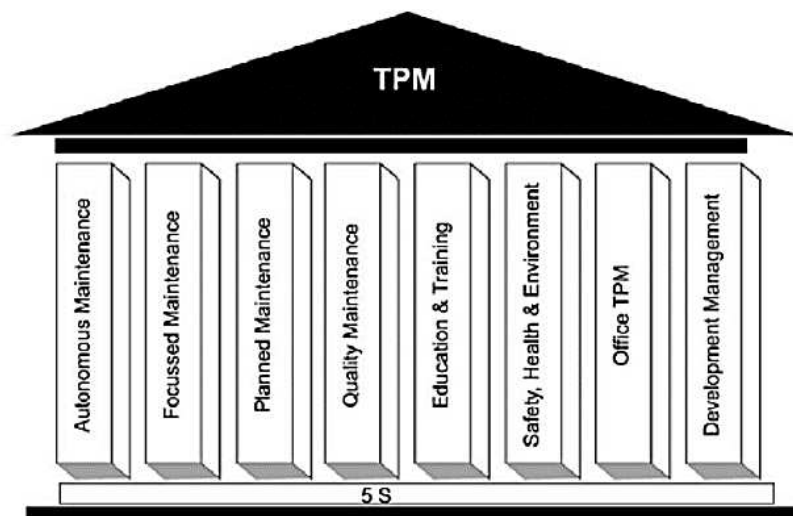


Figure 1. Pillars of TPM.

Source: Ahuja, Khamba, 2008.

Thanks to its comprehensive approach, TPM is becoming one of the most frequently used maintenance techniques used in the manufacturing industry.

3. Methodology and research area

The analysis was carried out on the basis of data collected in a production plant characterized by a high level of automation of production operations in the electrical industry. The work focused on obtaining data related to the failure rate of machines and devices operating on a production line consisting of three stations, i.e. extruders, a device for cutting and bending a metal washer, and an assembly station in the form of a specially constructed station. In the production plant analyzed, production is carried out on a mass scale and the failure of one of the stations on the line causes the entire process to stop. The production process is carried out in a maximum of two shifts or depending on the size of orders in a given period of time. The data analysis was carried out on the basis of obtaining information regarding, among others: production line operating time (operating time), failure time, number of failures, repair time of production equipment and the time and number of maintenance before implementing the techniques included in the TPM tool (data collection period 12 months) and after their implementation (data collection period: 9 months). The scope of activities in the area of implementation of the TPM tool on the production line included, among others:

- Information regarding downtime and operating time was obtained on the basis of failure, stoppage and maintenance reports, as well as data from time devices. Introduction of solutions based on real-time analysis of the wear of active elements at the assembly station in the form of installing vibration sensors. The implementation of the solution allows for continuous monitoring of the technical condition of devices in the area of potentially most critical factors.
- Preparation of standardized maintenance instructions for devices included in the production line, along with a check list. Introduction of a number of training courses to standardize activities related to the maintenance and repair of devices. Detailed repair reports and their periodic analysis, allowing for more precise identification of potential areas of failure and how to remove them.
- Implementation of the 5S tool and its regular internal self-discipline audits.
- Implementation of a formal list of parts and possible substitutes that can be used in a given production device from manufacturers that have been assessed and the level of wear of these parts is known based on a historical analysis of their use.

The next stage of the research was to conduct a statistical analysis to determine the statistical significance of the observed differences in machine and equipment failure times before and after the implementation of the TPM tool. In order to determine the statistical significance of differences between failure times before and after the implementation of the TPM tool, the Mann Withney U test was performed. The non-parametric Mann-Whitney U test is used to verify the hypothesis that the differences between the medians of the examined variable in two populations are insignificant, assuming that the distributions of the variable are close to each

other (Więckowska, 2018). The hypotheses concern the mean ranks for the compared populations or are simplified to the medians:

$$H_0 : \theta_1 = \theta_2 \quad (1)$$

$$H_1 : \theta_1 \neq \theta_2$$

where θ_1, θ_2 - medians of the examined variable in the first and second population. The value of the test statistic is determined, and on its basis the p-value is compared with the significance level α :

if $p \leq \alpha \Rightarrow$ we reject H_0 accepting H_1 ,

if $p > \alpha \Rightarrow$ there is no reason to reject H_0 .

Depending on the sample size, the test statistic takes the form:

for a small sample size:

$$U = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - R_1 \quad (2)$$

or

$$U = n_1 n_2 + \frac{n_2(n_2 + 1)}{2} - R_2 \quad (3)$$

where:

n_1, n_2 – number of samples,

R_1, R_2 – sum of ranks for the sample;

for a large sample size:

$$Z = \frac{U - \frac{n_1 n_2}{2}}{\sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12} - \frac{n_1 n_2 \sum (t^3 - t)}{12(n_1 + n_2)(n_1 + n_2 - 1)}}} \quad (4)$$

where t – the number of cases included in the tied rank.

The assumed confidence level α for each of the conducted analyzes was 0.05.

Then, based on the data obtained, indicators were designated to determine the duration of the failure (Mean time to Repair - MTTR) and the length of time until the next failure occurred (Mean time to Failure - MTTF).

$$MTTR = \frac{\sum_{i=1}^N T_i}{N} \quad (5)$$

$$MTTF = \frac{T_D - \sum_{i=1}^N T_i}{N+1} \quad (6)$$

where:

T_i – failure time,

N – number of failures,

T_D – available time of machines or groups of machines.

4. Results and discussion

As a result of the analysis of the production process carried out over a total period of 21 months, data was obtained regarding operational time and failure time before and after the implementation of the TPM tool. The data are presented in Table 1.

Table 1.

Summary of operational time and failures before and after TPM implementation

Month	BEFORE IMPLEMENTING TPM		AFTER IMPLEMENTING TPM	
	Operating time [h]	Failure time [h]	Operating time [h]	Failure time [h]
1	417,3	29,5	415,5	6,5
2	411,6	25,8	420,1	7,5
3	425,5	21,3	395,5	9,2
4	391,7	31,5	420,5	7,5
5	401,5	29,3	451,5	6,4
6	412,7	26,3	410,5	7,1
7	421,1	20,1	341,7	1,2
8	395,5	31,8	447,4	5,9
9	393,4	19,3	420,7	7,1
10	387,5	31,5	X	
11	399,5	21,7		
12	352,1	24,9		

Source: own elaboration.

The obtained results indicate a reduction in machine failure time by 5 percentage points, from 7% before implementing the techniques included in the TPM tool in relation to operational time, to 2% after implementing solutions aimed at improving the situation related to maintenance.

Then, based on the obtained results, a statistical analysis of the differences between failure times before and after the implementation of the TPM tool was performed using the Mann Withney U test, the results are presented in Figure 2.

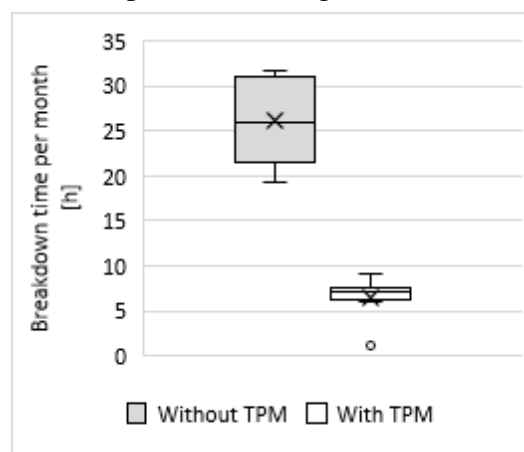


Figure 2. Failure duration.

Source: own elaboration.

As a result of the study, it was found that there are significant differences in the duration of failure compared to the state before the implementation of TPM ($p > a$). The obtained results seem to confirm the fact that after implementing the solutions included in the TPM tool, the machine failure time is shortened. In the work (Singh et al., 2013), a reduction in failure time and an increase in product quality was observed, which allowed for an increase in production efficiency by 16 points. A similar result of the effectiveness of the TPM tool implementation was described in the works (Pinto et al., 2020) and (Singh et al., 2022). Then, based on the data obtained, the MTTR and MTTF indicators were calculated and their results were compared before and after the implementation of the solutions included in the TPM tool. The obtained values are presented in Figures 3 and 4.

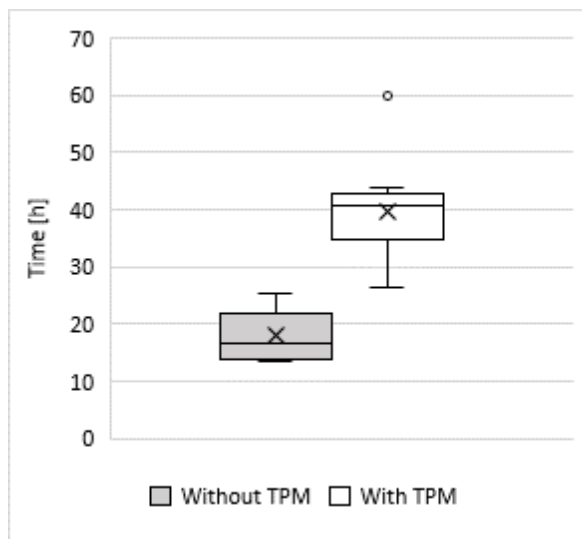


Figure 3. MTTF indicator level.

Source: own elaboration.

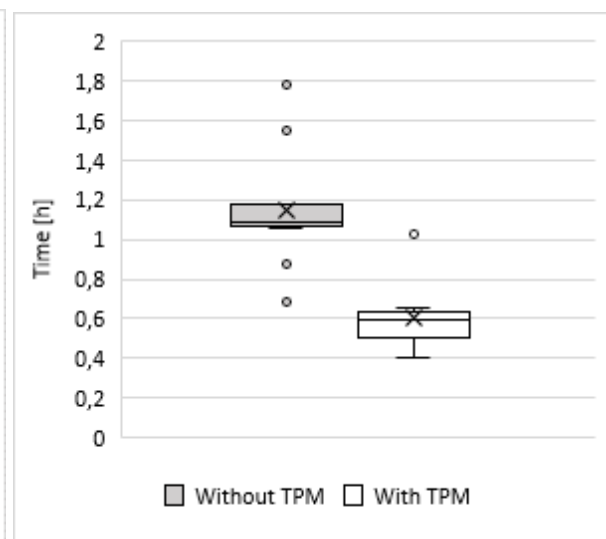


Fig. 4 MTTR indicator level.

Source: own elaboration.

As a consequence of the obtained results, a significant reduction in the duration of a single failure was observed by approximately 34 minutes, which was due to the implementation of standardized procedures regarding device repair and maintenance. The introduced actions allowed for faster identification of failures and their removal in a standardized way. It was also found that the time between the occurrence of subsequent failures increased from an average of 17.9 hours to over 40.5 hours. The reason for such a significant extension of the time between failures was activities related to data analysis in the area of vibration monitoring within active elements, which allows for earlier replacement of key parts with confirmed quality of workmanship. The reduced number of failures and corrective actions contributed to the extension of production line operating periods. The outcomes obtained as a result of the analysis confirm the effectiveness of the implementation of the TPM tool in the production plant, which was also indicated in other literature (Singh et al., 2022). A similar result was described in the work (Pinto et al., 2020), which describes the results of implementing the TPM tool, which allowed for a 38% reduction in the number of repairs and a 23% reduction in the number of interruptions related to failures. It should also be noted that the changes introduced in the field of maintenance of machines and devices did not negatively affect the quality manufactured products.

5. Conclusion

The article presents the results regarding the failure time of machines and devices in a production plant analyzed before and after the implementation of the TPM tool. The obtained results made it possible to present the scale of changes in the scope of, among others, MTTR and MTTF indicators, while confirming the positive impact of the implementation of techniques included in the TPM tool on extending the operating time of machines and devices without failure and reducing the time of failure.

Moreover, as a result of the Mann Withney U test, it was found that there are significant differences in the duration of failure of production machines and equipment compared to the state before the implementation of TPM ($p > \alpha$). The obtained results showed a reduction in machine failure time by 5 percentage points compared to the total production time.

Due to the great popularity of the TPM tool and the results obtained using measurement methods in a real production process, they may encourage decision-makers in other production plants to implement solutions consistent with the LM philosophy. It should be noted, however, that the data on the basis of which the analysis was carried out comes from one production plant (case study), which does not allow defining a clear rule describing the impact of LM tools on production processes. However, the results obtained allow us to confirm the assumptions about the validity of implementing the TPM tool for individual parameters related to maintenance. A detailed analysis of the results obtained and comparison of results from other production plants may allow the identification of reasons for better adaptation of LM tools and their impact on the production process. In further research, in addition to comparing parameters related to machine failure rates before and after the implementation of Lean Manufacturing tools, the factor of assessing the correctness of their implementation and functioning during data acquisition can also be taken into account. Such action will allow to assess not only the impact of the implementation of LM tools on the parameters of the development process, but also the quality and durability of this implementation as a function of time.

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CONSUMER SEGMENTATION USING CLUSTER ANALYSIS AS A SOURCE OF DATA TO IMPROVE PRODUCT QUALITY

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Purpose: Identification of energy drink consumer segments in terms of assessing the importance of product quality attributes and variables formally characterizing the sample.

Design/methodology/approach: Cluster analysis was used to segment consumers. The Ward agglomeration method and then the k-means method were used. The scope of the analysis included detecting structure in the data by arranging the surveyed consumers into groups in such a way that the degree of their connection within the same group was as high as possible. This stage of the analysis was carried out on the basis of research results regarding the identification of consumer-preferred quality attributes of energy drinks, which was carried out among people buying and drinking these products in accordance with the IPA (Importance–Performance Analysis) implementation importance method.

Findings: The result of the analysis was to obtain a three-cluster model specifying the segmentation of consumers according to the assessment of the importance of the qualitative attributes of energy drinks and the formal characteristics of the sample.

Research limitations/implications: The cluster analysis method used to identify consumer groups allowed for the detection of structures in the data without explaining why they occur. Therefore, the research is open and it is assumed that it will be continued in this area.

Practical implications: Consumer segmentation may provide guidance for producers in the process of designing the quality of tested products and adapting their quality attributes to consumer preferences. In addition, it may also influence the modification of manufacturers' strategies, e.g. towards the implementation of a strategy of focusing on costs or differentiation and help achieve a competitive advantage.

Originality/value: Demonstrating the usefulness of the cluster analysis method in consumer segmentation on the example of energy drinks, i.e., a currently particularly fashionable and dynamically developing category of food products, and at the same time a controversial range of functional food.

Keywords: consumer segmentation, cluster analysis, quality, energy drinks.

Category of the paper: Research paper.

1. Introduction

Meeting customer needs is the primary goal for competing manufacturers. Buyers are constantly looking for something new, unique and personalized that allows them to stand out (Berbeka, 2016). This trend results from the needs of modern civilization and is also characteristic of the development of the fortified food market. Recently, the development of the food industry has focused primarily on the production of functional foods (Misra et al., 2021). The increase in interest in functional food is the result of increased consumer awareness in the aspect of nutrition, as well as the fashion for an active lifestyle and the development of sports passions (Marciniak et al., 2019). When making purchasing decisions, consumers are guided by various factors and willingly reach for food that reduces mental and physical stress or increases the body's efficiency. Therefore, among others Food manufacturers offer products that contain substances that have an impact on the human body beyond just the nutritional effect (Grudnowski et al., 2016).

The marketing activities of modern enterprises and the development of market strategies are determined by the growing role of consumers. In a company's strategy, information about the value of a given product for the consumer and, consequently, how much the customer is willing to pay for it is crucial. Decisions at the stage of building a strategy for a production organization must be made not only on the basis of one's own experience, but also on the basis of analyses of consumer behaviour models (Maciejewski, 2012).

There are currently eight categories of functional beverage types, including energy drinks, performance-enhancing drinks, weight-control drinks, and drinks that improve digestion, immunity, circulatory system and cognitive function (Gupta et al., 2023). Functional beverages are the fastest growing segment, especially in the development of new food products worldwide. The energy drinks market belongs to the dynamically developing food sector (Giri et al., 2023). There are at least 50 brands of these products available in Poland. Manufacturers maintain constant interest in this category by investing in introducing new products. For example, in 2017, 100 new products appeared on the market (Mroziak, 2018). Every fourth customer chooses energy drinks, and in 2022, Poles bought 800 million cans of heavily sweetened drinks with caffeine or taurine. According to Euromonitor data, in the last two years the increase in the value of the market for these products amounted to 46%, and it is estimated that in 2023 it will reach PLN 3,25 billion. The sector's advertising expenditure amounts to PLN 123 million (Ptak-Iglewska, 2023). It is also forecast that in 2027 the market value may reach nearly USD 154,8 billion, and in the years 2024-2032 this market will grow successively at the level of 7,5% per year (Expert Market Research, 2023).

Since energy drinks have a relatively similar physicochemical composition, it can be considered that they belong to the market of products that are difficult to differentiate other than by using marketing tools (Kowalski, 2017). In the case of this type of products, differentiation

is possible at a level higher than the actual product or its additional functions, and an effective element of differentiation may be, for example, a brand, i.e. an element that creates a certain awareness, reputation and is important on the market (Keller, 2008).

Global producers declare that the consumption of their products meets the need to keep the body and mind active and therefore they are used by various groups of recipients, i.e. people working at night, drivers, athletes, students and young people. In addition, they also notice differences between customers and engage in adapting the marketing strategy to local or cultural conditions (Czernichowski, 2019). Cultural conditions and eating habits determine the preferences of consumers, who create requirements for food available on the market (Gurbuz, Macabangin, 2019; Ramya, Mohamed Ali, 2016). In order to meet consumer expectations, manufacturers must be open to innovation and, as a result, modifications to the composition of products (Mroziak, 2018). They must also adapt to the expectations of the target segment by, among others, name, taste and advertising, including packaging (Expert Market Research, 2023). A wide range of energy drinks and strong competition from producers competing for sales markets, acquiring and retaining customers, force constant diagnosis of the current characteristics of consumers and their functional expectations in relation to these products. Moreover, when analysing target groups, it is impossible not to mention health restrictions and even contraindications and legal restrictions in relation to the consumption of energy drinks for, among others: consumers of different ages. This fact is confirmed by the ban on the sale of drinks with caffeine or taurine (energy drinks) in Poland as of January 1, 2024 to people under 18 years of age (Dz.U.2023.1718).

Identifying differences in consumer preferences and defining groups of potential recipients should support product design and building a market strategy in the changing environment of the production organization. Therefore, the aim of this study is to: identify consumer segments in terms of assessing the importance of quality attributes and variables formally characterizing the sample of respondents. The study was carried out on the example of energy drinks, i.e. a currently fashionable and popular representative of functional food products. In accordance with the assumed aim of the study, a working hypothesis was formulated: the use of cluster analysis leads to the segmentation of energy drink consumers according to their quality preferences and supports the improvement of the quality of these products.

To achieve the assumed objective, the cluster analysis method was used. An element of the new approach presented in the work is the use of the cluster analysis method in the segmentation of consumers of energy drinks and focusing the conclusions on obtaining data allowing for improving the quality of these products. Of course, towards striving for product perfection and full consumer satisfaction. The undertaken task of segmenting consumers of energy drinks was carried out as a continuation of the analysis of our own research conducted among people buying and consuming these products, regarding the assessment of their preferred quality attributes. This study was carried out in accordance with the IPA implementation validity method (Importance–Performance Analysis) (Martilla, James, 1977).

2. Research method

The basis for this stage of work, i.e. segmentation of energy drink consumers, were the research results carried out using scales of implementation importance regarding the measurement and assessment of product quality. This is a group of matrix methods in which the analysed objects are divided into two IPA criteria, i.e. measuring the perception of importance and the degree of fulfilment of expectations in relation to factors - variables affecting the quality of the analysed product (Martilla, James, 1977; Abalo et al., 2007; Biesok et al., 2016; Lotko et al., 2018). The research was conducted using the survey method, the tool was a survey. The questionnaire included questions constituting a formal description of the respondents and a substantive part regarding the features characterizing the analysed product. The selection of the sample was purposeful. The baseline survey conducted using the IPA method covered 300 consumers and was conducted among consumers and users for a total of three groups of products and services (food, non-food and services). The stage of this study, i.e. customer segmentation using cluster analysis, was carried out for a food product based on the results obtained from respondents who declared consumption of energy drinks.

Cluster analysis (data segmentation or clustering) used for customer segmentation has been gaining popularity in recent years (Gore, 2000; Stevens, 2009; Lotko et al., 2018). The method belongs to the group of undirected exploration methods, which means that all relationships and regularities are detected based on the input variables. It includes algorithms and methods for grouping similar objects into similar categories. The cluster analysis method is useful when it is necessary to classify a large amount of information collected during research into a reasonably reduced set. Technically popular methods used in cluster analysis are: agglomeration (hierarchical tree), grouping of objects and features, k-means, EM (expectation maximization) (StatSoft, 1997).

There are two types of clustering algorithms distinguished in the literature: hierarchical and non-hierarchical. Hierarchical methods lead to obtaining a tree structure of the elements of the analysed set, which in the horizontal version is a hierarchical tree diagram, while in the vertical version - an icicle diagram. The analysis results are presented as a tree showing subsequent steps of the algorithm (Migut, 2009). In this way, the final segmentation was obtained in this analysis. Importantly, because the method does not require making prior assumptions as to the number of clusters obtained, the graph could be cut off at the appropriate height from the researcher's point of view to enable a meaningful interpretation of the results. It should be noted that among the hierarchical methods, the most popular method is the agglomeration method. Unfortunately, this method also has some disadvantages, including: for large data sets, significant computational power is required for hierarchical algorithms. In turn, non-hierarchical methods are computationally fast, but they require declaring a predetermined number of clusters, which significantly affects the resulting segmentation. The k-means method

is popular here (StatSoft, 1997; Stevens, 2009). In developing the results of this study, first the agglomeration method (Ward's algorithm) was used to identify the number of clusters, and then the k-means method was used to analyse the structure of the detected clusters.

3. Results and discussion

3.1. Characteristics of respondents

Four criteria were adopted to characterize the respondents, i.e. gender, age, education, and average monthly income. Detailed characteristics of the research sample are presented in Table 1.

Table 1.

Characteristics of the sample

	Metric variable	[%]
sex	female	60
	male	40
age	<25	55
	25-40	18
	41-55	15
	>55	12
education	elementary	0
	secondary education	61
	higher education	39
income	<1000	21
	1000-2500	34
	2501-4000	20
	>4000	25

Source: own elaboration.

It should be noted that women constituted almost two thirds of the respondents. Moreover, more than half of the respondents were young people under 25 years of age. The remaining respondents are groups with a much smaller size. People aged 25-40 years accounted for 18%, and the percentage of people aged 41-55 years was 15%. The smallest group of respondents were people over 55 years of age (total 12%). Such a large number of young respondents in the study who are consumers of energy drinks can be considered consistent with the research (Zucconi et al., 2013), in which we found that 68% of young people (of the European Union Member States) drink energy drinks. Similarly, according to research by the consulting company KPMG Polska, consumers of these products are usually people under 30 years of age, most often students (KPMG, 2016).

Respondents with secondary or higher education constituted 61% and 39%, respectively. The lack of participation of respondents with primary education in the study may probably be due to the fact that the study was carried out only among adult respondents. Moreover, there is

a constant increase in the education level of society and there are fewer and fewer people (consumers) who do not continue their education after primary school. According to data from the Central Statistical Office, only 11.7% of the Polish population aged 13 and over have primary education (GUS, 2022).

The characteristics of the sample were complemented by a variable - average monthly income. The largest surveyed group were respondents declaring an income of PLN 1,000-2,500. The relatively low indication (25% in total) of income above PLN 4,000 can be explained by the fact that many young respondents took part in the study and may still be studying or at the beginning of their professional career.

3.2. Segmentation of respondents

In order to segment the surveyed respondents, cluster analysis was used twice (first, agglomeration using Ward's algorithm, and then the k-means method). Figure 1 shows the results of grouping cases (rows) obtained using the agglomeration method in the form of a tree diagram (Ward).

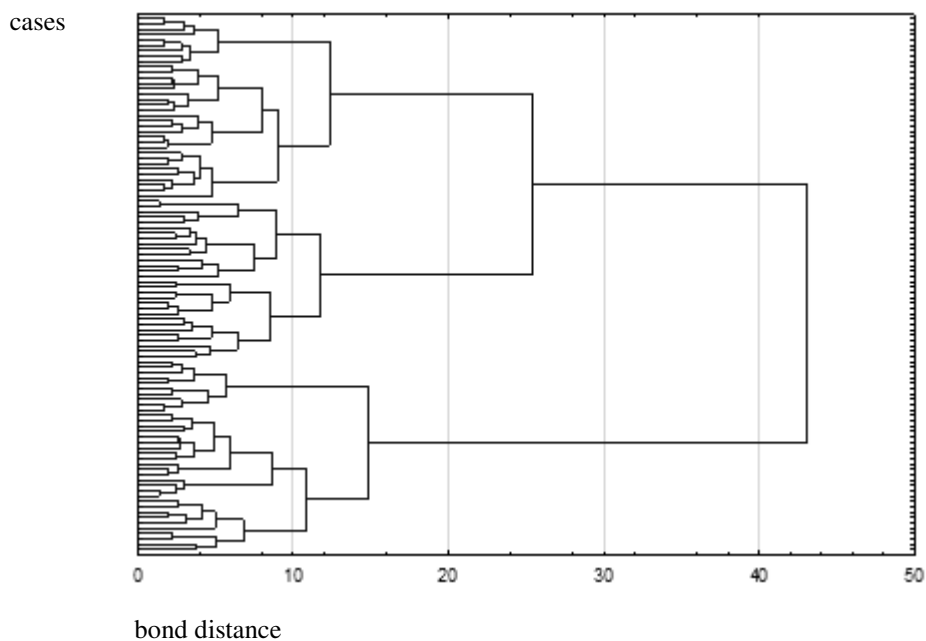


Figure 1. Grouping cases in clusters with the use of the agglomeration method (Ward).

Source: own elaboration.

The analysis of Figure 1 shows a clear division into 3 clusters, resulting from a significant increase in bond length in the range of 15-25. Therefore, a solution with 3 clusters was adopted as the basis for the proposed segmentation model.

Then, the cluster analysis was performed again, this time using the k-means method. In this way, information was obtained about the assignment of cases to clusters and the average values of variables in the clusters. The latter are summarized in table 2.

Table 2.*Average values of quality attribute weights for identified clusters*

Attribute	Cluster 1	Cluster 2	Cluster 3	Total
taste	4,72	4,67	4,17	4,54
smell	4,30	4,37	3,80	4,17
colour	3,40	3,63	3,37	3,46
caloric value	4,42	4,07	2,87	3,85
sugar content	4,40	4,10	3,00	3,89
CO ₂ saturation	4,10	3,83	2,87	3,65
content of active substances	4,28	4,00	3,43	3,94
health safety	4,67	4,60	4,20	4,51
packaging	3,38	3,10	2,93	3,16
price	4,47	3,33	3,73	3,91

Source: own elaboration.

3.3. Characteristics of consumer clusters due to the assessment of the importance of beverage parameters

Based on the results obtained, customer profiles were identified from each segment due to the quality features of the analysed product. On the basis of data contained in Table 2 regarding individual attributes, it can be seen that in cluster 3 the weight of the attribute taste is much lower than in the other two (4,17 vs. 4,72 and 4,67). Therefore, it was found that the attribute taste is less important for consumers assigned to cluster 3. In turn, smell turned out to be the most important for consumers belonging to cluster 2 (4,37). However, there is a clear difference in the importance attached to this feature by consumers of cluster 3 (3,80). It is possible to notice a relatively similar level of importance of the colour attribute for all respondents, practically regardless of which cluster they belong to.

Comparison of the perception of the importance of the parameter caloric value of the product indicated a clearly different position of the respondents from cluster 3. For them, the weight assigned to this parameter is the lowest (2,87 vs. 4,42 and 4,07). Similarly, the same segment of respondents did not attach much importance to the sugar content in energy drinks (3,00 vs. 4,40 and 4,10). However, the parameters such as caloric value, sugar content, carbonation and the content of active substances were the most important for consumers from cluster 1. According to the respondents (regardless of which segment they belong to), the packaging turned out to be the least important attribute of the product. It should be noted that the question about the importance of packaging was a generalization because the respondents' attitude to packaging features (e.g. material, functionality, aesthetics) was not examined. It can be assumed that specifying the aspect of the beverage packaging in terms of its characteristics would perhaps indicate a greater differentiation in the assessment of the importance of this attribute among the respondents.

Generally, for all respondents, taste and health safety are two key quality parameters of the analysed products, and the respondents assigned the least importance to packaging. A comparative analysis of the weight values of the considered attributes in the identified clusters also indicated that taste is particularly important for consumers from clusters 1 and 2,

while consumers from cluster 3 put health safety first. In this aspect, the presented research results are partially consistent with similar ones already published and confirm that the main parameter important for consumers is safety and that consumers mainly associate the quality of the analysed group of drinks with this attribute (Gupta et al., 2023; Osmólska et al., 2022).

It was noticed that consumers from cluster 3 indicated the lowest weights for all assessed attributes, which means that this segment includes consumers with low requirements for the quality of the analyzed product. However, generalizing the perception of the importance of quality attributes of energy drinks by consumers of cluster 1, it turned out that they are the opposite of cluster 3. Cluster 1 includes consumers for whom quality attributes are important (color and packaging the least), while at the same time the price of the product is important. These may be people who are not willing to pay a high price for high quality, or price is an indicator of quality for them. In turn, for consumers of segment 2, the price of the product is the least important (compared to the other clusters), and in terms of the level of weight assigned to quality attributes, this group is placed between the other two clusters.

Since price plays an important role in the consumer's perception of product features, i.e. it shapes consumer expectations regarding their quality (Shiv et al., 2005), taking into account the results of this study, it was possible to name the identified consumer clusters using characteristics and nomenclature individual price segments of consumers proposed by Szczepański (2005). Therefore, in the context of quality features versus product price, based on this stage of this study, the following names were proposed for three distinguished clusters of consumers drinking energy drinks: cluster 1 - economic customer (important quality features - important price), cluster 2 - premium customer (important quality features - not important price), cluster 3 - customer standard (similar level of importance for quality features and price, and awareness that “quality costs money”).

3.4. Characteristics of consumer clusters according to their birth features

Whereas:

- price is not the only means of communication with the customer (Kotler, 2002),
- the process of shaping the product image in relation to the price image depends on a number of factors (Łukasik, Schivinski, 2014),
- energy drinks are difficult to differentiate products (Kowalski, 2017),
- for a group of products that are difficult to differentiate, buyers generally do not consider price as an indicator of quality (Bondos, 2016),

the structures of the identified clusters were analysed according to individual metric variables, i.e. gender, age, education and income level of the respondents. This approach will help adjust the product specifications in terms of preferred quality parameters to the characteristics of consumer segments. The results of the obtained cluster structure are presented in Table 3.

Table 3.
Structure of clusters according to metric variables

Metric variable		Cluster 1 [%]	Cluster 2 [%]	Cluster 3 [%]	Total [%]
sex	female	83	60	47	60
	male	17	40	53	40
age	<25	79	75	33	55
	25-40	10	15	24	18
	41-55	7	5	24	15
	>55	3	5	20	12
education	elementary	0	0	0	0
	secondary education	76	80	45	61
	higher education	24	20	55	39
income	<1000	34	40	6	21
	1000-2500	41	35	29	34
	2501-4000	17	10	25	20
	>4000	7	15	39	25

Source: own elaboration.

The data in Table 3 show that cluster 1 can be considered highly feminized. There is a clear predominance of women here (83% of them compared to the fraction in the sample of 60%). As stated earlier, this focus attaches great importance to the quality parameters of products, and at the same time, price is also particularly important for them. Therefore, taking into account the characteristics of women consumers (Gemnius Polska, 2020), it is advisable that producers, when adapting the product to this group of recipients, should send a message regarding the impact of the product (beverage) on improving their quality of life. Hence, as the obtained research results indicate, health safety and caloric value are the main two quality parameters on which the manufacturer should focus on improving, and which respondents from this segment indicated as one of the most important quality features (apart from sensory values, i.e. taste and smell). Researchers Gupta et al., (2023) also reached similar conclusions regarding the correlation between diet and health for the protection of consumers' overall well-being.

Identified clusters 1 and 2 are mostly young people (79% and 75% aged up to 25, respectively, compared to 33% for cluster 3), and middle-aged and older people belong to cluster 3. Therefore, clusters 1 and 2 are clearly "youthful" in nature and cluster 3 groups mature consumers. In cluster 3, there is a clearly higher share of people with higher education (55% compared to 39% in the sample and 24% and 20%, respectively, in clusters 1 and 2). Therefore, the third of the identified segments groups clearly better educated people than the other two, which corresponds to the results regarding the age structure of the respondents.

Taking into account the respondents' income, it was found that in the first cluster there is a clearly larger fraction of people with an income below PLN 1,000 and in the range of PLN 1,000-2,500 (34% and 41%, respectively) compared to 21% and 34% in the sample). At the same time, cluster 3 included by far the largest fraction of people with the highest income, i.e. above PLN 4,000 per month (39% compared to 25% in the sample). Cluster 2 contains a proportionally larger fraction of people with average income.

4. Conclusions

Knowing the product quality attributes that are important for customers, the manufacturer knows which features important for the recipient must be improved in order to best adapt the offer and marketing communication to the expectations of individual customer groups.

Comparison of respondents' preferences regarding the importance of quality features of energy drinks showed that for none of the distinguished consumer groups the content of active substances is a key quality attribute. The respondents mainly declared that they expected products to be safe for health. Apart from this attribute, the most important parameters, according to the identified consumer clusters, are related to sensory sensations (taste, smell), but they also attach importance (especially cluster 2) to the sugar and calorie content.

However, the results of our own research also allowed us to identify the features of energy drinks that all respondents considered the least important, regardless of the segment they belonged to. These are the packaging and color of the product. Knowledge regarding consumers' perception of the importance of these attributes is of practical importance. It can be a valuable guide for manufacturers when deciding on areas for improvement and will allow them to focus on attributes that are important to consumers and invest more in this area, while preventing over-investment in improving product features that are less important to consumers and which they do not expect to improve. Therefore, this line of reasoning leads to a rational improvement in product quality and at the same time has an economic aspect. This approach is especially important in the current reality of market and price competition and the trend of product sustainability.

It should be noted that the research tool used has some limitations. The cluster analysis method is dedicated to exploratory research. The grouping method is used to create taxonomies and does not make it possible to confirm the validity of defined segments. Its significant limitation is its subjective nature. This is a typical problem for social research. However, this method makes it possible to identify clusters for cases (consumers) and, among others, this was the reason for using it to analyze the results. Another limitation of the presented study resulted from the fact that the knowledge of beverage consumers regarding the quality categories of these products was not analyzed. This limited a deeper analysis of the differences in the importance of the quality criteria indicated by the respondents. This was taken into account when developing the survey questionnaire, where the focus was on measuring attribute weights. However, as a result of the study, it was possible to confirm the universal nature of the analysis method used.

The conducted study opens new directions for future research. The next step may be, for example, the continuation of the analysis in the following areas: whether the answers provided result from the respondents' conscious knowledge and to what extent the answers are given at the level of minimum involvement of the respondents. The research results encourage

the continuation of the use of deeper statistical analyzes to test cause-and-effect models, which will be the direction of subsequent research.

Based on the results of the study, it can be concluded that energy drink producers actually have two options to build product value and meet consumer demands: either lowering the price or providing product features that are important to customers and expected by them. By choosing a specific concentration strategy option, manufacturers can serve their customers and at the same time strive for market leadership.

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PROJECT SCHEDULING UNDER CONSIDERATION OF TEAM-BASED DEPENDENCIES BETWEEN PROJECT ACTIVITIES

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Purpose: The purpose of the paper is to propose two models incorporating the information about project activities that share the same human resources in order to achieve a more realistic estimation of project duration. Uncertainties about the duration of activities are also taken into account.

Design/methodology/approach: The objective is achieved through fuzzy modelling and linear programming, as well as through modelling of team dependencies between activities.

Findings: It was shown that the fact of sharing the same human resources by project activities may strongly influence project duration estimation and it is not advisable to ignore such information in project planning. It was also proposed how to model such dependencies and consequently arrive at more accurate project duration estimations. Simultaneously, modelling of project uncertainties and their practical importance have also been shown.

Research limitations/implications: This work contributes to unexplored subject of considering dependencies and uncertainty simultaneously in project scheduling. It contributes to the research on how to include team dependencies between project tasks and uncertainty in project scheduling to provide reliable information on project duration. However, many more dependencies between tasks should be considered and other methods of uncertainty modelling taken into account. Real world cases of terminated projects should be used as case studies.

Practical implications: The proposed models will significantly increase the accuracy of project duration estimation in all types of organisations, which in turn will help to save time and money lost as a result of project delays.

Originality/value: The paper is addressed to both researches and practitioners who deal with the problem of project scheduling. It proposes a novel method of increasing the accuracy of project duration estimation that takes into account team-based dependencies between project activities along with uncertainty.

Keywords: project scheduling, fuzzy duration, sharing resources, project duration estimation.

Category of the paper: Research paper.

1. Introduction

Knowledge of the duration of projects is crucial for effective project management and determining when an organization can leverage the project's results and products. However, the high rate of considerable project deadline overruns (Demeulemeester, Herroelen, 2002) shows that determining project duration in the phase of project planning is not an easy task. There are several reasons responsible for this issue, like uncertainty (Perminova et al., 2008), various human biases (Toet et al., 2016), project inherent complexity and newness, etc. All these issues are somehow addressed in the literature: e.g., we have the possibility to use probability or fuzzy distributions to model values that are not completely known (Bonnal et al., 2004; Chanas, Zieliński, 2001; Hullet, 2009; Malcolm et al., 1959). There is one aspect, however, that on one hand considerably adds to the complexity in developing project schedules and, consequently, determining their duration, and on the other hand is usually ignored in the description of project management methods and methodologies: the dependencies between project activities, or (here we assume the two terms to be synonyms) project tasks.

It is apparent that between tasks in the project some dependencies may occur, such as sharing the same resources (equipment or teams) or scope of some tasks being dependent on the decisions or results of others. The conclusion that these dependencies may influence the duration of related activities is straightforward. Understanding and incorporating them into the scheduling process allows for developing more nuanced and useful schedules, as they will closer reflect the project reality.

As this aspect is generally absent in the literature on project scheduling (uniquely rare references in the context of construction projects have been identified (Salkeld, 2016)), the objective of this paper is to propose two models incorporating one type of task dependency – that based on sharing the same team or the same person executing the task. We will call this dependency type team or team-based dependencies. Uncertainty about project duration will also be included in the models and will be expressed by means of fuzzy numbers.

The outline of the paper is as follows: in Section 2 we discuss the problem of team based dependencies, in Section 3 we propose two fuzzy models including information about activities that share the same resources and allowing to take into account uncertainties about the duration of project activities, and in Section 4 we illustrate the approach with a real world research project. The paper terminate with some conclusions.

The paper is based on a master thesis successfully defended at the Faculty of Management of Wrocław University of Technology (Pikiewicz, 2023).

2. Team dependency

As mentioned above, the problem of dependencies between different tasks in projects is a complex one. The team dependency will be the main focus of this paper – this dependency type is fairly universal for different types of projects, as several teams working on one project is a common practice.

Team dependency occurs when more than one team works on more than one task in the project. Teams can have different experiences, sets of skills, knowledge, and commitment to the project. All of these influence their work performance and how they fulfil their duties. For example, a new team consisting of people with little experience (e.g. in junior positions) and new to the company may work slower on all tasks assigned to them than their more experienced colleagues.

In short, it is not irrelevant who and under which conditions performs individual project tasks. If two or more tasks are performed by the same team under the same conditions, this must be taken into account when scheduling the project. Including such a dependency in project scheduling can improve its relevance. If the PM knows that the team has lower (higher) work performance, they can expect that the project activities that have been assigned to them may take longer (shorter) than anticipated. Taking such pieces of information into account, PM can obtain a more reliable indication about planned project duration. We are going to propose two models for the project planning stage that include this information type. They will be based on a fuzzified standard model that will be presented in the first place.

3. Proposed models

3.1. Fuzzified standard model

To incorporate information about the work performance of the teams into the scheduling process, we propose an extended version of standard linear programming model used to optimize project duration (Swanson, 1973). The extension consist in replacing crisp task durations with fuzzy ones, modelled by means of triangular fuzzy numbers. A triangular fuzzy number $\tilde{t} = (t^a, t^b, t^c)$ (Zadeh, 1965) is defined as a triple of crisp numbers $t^a \leq t^b \leq t^c$, where the extreme values are seen as possible to the degree 0, the intermediate value as fully possible (to the degree 1), and the possibility degree diminishes linearly between the intermediate and the extreme values. The extreme values are the optimistic or pessimistic ones, depending on the situation being modelled. Arithmetical operations and relation between fuzzy numbers themselves and between a fuzzy number and a crisp number can be defined in many ways. In the following, we will specify the choice we made in this paper.

The basic model uses the following notation:

$$\text{Objective function} \quad \min \tilde{z} = \tilde{x}_N, N \in \mathbb{N} \quad (1)$$

Subject to:

$$\begin{aligned} \tilde{x}_j &\geq \tilde{x}_i + \tilde{t}_{ij} \\ \text{where } A_{ij} &\in \mathcal{A}, i, j \in \mathbb{N}, \\ \tilde{x}_j, \tilde{x}_i &\geq 0, \end{aligned} \quad (2)$$

where:

\mathbb{N} – set of nodes in the network, $\mathbb{N} = \{j: j = 1, \dots, N\}$, where N denotes number of nodes in the network,

$E = \{(i, j), i, j \in \mathbb{N}: \text{such that there exists a link from } i \text{ to } j\}$. Note that all couples (i, j) in set E satisfy $i < j$,

\mathcal{A} – set of activities in the network, $\mathcal{A} = \{A_{ij}: (i, j) \in E\}$,

$\tilde{t}_{ij} = (t_{ij}^a, t_{ij}^b, t_{ij}^c)$ - fuzzy duration of activity A_{ij} : all three values of the fuzzy number are provided by the PM, with the additional constraint $t_{ij}^a > 0$. Note that t_{ij}^a is the optimistic value – the shortest duration possible of an activity, and t_{ij}^c is the pessimistic value – the longest possible duration,

fuzzy decision variables $\tilde{x}_j = (x_j^a, x_j^b, x_j^c)$, representing the not fully known earliest possible finish time of all activities that end at node $j, j = 1, \dots, N$. The interpretation of the three parameters of the triangular fuzzy number is analogous to the one of the fuzzy tasks duration.

The objective function (1) is the duration of the project, which should obviously be minimised. This value is equivalent to the earliest possible finish time of all the activities that have the finish node as their final node. The constraint (2) is created basing on the rules for constructing project networks: for each activity $(i, j) \in \mathcal{A}$, the node i needs to occur and the activity needs to be carried out before node j (Winston, 1991).

To properly include the consequence of introducing fuzzy numbers to the model, the following solution has been selected: the model will be calculated three times for the combination of the first, second and third parameters of the fuzzy triangular numbers \tilde{t}_{ij} and \tilde{x}_j . Thus, three standard models will be solved and finally the fuzzy solution of the fuzzy model will be obtained. The resulting values from the three calculations are arranged to form a triangular fuzzy objective value $\tilde{z} = (z^a, z^b, z^c)$. The fuzziness expresses the uncertainty about project duration inherent to the project planning process. Obviously, other methods of solving the fuzzy linear programming model may be chosen; here, we decided to choose the simplest one, that has most chances in be applied in practice.

3.2. Proposed model 1 – team dependencies

In the 1. model we take into account the information which team is assigned to each activity A_{ij} . We assume we have K teams, and $\tilde{t}_{ij}^k = (t_{ij}^{k,a}, t_{ij}^{k,b}, t_{ij}^{k,c})$ stands for the fuzzy duration of activity A_{ij} if performed by team k . Additionally, we introduce the notion of the work quality of individual teams: $\tilde{q}_k = (q_k^a, q_k^b, q_k^c)$ – fuzzy quality of team $k, k = 1, \dots, K$. If the quality of work has been taken into account in \tilde{t}_{ij}^k , we can take $\tilde{q}_k = (1, 1, 1)$, but if the PM wants to introduce the additional information about the work quality, they can select other \tilde{q}_k .

We propose the following function:

$$f\left(\tilde{t}_{ij}^k, \frac{1}{\tilde{q}_k}\right) = (t_{ij}^{k,a} \times \frac{1}{q_k^c}, t_{ij}^{k,b} \times \frac{1}{q_k^b}, t_{ij}^{k,c} \times \frac{1}{q_k^a}) \quad (3)$$

In the (3) we chose to multiply not values of both triangular numbers in their original order, as they will not provide an interpretable result, but instead we multiply the values that have the same meaning. So to obtain the most optimistic duration of a task with inclusion of team quality, we multiply the most optimistic provided task duration ($t_{ij}^{k,a}$) with the most optimistic quality of the team ($\frac{1}{q_k^c}$). Other values are obtained analogously. This proceeding, described by (3), results in a fuzzy number with a straightforward interpretation:

- The first value is the most optimistic scenario, where at the same time the task has the shortest duration and the team has the highest possible quality,
- The second value reflects the most possible result, both the task and the quality parameters takes on the most possible values,
- The third value is the most pessimistic scenario, the task has the longest duration and the team has its weakest performance possible.

We propose to solve the model analogous to the fuzzified standard model, but instead of constraint (2) the following one will be used:

$$\tilde{x}_j \geq \tilde{x}_i + f\left(\tilde{t}_{ij}^k, \frac{1}{\tilde{q}_k}\right) \quad (4)$$

3.3. Model 2 – with teams dependencies and updating procedure

During the execution of the project PMs gain knowledge, also about the actual work of the teams. Therefore, we propose to enrich Model 1 with the data about real realizations of the tasks that have been completed up to each control point $m = 1, \dots, M$. Constraint (4) will be replaced with constraint (5):

$$\tilde{x}_j \geq \tilde{x}_i + f\left(\tilde{t}_{ij}, \frac{1}{\tilde{q}_k(CP_m)}\right), \quad (5)$$

where $\tilde{q}_k(CP_m)$ is the team quality, updated for those activities that have been completed up to the control point $CP_m, m = 1, \dots, M$ in the following way:

- $q_k^a(CP_m)$ stands for $\min\left(\frac{t_{ij}^{k,b}}{t_{ij}^k(CP_m)}\right)$, where $(i, j) \in \mathcal{C}_k(CP_m)$,
- $q_k^c(CP_m)$ stands for $\max\left(\frac{t_{ij}^{k,b}}{t_{ij}^k(CP_m)}\right)$, where $(i, j) \in \mathcal{C}_k(CP_m)$,
- $q_k^b(CP_m)$ can be chosen as an average of $\left(\frac{t_{ij}^{k,b}}{t_{ij}^k(CP_m)}\right)$ - the PM makes the choice based on the data and their experience,
- $t_{ij}^k(CP_m)$ is the actual duration of activity A_{ij} and $\mathcal{C}_k(CP_m)$ is the set of activities completed by the control point CP_m , $m = 1, \dots, M$.

For the teams that have not completed any of their assigned tasks before the control point, the constraint (4) from the first model is used, where the quality is solely provided by the PM at the beginning of the project. It is important to emphasize that to derive a fuzzy quality of the teams in this model, all the tasks completed by the team are taken into consideration up to and including the moment CP_m . The ratios used to calculate $\tilde{q}_k(CP_m)$ reflect, for each team, the relation between the planned durations and the actual ones. This approach allows to update information about the team performance. It is important, as the team performance may strongly depend on the project. If the project requires special competencies, not needed in other projects in which the team took part, previous information on team work quality will not be relevant, but using Model 2 we can update the quality based on the most recent tasks. Full form of the Model 2 is shown in the Appendix.

4. Case study illustrating the proposed models.

The research project that is used as the basis for the case study is a research planned to take place at Wrocław University of Science and Technology at Faculty of Management. The project was unfortunately not executed, as it did not receive funding, but the planning phase was fully carried out. Data from this stage are the basis for the case study, the rest of the data are estimations made by the authors of the paper.

4.1. The project and its teams

The main aim of this project is to develop a Scrum use maturity model in organizations carrying out IT projects. Other objectives include inventing a new definition of maturity of using project's methodologies adapted to the characteristics of Scrum, and assigning goals to be achieved at each level of maturity. Researchers who planned this project highlighted that as Scrum is based on empiricism, the maturity model should be based on the knowledge and experience of people working in and with Scrum in their everyday work.

To fulfil the aforementioned goals, the tasks included in Table 1. were defined for the project. In Table 1., there is also information about the planned durations of each activity and their predecessors. The duration was assessed both by means of crisp and fuzzy numbers.

Table 1.
Tasks in case study project

ID	Task	Predecessors	Duration in days	Fuzzy duration in days
A	Identification of Scrum practices and values	-	15	(10, 16, 23)
B	Development of a glossary of Scrum terms	-	7	(2.5, 4, 10)
C	Preparation of a questionnaire and interview sheets	A, B	12	(8, 11, 14.5)
D	Implementation of the questionnaire in a survey software	C	3	(1.5, 2.5, 6)
E	Adaptation and programming of the selected data clustering algorithm in order to identify similar practices	D	20	(14, 21, 32)
F	Conducting a pilot study	E	10	(6, 10, 22)
G	Analysis of pilot study results, modification of the questionnaire and interview sheets	F	15	(9, 14, 20)
H	Conducting a proper research	G	30	(22, 28, 40)
I	Analysis of research results focused on the identification of groups of similar practices by means of a selected clustering algorithm	H	15	(10, 14, 21)
J	Analysis of research results focused on the "soft" supplementary information obtained in direct interviews	H	15	(9, 13, 20)
K	Development of the Scrum use maturity model	I, J	30	(23, 30, 45)
L	Verification of the Scrum use maturity model	K	15	(9, 13, 18)

Source: based on the plan for the project and own study.

If we examine the predecessors, it is visible that the majority of tasks were planned to be carried out in sequence, only two pairs of tasks were planned to be performed simultaneously.

The project was planned to be carried out at the Faculty of Management. The teams that could perform tasks in the project are composed of persons working or studying at this Faculty. For this project, the crucial expertise items regard project management, applications mathematics to managerial problems and knowledge of optimisation algorithms.

Based on an analysis of the competencies and expertise at the Faculty, four teams were identified that could participate in the execution of this project:

- Team 1 – employees with high level of knowledge and experience in project management area,
 - assigned tasks: C, F, G, H, J;
- Team 2 – employees with medium to high level of knowledge of mathematics and project management,
 - assigned tasks: K, L;
- Team 3 – students and PhD students at the Faculty,
 - assigned tasks: A, B, D;
- Team 4 – computer scientists with a medium level of expertise in algorithms,
 - assigned tasks: E, I.

The proposed method of allocation allows the skills of each team to be used effectively by selecting the tasks that require their specific knowledge. The choices were also made in such a way that the tasks are demanding enough for the expertise of the team members. The suggested approach is cost effective and allows for the personal development of team members and can lead to increased motivation of work.

When there are several teams working on a project performing more than one task, it is obvious that the dependency of the teams working on different tasks in the project occurs. To be able to use the models with team dependencies, PM managing the project needs to assess the quality of each of the teams. This is the last information required along with the duration of each task in the form of a crisp and fuzzy triangular number and their assignment to the teams. The qualities of each team are summarized in the Table 2. below.

Table 2.

Teams quality in the form of crisp and triangular fuzzy number

Team	Crisp quality	Fuzzy quality
Team 1 – high project management	1.2	(1, 1.15, 1.3)
Team 2 – mathematics and project management	1.15	(1, 1.1, 1.25)
Team 3 – students and PhD students	0.8	(0.7, 0.8, 0.95)
Team 4 – computer science	1.05	(0.9, 1, 1.15)

Source: based on the plan for the project and own study.

Looking exclusively at crisp values gathered in Table 2., it can be seen that three teams have a higher performance than the organisational average (assumed to be 1), only the students got a lower score. However, when the fuzzy quality is considered, the information is not as unambiguous any more. Team 4 may be better or worse than the average, depending whether the pessimistic case occurs or not. For Teams 1 and 2, the situation is clearer: in the worst case scenario they work as an average team, in the best case they have a higher performance.

When all the required data is collected, we can proceed to the implementation of Model 1 with team dependencies - first at the moment 0 of the project. This will allow us to gain a first insight into the possible duration of the whole project, as well as individual tasks. Moreover, PM can observe the impact of different qualities of the teams and how they influence the tasks duration.

Using fuzzy data from Tables 1 and 2, Model 1 was applied, with the following results:

Table 3.*Triangular decision variables at the moment 0 of the analysed project*

Decision variable	x_j^a	x_j^b	x_j^c
\tilde{x}_1	0	0	0
\tilde{x}_2	2.6	5	14.3
\tilde{x}_3	10.5	20	32.9
\tilde{x}_4	16.7	29.6	47.4
\tilde{x}_5	18.3	32.7	55.9
\tilde{x}_6	30.4	53.7	91.5
\tilde{x}_7	35	62.4	113.5
\tilde{x}_8	42	74.6	133.5
\tilde{x}_9	58.9	98.9	173.5
\tilde{x}_{10}	65.8	110.2	193.5
\tilde{x}_{11}	67.6	112.9	196.8
\tilde{x}_{12}	86	140.2	241.8
\tilde{x}_{13}	93.2	152	259.8

Source: own study.

The information about the expected finish times for tasks can be of great value for the PM, especially if it is not averaged by force, but presented including the uncertainty. Basing on this information and a risk analysis, schedules and some deadlines can be altered to better reflect the possible finish times. In Table 3. it can be seen that for some tasks the difference between the most optimistic and pessimistic values is quite large. The reason behind it is that it is a research project. Such projects are highly uncertain, the duration of their tasks depends on many factors and is difficult for foresee exactly (Klaus-Rosińska, 2019). It can be noticed that, as a result, the finish times vary strongly and this affects the duration of the whole endeavour. It is crucial for the PM to be aware of this, as it reflects how the task may be carried out by the teams. Moreover, the knowledge about different possible values of finish times shows how much time the different stages of the project may take in various scenarios. It allows the PM to be better prepared for both optimistic and pessimistic scenarios and plan accordingly. In research projects it is crucial to know the possible values of the project finish time, because of the need to meet very strict deadlines, such as submitting project documentation to the Ministry or other academic institutions, or sending reports on the progress of the research (Klaus-Rosińska, 2019). In addition, the PM can monitor more closely those tasks with a wide range of possible finish times that they perceive as vital to the project, to ensure that they are completed before the important deadlines.

To gain a better understanding how the fuzzy information about the task finish times can be used, one of the decision variables will be analysed. The finish time of the task G (x_8) (*analysing the results of the pilot study and making adjustments to the questionnaires*) marks the end of the preparation phase of the project. After this task a proper research will be carried out. The finish time of this task will determine when the main research phase can start. It will influence planning the interviews and the travel required to conduct them and the moment when certain teams will be needed in the project, so that they can schedule their other research and teaching activities accordingly. The possible finish times for this task determined using

Model 1 are represented by the fuzzy number $\tilde{x}_8 = (42,74.6, 133.5)$. It can be seen that it covers a fairly wide range, as the difference between the optimistic and the pessimistic finish times equals to 91.5 days (with around 55% and 80% deviations from the most possible time). This task is carried out by Team 1, with the average work quality in the worst case scenario and much better work quality in more positive scenarios. Having this information at their disposal, the PM can take measures to ensure that the quality of the team is high enough to fall into the more optimistic interval of the task duration values.

Another way of analysing the results is to plot a graph of a triangular fuzzy number to observe the degree of possibility of each value. The graph makes the triangular fuzzy number and all the possible values more visible for the decision maker. For example, such an approach can be used to analyse the tasks that have strict deadlines. In this way, the PM can notice what other values are highly possible and be better prepared for these scenarios. The analysis of the graph in this case study was applied to the values of the objective function. The graph of the project duration obtained through calculations of Model 1 is shown in Figure 1.

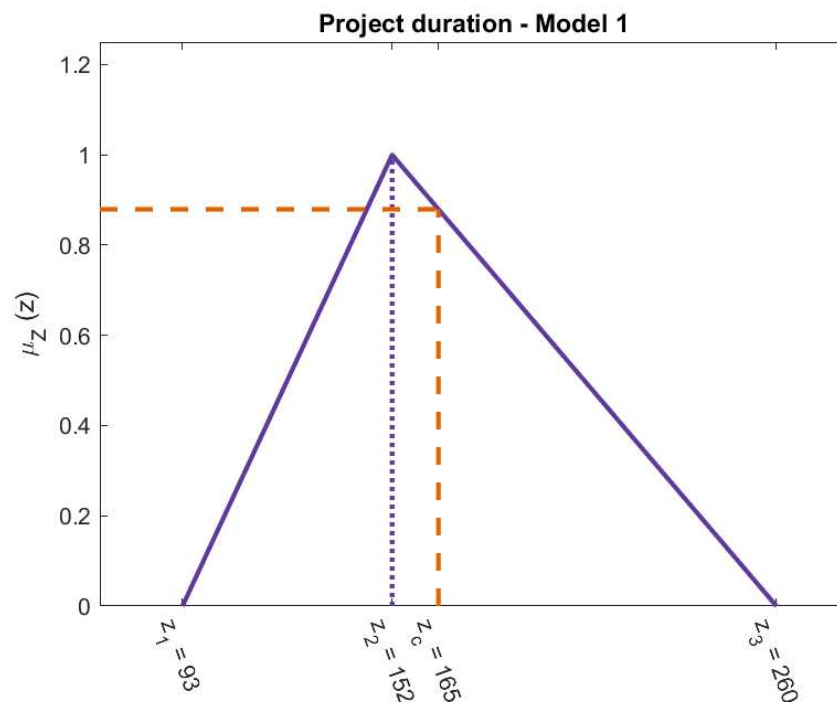


Figure 1. Fuzzy project duration including team dependency.

Source: own study.

In Figure 1. it is visible that as the decision variables had wide range of possible finish times, the duration of the entire project obviously has this feature, too. This wide range also follows from the characteristics of research projects mentioned before. In Figure 1., the y-axis shows the degree of possibility of each value of the project duration, and x-axis shows the different possible project durations. The shape of the triangle was formed based on the three values of the fuzzy triangular number $\tilde{z} = (93,152,260)$ and their degree of possibility. The project duration equal to 152 days is the most possible one. With this information the

PM can plan the most possible deadline and the moment when the results can be presented. However, they should not base this decision solely on the most possible duration, because there are also other durations that are possible and should not be neglected. Since the difference $z_2 - z_1$ is smaller than the difference $z_3 - z_2$, it can be concluded that durations longer than the most possible one are a serious issue here. The PM should be more prepared for the pessimistic scenarios.

In Figure 1. the duration equal to 165 days was marked. It is the duration of the project obtained from the standard model with crisp parameters and variables, it is shown by means of the orange dashed line with the label z_c . It allows us to compare the two approaches. It can be noticed that in this case, this duration is more pessimistic than the most possible one in the fuzzy model. It still has a high degree of possibility and the PM should take it into the consideration. Its degree of possibility can be calculated as follows:

$$\mu_z(165) = \frac{z_3 - x}{z_3 - z_2} = \frac{260 - 165}{260 - 152} = 0.88 \quad (6)$$

Next, the second version of the fuzzy model can be calculated to check how this influences the results (Model 2). One update was performed for the Team 1. It was selected because it has been assigned the most tasks and it is more interesting to observe updates and deriving quality from actual realizations.

The hypothetical control point took place after finishing the task G – *Analysis of pilot study results*. It is assumed that up to this point tasks A-G have been completed and the actual realizations of durations were as follows:

- Task A – 17,
- Task B – 6,
- Task C – 10,
- Task D – 3,
- Task E – 23,
- Task F – 8,
- Task G – 13.

Task C, F and G were performed by the team whose quality will be updated and the model will be recalculated with this newly gained knowledge.

First the quality of performance on each task is calculated as described in the Model 2: the most possible duration is divided by the actual duration of the task. From these values the maximum, minimum value needs to be identified. The new, updated fuzzy quality of team 1 is $\tilde{q}_1 = (1.08, 1.1, 1.25)$. It can be noticed that this new quality differs from the one provided at the beginning of the project. The most optimistic quality is lower by 0.05, the most possible is also lower by the same amount. These are negative changes after the update. Positive change can be observed for the most pessimistic value, it is larger by 0.08. The positive information is that even after the update, the team still is more efficient than the organisational average. However, seeing these differences highlights how important it is to perform systematic project

control and updates throughout such uncertain projects. Especially quality of the teams should be based on their more recent work, as their performance may change due to different factors, such as characteristics of the tasks, the team engagement in the project etc. Now this new quality is used in the calculations of the final estimated duration of the remaining tasks assigned to Team 1, which are H and J. The durations of the tasks that have been completed before the control point are treated in the model as crisp values. New finish times for the remaining tasks are shown in Table 4.

Table 4.

Triangular decision variables updated after the 1st control point – updated quality of Team 1

Decision variable	x_j^a	x_j^b	x_j^c
\tilde{x}_9	91.6	99.5	111
\tilde{x}_{10}	98.8	111.3	129.6
\tilde{x}_{11}	100.3	113.5	134.4
\tilde{x}_{12}	118.7	140.7	179.4
\tilde{x}_{13}	126	152.5	197.4

Source: own study.

In Table 4, the finish times of the tasks assigned to Team 1 are shown in bold. The first thing to notice is that the difference between the values is smaller than in finish times obtained from the model at moment 0. The quality of Team 1 does not have such a wide range of possible values as it was estimated previously, and this influences the range of possible durations of their tasks. For tasks H and J there is also another reason, the updated quality. It may be interesting to look not only at the finish times, as these also depend on the previous tasks, but also at the duration of the tasks assigned to Team 1. As an example, the duration of task H is analysed. In this model, the final duration of the task is the product of a function of the duration of the task and quality of the team. Before the update, the fuzzy duration of the task H was $\tilde{t}_{8,9}^1 = (16.9, 24.3, 40)$, and after the update it is $\tilde{t}_{8,9}^1 = (17.6, 25.5, 37)$. The most pessimistic duration is now smaller, thus the worst possible scenario is better. But the most optimistic and most possible scenarios have become slightly worse. Taking that into consideration, this update allows for more realistic estimates of the remaining tasks and their durations.

The duration of the entire project, in the form of a fuzzy triangular number, is shown in Figure 2, after the update of the quality Team 1 and with the data about actual durations of tasks A, B, C, D, E, F and G.

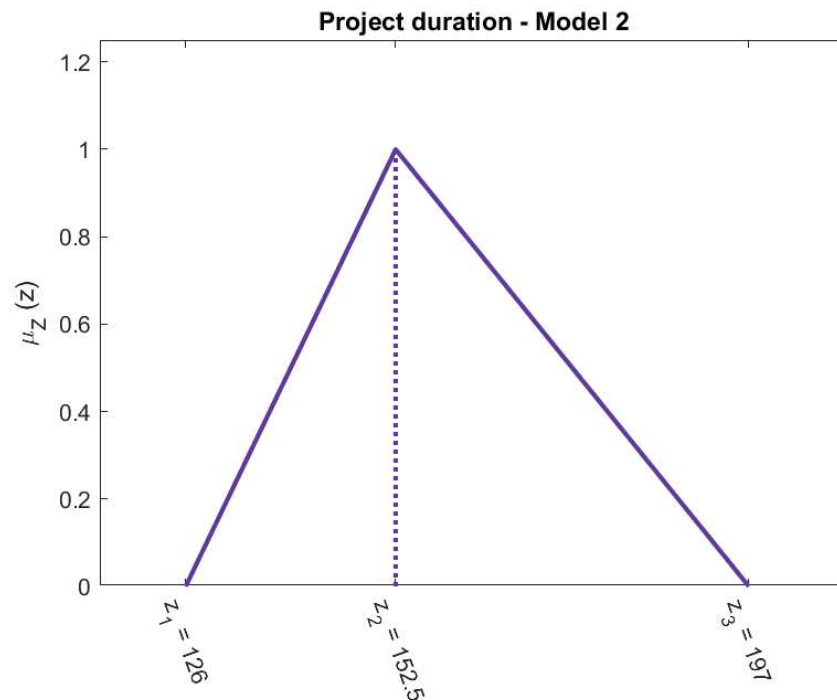


Figure 2. Fuzzy project duration updated after the 1st control point.

Source: own study.

After the updating procedure the fuzzy project duration is now $\tilde{z} = (126, 152.5, 197)$. The first thing to notice in Figure 2. is that the support of the triangle is now much narrower, as the difference between the most optimistic and pessimistic project duration has become smaller. As more than half of the tasks have been completed before the control point, the level of uncertainty is now lower, as it only affects the remaining tasks and not the entire project. The same tendency is observed here: the most pessimistic duration is much smaller, the most optimistic and possible are larger, with the most optimistic being larger by a greater amount than in the fuzzy project duration obtained from the model at moment 0. The reasons are the same as for the finish times of the tasks. The updated fuzzy project duration still has the same negative tendency. With this update, the PM will have a clearer vision on the end of the project and for what possible deadlines they should be prepared. It also shows how important the updating procedure is in project schedule management, as at the beginning of the project the knowledge about this particular undertaking is very limited.

5. Conclusions

Accurately determining project durations is crucial for effective management and timely achievement of project objectives. However, bypassing the information on dependencies between project activities hinders accurate scheduling. In addition, the inherent uncertainty in

projects poses further challenges in developing schedules and estimating tasks durations. To tackle these two obstacles and enable creating more reliable schedules, we proposed two forms of a fuzzy model with the team dependency. The first model we introduced is applicable for the moment 0 of the project to gain a first insight into the possible duration of the project and its activities. Knowledge acquisition throughout the project was used by us in the second proposed model to enhance the estimation accuracy – the quality of the team is updated, basing on their performance in the ongoing project. Simultaneously considering team dependencies (this aspect has not been considered in the literature so far) and uncertainty constitutes a novel solution to improving project scheduling.

It should be noted that the problem of identifying and understating task dependencies is a complex one, as they can vary between different types of project and comprise many different aspects. Construction projects have different characteristics of tasks than the IT industry or research projects. Moreover, the environment of various types of the projects also differs, which will also influence the occurrence of different dependencies. It shows that this neglected area is worth of researching and understanding as it is not a trivial problem. The dependency researched in this paper could also be further analysed, for example inclusion of the learning curve of each team could be an important and promising approach. Modelling several dependencies simultaneously is also an interesting direction of research.

In this paper triangular fuzzy numbers were employed. There are however many other types of fuzzy numbers that can be explored in the context of such models. It is important to consider that in some cases other types of fuzzy numbers may better reflect the current state of knowledge and subjective information about the project. Moreover, the approach to calculating fuzzy model was simplified, to be more accessible for PMs. Other, more sophisticated methods can be used in the future to improve the quality of the proposed mathematical models.

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Appendix

The final form of the Model 2 is as follows:

$$\text{Objective function:} \quad \min z = \tilde{x}_N, N \in \mathbb{N} \quad (10)$$

Subject to:

$$\tilde{x}_j \geq \tilde{x}_i + f\left(\tilde{t}_{ij}, \frac{1}{\tilde{q}_k(CP_m)}\right), \quad (11)$$

for $k = 1, \dots, K$ s. t. $A_{ij} \in \mathcal{R}_k, i, j \in N, k = 1, \dots, K, m = 1, \dots, M,$

$$\tilde{x}_j \geq \tilde{x}_i + f\left(\tilde{t}_{ij}, \frac{1}{\tilde{q}_k}\right), \quad (12)$$

for $k = 1, \dots, K$ s. t. $A_{ij} \in \mathcal{A}_k \wedge \mathcal{C}_k(CP_m) = \emptyset, i, j \in N,$

$$\tilde{x}_i, \tilde{x}_j \geq 0,$$

where $i, j \in \mathbb{N}$.

Together with the information about completed tasks a new element of the model comes into play. Because some of the tasks that the teams are working on can be completed before the control point CP_m and their real durations will be known, the set of activities of each team \mathcal{A}_k needs to be divided into two further subsets:

- $\mathcal{C}_k(CP_m) \subset \mathcal{A}_k$ – set of completed tasks of the team,
- $\mathcal{R}_k \subset \mathcal{A}_k$ – set of remaining tasks of the team k ,
- The remaining tasks include those in process, thus we have $\mathcal{C}_k \cup \mathcal{R}_k = \mathcal{A}_k$.

The set of completed tasks will no longer be subject to decision making; their actual durations are already known, therefore, they can be treated as constant and not variables.

WOMEN'S EMOTIONS AND FOOD CHOICES – A STUDY OF GDYNIA CITY RESIDENTS, POLAND

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Purpose: The main objective of the research was to assess the impact of emotions on women's eating behaviour and to determine whether women's eating behaviour under the influence of emotions is dependent on education, marital status and professional status.

Design/methodology/approach: The research instrument was a survey questionnaire administered through the computer-assisted web interviewing (CAWI) method using Google Forms. The survey was conducted in spring 2023 among a group of 393 female respondents in Gdynia (northern Poland). The interview questionnaire consisted of thematic blocks including scales concerning the assessment of: the influence of emotions (happiness and sadness) on women's eating behaviour. The chi-square test with Yates' correction and the Mann-Whitney U test were used to determine the relationship between the study variables.

Findings: It was found that the type of emotion influenced eating behaviour in the study group of women. The respondents consumed fruit and vegetables and dairy products when feeling positive emotions (happiness), and consumed sweets, salty snacks and alcohol when feeling negative emotions (sadness). The present study showed that the frequency of eating under the influence of emotion may depend on education, marital status and professional status.

Research limitations/implications: The research has certain limitations. The results obtained are not representative and cannot be generalised to the population of women in Poland. The research is a pilot study.

Practical implications: Knowledge in this area is valuable in developing nutrition education programmes. In order to improve women's health, interventions must focus on increasing their self-efficacy in consciously regulating their emotions and the type of food they consume in emotionally aroused states.

Social implications: The research is part of health risk management and health promotion in the Polish population.

Originality/value: The research adds to the knowledge of human behaviour in the nutritional sphere by taking into account psychological factors.

Keywords: emotional food consumption, happiness, sadness, eating habits, health-related quality of life, female consumers.

Category of the paper: Research paper.

1. Introduction

The importance of emotions in human nutrition

Emotions play a significant role in everyday human life, affecting how we feel and respond to different experiences (Adolphs, Mlodinow, Barrett, 2019; Dziewicki, 2018; Izard, 2009; Šimić et al. 2021). Human beings experience many different emotional states at every stage of their lives. However, we are often unable to name them and thus are unaware of their impact on our behaviour. In order to modify the emotions we feel, we generally attempt to regulate them, either automatically or intentionally, being at different levels of consciousness. However, it can be seen that each individual shows an individual approach to recognising his or her own emotional state. Conscious emotion regulation becomes a strategy to even out the emotional state, while at the same time the actions associated with it turn into a habit in the long term (Brytek-Matera, 2020).

Research by Bui et al. (2021) and Devonport, Nicholls and Fullerton (2019) showed that positive emotions can influence food consumption in the same way as negative emotions. Due to the variability of emotions, it is therefore difficult to predict how a particular emotion will affect the diet of a particular group of people. According to research, positive emotions increase the motivation to eat when they are felt, whereas when negative emotions are felt, the desire to eat decreases. When feeling positive emotions, people often give up self-imposed restrictions, such as restrictive diets, in order to maintain the effect of happiness and the emotional state felt (Brytek-Matera, 2020). Women experiencing positive emotions eat more compared to those in a neutral mood; moreover they increase their snack intake in response to positive emotions compared to negative ones (<https://www.wspolczesnadietetyka.pl>). Students also show more emotional eating behaviour compared to older people. Moreover, the literature reports that older people following a Mediterranean diet show more restrained, emotionless eating behaviour (Ferreira-Pêgo et al., 2020).

The effect of ‘comfort eating’ can often be encountered, where a person wants to induce a positive mood or maintain it. ‘Comfort eating’ in the context of feeling negative emotions more often applies to women who want to improve their mood, while men use this principle when they want to sustain positive emotions. When feeling positive emotions, people are more likely to reach for savoury and salty snacks, such as pizza. The opposite is true when feeling negative emotions. This is when sweets are consumed, being associated with childhood or good memories when cakes and ice cream were consumed (Brytek-Matera, 2020; Finch, Cummings, Tomiyama, 2019; McKay et al., 2021).

Eating is the most popular method of regulating emotions, primarily negative ones. Eating then acts as a mood regulator, a mood enhancer. Evidence indicates that emotional eating is mainly influenced by emotions related to depressive states, anxiety or anger. Not only negative emotions affect emotional eating, but also positive emotions. Episodes of

overeating are observed as a reaction to the food-related element of the environment. However, the strongest episodes occur when experiencing negative emotions such as stress, fear and depressive states (Różycka, 2020). The frequent occurrence of an emotional eating episode can cause negative effects on the human body. The foods consumed are often high in energy and low in nutritional value, such as chocolate, finger foods, crisps, snacks of other types, and fast food (Pano et al., 2022).

Stress and difficulties in coping with emotions, experiencing them and low levels of personal resources are important psychological factors contributing to the development of overweight. Uncontrolled eating, especially if it is compulsive in nature, is a risk factor for food addiction. People who react in this way may consume increasing amounts of their chosen food in the future to cope with a negative mood, and this can lead to emotional eating disorders. Emotional eating is a phenomenon in which a person is unable to distinguish between the basic feeling of hunger and the emotional arousal felt when experiencing negative emotions, which promotes food cravings in stressful situations (Paans et al., 2018; Różycka, 2020).

When emotional eating is not dealt with for a long time and the cause is not known and not worked on, it can develop into compulsive overeating. It is a mental illness that causes bouts of excessive eating. Compulsive overeating resembles bulimia, but is not accompanied by laxative treatments. Overeating is a reaction to sadness, fear, and anger, and is intended to fill a void (Pilska, Jeżewska-Zychowicz, 2008). Women are more likely than men to develop eating disorders (Su et al., 2016).

The consumption of foods high in total fats and sugars was justified during a stage of evolutionary environmental change when energy-rich foods were rare. Therefore, by nature, humans prefer high-calorie foods that are characterised by high palatability. Nowadays, the desire to consume fat- and sugar-rich food (when it has become generally available) is an important factor in the development of diet-related diseases affecting quality of life (Carfora, Catellani, 2020; Czepczor-Bernat, Brytek-Matera, 2020; Ljubičić et al., 2022). Emotional eating can lead to the development of obesity and consequent diseases such as insulin resistance, type 2 diabetes, hypercholesterolaemia, atherosclerosis, hypertension or ischaemic heart disease (Żak-Gołąb et al., 2012). The ability to regulate food consumption cravings is therefore important (Brytek-Matera, 2022).

Influence of emotions on nutrition

Emotions have a significant impact on the food choices people make. Specific emotions, such as anger, fear, sadness, and happiness, affect the quality and quantity of food consumed, as well as metabolism and digestion (Betancourt-Núñez et al., 2022; Jasielska, 2011; Lange, 2021; Match, 2008). Moreover, the emotions felt influence the food (taste) preferences that the organism is requesting at any given time.

Diet has a fundamental impact on the regulation of negative emotions, under the influence of which a person becomes more prone to emotional eating (Bárbara, Ferreira-Pêgo, 2020). López-Moreno et al. (2021) classified approximately 38.6% of university students in Madrid as very emotional eaters or emotional eaters, and 37.2% as low emotional eaters. They also observed a weak positive correlation between emotional eating and BMI in female students. Increasingly, it can be seen that when a person's mental state deteriorates, it is accompanied by a consistent pattern of eating excessive amounts of high-energy foods. This is associated with a misperception of the feeling of hunger, which in reality is just emotional arousal. There is a correlation between emotional feeding and alexithymia. Alexithymia is defined as 'an inability to understand, identify and name emotions, and its characteristic symptom is difficulty distinguishing between emotional and physiological arousal'. In the literature, an alternative relationship can be observed between the desire to cancel out negative emotions and the effect of eating on mood. The behaviour in question is seen as an escape from the discomfort caused by experiencing negative emotions. The premise of the behaviour captured is to block awareness by focusing on a nearby available stimulus from the environment. This results in a 'state of cognitive deconstruction' that disrupts spatio-temporal perception and analysis of the consequences of such behaviour (Żak-Gołąb et al., 2012).

There is also a mechanism responsible for consuming large amounts of foods rich in simple carbohydrates. The individual believes that it is due to the consumption of these foods that a surge of positive emotions occurs, which in the short term improves mood (Żak-Gołąb et al., 2012). Negative emotions prompt people to reach for sweet-tasting products to reduce the unpleasant state. When experiencing negative emotions and reaching for snacks, we do not control the amount of food we consume. Normal-weight individuals do not feel the need to eat large amounts of sugary snacks when experiencing negative emotions, in contrast to obese individuals. This is because the mechanism responsible for the release of serotonin in response to high-sugar foods does not work properly in overweight individuals (Czeczor, Brytek-Matera, 2017). When feeling sad, the brain demands more dopamine, the happiness hormone. Happiness is felt when we eat something sweet, so feelings of sadness can lead to increased cravings for sweet products to make us feel better, if only for a moment (Lange, 2021). Given that both positive and negative emotions influence the food choices made by different generations of consumers, an exploration in this area is warranted.

The aim of this study was to assess the impact of emotions on women's eating behaviour and to determine whether women's eating behaviour undertaken under the influence of emotions is dependent on education, marital status and professional status.

2. Research methodology

The empirical research was carried out using indirect survey measurement. The research tool was a survey questionnaire. The survey was conducted in indirect form using the CAWI method (Google Forms). The survey was conducted in spring 2023 among 393 female respondents in Gdynia, Pomeranian Voivodeship (Table 1). The snowball sampling technique was used to select female respondents for the study sample. The respondents gave informed and voluntary consent to participate in the study. They also confirmed that they were aware of the risk factors associated with interviewing using the CAWI method. The study group was dominated by female students (56.49%), single women (60.30%) with higher education (Bachelor's degree and above) (57.25%).

Table 1.
Study sample characteristics

Parameters	n	[%]
Marital status		
Single women	237	60.30
Women in a relationship	156	39.70
Occupational status		
Working	171	43.51
Studying	222	56.49
Education		
Secondary education	168	42.75
Higher education	225	57.25

Source: own elaboration based on survey results.

The interview questionnaire consisted of thematic blocks including scales on the assessment of: 1. the impact of emotions (happiness and sadness) on women's eating behaviour, 2. the impact of emotions (happiness and sadness) on the frequency of food intake.

Respondents answering the questions 'how would you describe your eating behaviour accompanying the emotion of feeling happiness?' and 'how would you describe your eating behaviour accompanying the emotion of feeling sad?' could indicate 1 of 6 answers: I eat what I usually eat, I eat what I like, I eat nothing, I eat more, I eat less and I do not pay attention to what I eat. With the intention of assessing the frequency of food intake when feeling extreme emotions such as happiness and sadness, 4 categories of food intake frequency were used, to which points were assigned: always (4 points), often/mostly (3 points), rarely (2 points), never (0 points). Based on the sum of the points, a division into 3 levels of food consumption was adopted. 1/3 and 2/3 of their point range (scale from 0 points to 4 points) was used as a criterion for division: low consumption level (<1/3 of the range: 0-1.32 points), moderate consumption level (1/3 to 2/3 of the range: 1.33-2.66 points), high consumption level (> 2/ range: 2.67-4 points).

A reliability test was carried out using Cronbach's alpha coefficient and the α value obtained was 0.902, indicating high reliability. The results were presented by means of the percentage distribution of the individual responses (% indicated). A chi-square test with Yates' correction was conducted to determine the relationship between marital status, occupational status and education and statements regarding the consumption of specific food groups in a state of happiness or sadness in the study groups. The Mann-Whitney U test was used to assess the effects of marital, occupational and educational status on the consumption of products for the emotional states of happiness and sadness. A significance level of $p < 0.05$ was assumed for all statistical analyses. Calculations were performed using Excel 2000 and Statistica 13.3 (Tibco Software, Palo Alto, USA).

3. Results and discussion

Emotions as a reaction to the cognitive evaluation of environmental stimuli are an integral part of human existence, behaviour and functioning (Adolphs et al., 2019; Šimić et al., 2021; Izard, 2009). As it turns out, emotions are also closely related to food choice and feeding rituals as a social activity, but they are also related to mood, which is stronger and lasts longer (Chávez-Servín et al., 2022). Previous research has confirmed the link between mood or emotional states and food choice and various eating disorders, as well as the perception that eating can be a way to fill the void that can arise from conditions such as loneliness, sadness, depression, social isolation and other emotional moods caused by stress, excitement and tension, conflicting social relationships, and other stressful life events (Devonport et al., 2019). It is important to note that women are more likely to develop eating disorders than men (Su et al., 2016). Tables 2 and 3 show the impact of emotions of happiness and sadness on women's eating behaviour. There was a significant difference in reported eating behaviour when experiencing happiness between those with different marital status and occupational status ($p < 0.01$). Single women (58.02%) ($\chi^2 = 11.13$; $df = 1$; $p < 0.01$) and female students (54.20%) ($\chi^2 = .14$; $df = 1$; $p < 0.01$) were significantly more likely than married or partnered persons (34.35%) and professionally active persons (38.17%) to state that they eat whatever they like when feeling happy (Table 2). In contrast, in the group in which education was the dividing criterion, significant differences were observed for the responses 'I eat nothing' ($\chi^2 = 4.65$; $df = 1$; $p = 0.03$) and 'I eat more' ($\chi^2=6.15$; $df=1$; $p=0.01$). Those with higher education, compared to those with secondary education, were significantly more likely to state that they both eat nothing in moments of happiness (8.40% and 3.05% respectively) and that they eat more (19.08 and 9.16% respectively) (Table 2).

Table 2.*Influence of emotion (happiness) on women's eating behaviour*

Statements	Marital status [%]		Occupational status [%]		Education [%]	
	Single women	Women in a relationship	Working	Studying	Secondary education	Higher education
I eat what I usually eat	53.44	34.35	37.40	50.38	38.17	49.62
I eat what I like	58.02	34.35	38.17	54.20	40.46	51.91
I don't eat anything	6.87	4.58	5.34	6.11	3.05	8.40
I eat more	15.27	12.98	12.08	16.07	9.16	19.08

Source: own elaboration based on survey results.

In contrast, when experiencing sadness, people with different marital status varied significantly for the response: 'I eat what I like' ($\chi^2 = 11.84$; $df = 1$; $p < 0.01$) (Table 3). Single women (41.98%) were significantly more likely than married or partnered women (20.61%) to state that, when feeling sad, they chose to consume those foods that they liked. In contrast, in the group in which occupational status was the dividing criterion, a significant difference was observed for the response: 'I do not pay attention to what I eat' ($\chi^2 = 6.89$; $df = 1$; $p = 0.01$). Those who were studying were significantly more likely than those who were professionally active to state that sadness did not influence their food choices (33.59 19.85% respectively) (Table 3).

Table 3.*Influence of emotion (sadness) on women's eating behaviour*

Statements	Marital status [%]		Occupational status [%]		Education [%]	
	Single women	Women in a relationship	Working	Studying	Secondary education	Higher education
I eat what I usually eat	23.66	19.85	20.61	22.90	17.56	25.95
I eat what I like	41.98	20.61	26.72	35.88	27.48	35.11
I don't eat anything	27.48	15.27	16.03	26.72	18.32	24.43
I eat more	23.66	18.32	16.79	25.19	17.56	24.43
I don't pay attention to what I eat	31.30	22.14	19.85	33.59	22.90	30.53

Source: own elaboration based on survey results.

The relationships between emotional reasons or states such as mood, loneliness, boredom or mood enhancement as reasons for food consumption, and predictors of food intake, such as age, gender, marital status, occupation or physical activity, among others, confirm the complexity of factors influencing eating behaviour (Guiné et al., 2020; Ljubičić et al., 2022; Ljubičić et al., 2023). Levine (2013) in his study confirmed the link between loneliness and eating disorders. St John et al. (2021) found that for women, place of residence is a factor in loneliness or social isolation. Emotions, especially those caused by stress, can contribute to apathy, social isolation, fatigue or less physical activity. Stress activates 'reward pathways' in

the brain and increases appetite for palatable foods. This combination of neuronal adaptations often leads to an increase in the consumption of palatable foods, such as foods high in fat and/or sugar (Klatzkin, Nolan, Kissileff, 2022). Additionally, loss of appetite is also a typical adaptive response to negative emotions (van Strien et al., 2019). Stress can particularly affect appetite through hormonal regulation. For example, in acute stress, norepinephrine inhibits appetite, whereas in chronic stress, cortisol stimulates appetite (Torres, Nowson, 2007). Ljubičić et al. (2023) observed in their study that stress contributed to increased consumption of energy-dense foods.

When analysing the frequency of consumption of selected products during feelings of happiness, significant differences were observed for most products in the group of respondents taking into account the division by marital status and occupational status (Table 4). When analysing bread and cereal and flour products, the answer 'mostly' prevailed in all the groups studied. Singles were significantly more likely to choose this answer than couples and those with higher than secondary education (24.43 and 19.08% each, respectively), and those studying were significantly more likely to choose this answer than those who were economically active (25.19 and 18.32%, respectively). In the case of milk and milk products, as well as yellow and blue cheese, the most frequent answer given regarding consumption in a state of enjoyment was also 'mostly'. It was significantly more often indicated by singles than by those in relationships (30.53 and 16.79% and 28.24 and 13.74% respectively), by those in education than by those in employment (28.24 and 19.08% and 25.19 and 16.79% respectively), and by those with higher than secondary education (25.19 and 22.14% and 25.19 and 16.79% respectively). When reporting the consumption of fast food in all groups, the predominant response of frequency of consumption was 'rarely'. This response was indicated significantly more often by singles than by those in relationships (29.01 and 19.08% respectively), by those in education than by those in employment (31.30 and 16.79% respectively), and by those with secondary education compared to those with higher education (25.19 and 22.90% respectively). For the frequency of nut and seed consumption, considering the marital status of women, the predominant response was 'mostly'. Single women (20.61%) were significantly more likely to indicate this answer than those in a relationship (18.31%). On the other hand, in terms of occupational status, the answer 'rarely' predominated. Those who were studying, compared to those who were working, were significantly more likely to indicate it (20.61 and 9.92% respectively). For dried fruit, the predominant response indicated that it was rarely consumed in states of enjoyment. Single women and people in education were significantly more likely to report infrequent consumption of dried fruit than people in relationships and those in employment (25.19 and 23.66% and 15.27 and 16.79% respectively). In the case of consumption of chocolate and chocolate products, significant differences were observed only in the group divided by education. The most frequently indicated answer for frequency of consumption was 'mostly' and it was those with higher education, compared to those with secondary education, who indicated it significantly more often (22.14 and 19.08% respectively).

Table 4.
Feeling of happiness and frequency of food consumption

Statements	Marital status			Occupational status			Education			Mean score (rank) ±SD
	Chi2	df	p*	Chi2	df	p	Chi2	df	p	
Bread, cereal and cereal preparations	9.45	3	0.02	8.33	3	0.04	9.09	3	0.03	2.43±1.18
Milk and milk products	15.75	3	<0.01	11.99	3	0.01	12.15	3	0.01	2.44±1.12
Yellow cheese. Blue cheese	16.47	3	<0.01	20.26	3	<0.01	16.51	3	<0.01	2.37±1.19
Meat, sausages, cold cuts	6.96	3	0.07	12.22	3	0.01	5.92	3	0.12	2.24±1.28
Fast food. e.g. pizza, hot dogs, hamburger	14.39	3	<0.01	37.72	3	<0.01	17.08	3	<0.01	2.32±1.14
Salty snacks, e.g. chips, finger foods	5.20	3	0.16	9.89	3	0.02	5.93	3	0.12	2.49±1.01
Vegetables and fruit	12.43	3	0.01	6.33	3	0.09	0.49	3	0.92	3.04±0.89
Nuts, seeds, e.g. sunflower, pumpkin, etc.	9.25	3	0.03	11.97	3	0.01	2.24	3	0.52	2.51±1.16
Dried fruit	57.45	3	<0.01	28.76	3	<0.01	4.43	3	0.22	1.82±1.28
Fruit and vegetable juices	6.91	3	0.08	5.27	3	0.15	4.82	3	0.19	2.53±1.17
Sweetened fizzy drinks	5.50	3	0.14	4.72	3	0.19	1.68	3	0.64	1.93±1.41
Sweets, e.g. cakes, biscuits, bars, sweets	6.43	3	0.09	1.86	3	0.61	4.22	3	0.24	2.61±1.14
Chocolate and chocolate products	0.94	3	0.82	3.17	3	0.37	12.21	3	0.01	2.70±1.14
Ice cream	2.07	3	0.56	2.38	3	0.49	4.09	3	0.25	2.49±1.14

Source: own elaboration based on survey results.

When analysing the frequency of consumption of the same food items in the state of feeling sadness as reported by the female respondents, it can be observed that a higher mean value for the consumption of selected products was observed only for the consumption of sweet fizzy drinks, sweets, chocolate and chocolate products and ice cream (Tables 4 and 5). In contrast to the frequency of consumption of products during feelings of happiness, for sadness, significant differences were observed in the frequency of consumption of most of the analysed product groups (Table 5). The frequency of consumption of bread and processed cereals and fast food was dominated by the two responses 'rarely' and 'mostly'. Single women were significantly more likely to indicate that they rarely and mostly reach for bread and cereal products when feeling sad (21.37 and 12.98% and 19.85 and 11.45%, respectively), compared to women in relationships. The economically active compared to the learners for this group of products reported that they consumed them significantly less often (17.56 and 15.79% respectively). In contrast, students were significantly more likely to state that they usually eat bread and cereal products when feeling sad (17.56 and 13.74% respectively). Those with a higher education were significantly more likely to respond 'rarely' (19.85 and 14.50 % respectively) and 'mostly' (19.08 and 12.21 % respectively) compared to those with a secondary education. Single women were significantly more likely than those in relationships to report that when feeling sad, they usually reach for fast food (21.37 and 10.69% respectively). In contrast, women in relationships

consumed them significantly less often (16.03 and 12.21% respectively). Students were significantly more likely to indicate the frequency of fast food consumption by choosing the answer 'usually' (21.37 and 10.69% respectively), while economically active persons were significantly more likely to indicate the answer 'rarely' (15.27 and 12.98% respectively). Those with higher education were significantly more likely than those with secondary education to indicate that they consumed fast food infrequently (17.56 and 10.69% respectively). On the other hand, for the answer 'mostly', these people (in the question concerning the frequency of fast food consumption) did not differ significantly (16.03% each). For milk and milk products, yellow and blue cheeses, meat and meat products, vegetables and fruit, nuts and seeds, dried fruit and fruit and vegetable juices, the predominant responses regarding the frequency of their consumption when feeling sad were 'rarely' and 'never'. Salty snacks were significantly more frequently 'mostly' and 'always' consumed by single women, compared to women in relationships (24.43 and 9.92% and 16.79 and 9.16% respectively). For products that are a rich source of sugar, such as sweets and chocolate and chocolate confectionery, the predominant answers in all the groups analysed were 'mostly' and 'always', indicating the frequency of their consumption. Single women were significantly more likely to say they consumed sweets (23.66 and 12.98% for 'mostly' and 21.37 and 10.69% for 'always', respectively) and chocolate and chocolate confectionery (24.43 and 11.45% for 'mostly' and 19.85 and 12.98% for 'always', respectively) compared to women in relationships. Students were significantly more likely than the economically active to report consumption of sweets (25.95 and 10.69% respectively for the response 'mostly' and 16.79 and 14.27% respectively for the response 'always') and chocolate and chocolate products (25.95 and 9.92% respectively for the response 'mostly' and 16.85 and 15.38% respectively for the response 'always'). In contrast, people with a secondary education were significantly more likely to state that they 'usually' eat sweets and chocolate and chocolate products when feeling sad, compared to people with a higher education (20.61 and 16.03% and 19.08 and 16.79% respectively). In addition, those with a higher education were significantly more likely to state that they 'always' eat sweets and chocolate and chocolate products when feeling sad (19.85 and 12.21% and 20.61 and 12.21% respectively). Ice cream, when feeling sad, is significantly more often consumed by students, compared to the economically active (18.32 and 10.69% respectively for the answer 'usually' and 14.50 and 11.45% respectively for the answer 'always'). In contrast, an interesting situation was observed in the breakdown by education. Women with a higher education most often chose two opposite statements. Compared to those with a secondary education, they were significantly more likely to answer 'rarely' (21.37 and 12.21% respectively) and at the same time significantly more likely to answer 'always' (16.79 and 9.16% respectively), while no significant differences were observed for the answer 'mostly' (14.50% each).

Table 5.
Feeling of sadness and frequency of food consumption

Statements	Marital status			Occupational status			Education			Mean score (rank) \pm SD
	Chi2	df	p*	Chi2	df	p	Chi2	df	p	
Bread, cereal and cereal preparations	12.16	3	0.01	22.41	3	<0.01	14.80	3	<0.01	2.18 \pm 1.28
Milk and milk products	8.48	3	0.04	25.26	3	<0.01	9.20	3	0.03	2.00 \pm 1.21
Yellow cheese. Blue cheese	28.22	3	<0.01	26.57	3	<0.01	14.65	3	<0.01	1.88 \pm 1.33
Meat, sausages, cold cuts	28.69	3	<0.01	36.64	3	<0.01	35.69	3	<0.01	1.91 \pm 1.35
Fast food. e.g. pizza, hot dogs, hamburger	18.63	3	<0.01	10.80	3	0.01	4.61	3	0.20	2.53 \pm 1.28
Salty snacks, e.g. chips, finger foods	19.10	3	<0.01	4.71	3	0.19	7.04	3	0.07	2.65 \pm 1.18
Vegetables and fruit	20.02	3	<0.01	28.44	3	<0.01	9.22	3	0.03	1.15 \pm 1.18
Nuts, seeds, e.g. sunflower, pumpkin, etc.	5.41	3	0.14	19.37	3	<0.01	9.56	3	0.02	1.89 \pm 1.22
Dried fruit	23.99	3	<0.01	26.46	3	<0.01	6.26	3	0.10	1.68 \pm 1.37
Fruit and vegetable juices	14.61	3	<0.01	16.99	3	<0.01	4.85	3	0.18	2.13 \pm 1.25
Sweetened fizzy drinks	4.73	3	0.19	2.46	3	0.48	4.96	3	0.17	2.18 \pm 1.43
Sweets, e.g. cakes, biscuits, bars, sweets	26.23	3	<0.01	32.32	3	<0.01	19.25	3	<0.01	2.85 \pm 1.08
Chocolate and chocolate products	18.08	3	<0.01	29.06	3	<0.01	9.94	3	0.02	2.87 \pm 1.08
Ice cream	5.82	3	0.12	14.05	3	<0.01	12.41	3	0.01	2.58 \pm 1.21

Source: own elaboration based on survey results.

Eating under the influence of emotion is an important part of perpetuating poor eating behaviour. The strongest motivation to eat occurs when experiencing negative emotions (Devonport et al., 2019). Under the influence of anger, women are able to eat more than when feeling sadness or fear, in order to reduce uncomfortable sensations. Emotions of high intensity trigger the consumption of less food, while slight intensity of feeling depressed or bored stimulates reaching for larger amounts of food. The desire to consume more food is found in both people with eating disorders or obesity and healthy individuals (Kontinen, 2020; McKay et al., 2021; Macht, 2008). Eating restrictions result in frequent overeating as a reaction to depressed mood. In order to temporarily mask negative emotions, people often reach for their favourite foods to improve their mood (Finch, Cummings, Tomiyama, 2019). When negative emotions are experienced, the consumption of foods high in sugars and perceived to be palatable helps to reduce the emotions felt (e.g. stress), especially by those characterised by an emotional eating style. One of the most popular and best-associated foods consumed to regulate emotions is chocolate. For normal-weight individuals, eating chocolate reduces the time to experience negative emotions to 3 minutes (Szczygieł, Kadzikowska-Wrzosek, 2014). Standen et al. (2022) suggested that high fat or sugar content is not necessary for food to be pleasurable and protective against stress. Although it is assumed that food intake is abundant in these states, especially foods rich in energy, fat and sugar, it is worth asking whether all food consumed in the states mentioned is unhealthy. For example, fruits and vegetables, including dried ones, also contain significant amounts of sugar and thus, in addition to relieving stress, may have positive effects due to their

content of dietary fibre and other antioxidant substances and may have a strong preventive effect (Pano et al., 2022).

After dividing the female respondents into groups of low, medium and high consumption of products when feeling emotions such as happiness and sadness, it was observed that in the group in which marital status was the criterion for dividing women, single women reported moderate consumption of the food groups indicated in the survey questionnaire. Among women who were in relationships, those who had a high intake of food groups when feeling happiness and a moderate intake when feeling sad predominated (Table 6). The group of female respondents, divided by occupational status and education, was dominated by those with moderate food intake when feeling emotions such as happiness and sadness (Table 6). Based on the results obtained from the Mann-Whitney U test, no significant differences were observed for the level of food intake accompanying feelings of happiness due to education and accompanying feelings of sadness due to the marital status of the respondents (Table 7).

Table 6.

Level of food intake when feeling emotions: happiness and sadness

Dividing criteria	Level of intake	[%] women for level of intake for emotion happiness	[%] women for level of intake for emotion sadness
Single women	Low	3.80	18.99
	Moderate	70.89	53.16
	High	25.31	27.85
Women in a relationship	Low	9.62	11.54
	Moderate	42.31	59.61
	High	48.07	28.85
Professionally active	Low	8.77	8.78
	Moderate	47.37	57.89
	High	43.86	33.33
Studying	Low	4.05	21.62
	Moderate	68.92	54.05
	High	27.03	24.33
Secondary education	Low	3.57	21.43
	Moderate	69.64	57.14
	High	26.79	21.43
With higher education	Low	8.00	12.00
	Moderate	52.00	54.67
	High	40.00	33.33

Source: own elaboration based on survey results.

Table 7.

Influence of marital status, professional activity and education on the level of food intake when experiencing emotions: happiness and sadness

	Level of intake for emotion happiness		Level of intake for emotion sadness	
Single women	33976.50 ¹	15241.50 ³ ; 2.944 ⁴ ; 0.003 ⁵	45546.00	17343.00; 1.037; 0.299
Women in a relationship	43444.50 ²		31875.00	
Professionally active	36099.00	16956.00; 2.160; 0.030	36873.00	15795.00; 2.853; 0.004
Studying	41322.00		40548.00	
Secondary education	31300.50	17104.50; 1.611; 0.107	29928.00	15732.00; 2.843; 0.004
With higher education	46120.50		47493.00	

Explanatory notes: Mann-Whitney U-test; ^{1,2} sum of the ranks; ³ U; ⁴ Z; ⁵ p.

Source: own elaboration based on survey results.

4. Conclusions and future perspectives

Please put here the acknowledgements for private individuals or institutions that contributed significantly to the publication, as well as information about the projects, in which the article was created. This section is optional and can be omitted by the author

Emotions are a normal human experience and everyone can learn to manage them. Emotions affect consumers' food preferences at a given time, and when replicated over the long term, they develop into a habit. The present study showed that the type of emotion had an impact on eating behaviour in the group of women studied. Respondents consumed fruits and vegetables and dairy products when feeling positive emotions (happiness), and consumed sweets, salty snacks and alcohol when feeling negative emotions (sadness). When feeling extreme emotions (happiness and sadness), the surveyed group of women, regardless of marital status, occupational activity and education level, when feeling happiness preferred healthy snacks in the form of fruits and vegetables, and when feeling sadness consumed snacks containing a significant amount of added sugars: candy, ice cream, chocolate and chocolate products. Our study showed that the frequency of food consumption under the influence of emotion may depend on education, marital status and professional status. In addition, it was found that women who were in relationships and women with a higher education status consumed foods at high and then moderate levels when feeling happiness and sadness. Cereal products and sweets dominated among the foods consumed. Single women, regardless of the emotions felt (happiness and sadness), consumed food at a low level, followed by moderate levels.

In addition to physiological, economic and socio-cultural factors, psychological factors also have an important influence on the formation of eating behaviour. The conducted research adds to the knowledge of human eating behaviour by taking into account psychological factors. The phenomenon of uncontrolled/emotional consumption of food can turn into compulsive eating, and this in turn can lead to food addiction and directly affect the development of metabolic diseases of nutritional origin: overweight, obesity, insulin resistance, type 2 diabetes, hypercholesterolaemia, atherosclerosis, hypertension or ischaemic heart disease. Long-term exposure to stress factors can affect not only growth, but also inhibition of appetite, which also leads to eating disorders.

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THE IMPACT OF MACROECONOMIC STABILISATION ON THE DEVELOPMENT OF NON-LIFE INSURANCE MARKETS OF THE VISEGRAD GROUP IN 2004-2020

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Purpose: The article's purpose is to present the impact of macroeconomic stabilisation on the development of the non-life insurance markets of the Visegrad Group¹ between 2004 and 2020.

Design/methodology/approach: A critical review of literature is undertaken. The research used the Zeroed Unitarisation Method, the Macroeconomic Stabilisation Pentagon Model and the Reciprocal Correlogram.

Findings: The studies carried out indicate that insurance markets are influenced by a number of factors, which are both macroeconomic in nature and individual characteristics of the market in question (size and structure). The highest value of the synthetic indicator of the development of the non-life insurance market in the last period included in the analysis (2020) was recorded in Poland. The most favorable situation in terms of macroeconomic stabilisation was recorded in the case of Poland (0.518) at the end of the analyzed period.

Research limitations/implications: To verify the hypothesis regarding the impact of macroeconomic stabilisation on the development of insurance markets, scientific research requires further research on another group of countries (insurance markets).

Originality/value: The results of the research will contribute significantly to the development of theories on the determinants of the development of insurance markets.

Keywords: development, non-life insurance market, macroeconomic stabilisation, Visegrad Group (V4).

Category of the paper: Research paper.

¹ Hereinafter also as V4.

1. Introduction

Macroeconomic stabilisation issues are very important from the point of view of a permanently changing environment. In today's economic reality, stability is a very important aspect of the functioning of economies. Therefore, the primary objectives of global economies include maintaining macroeconomic stability. Maintaining macroeconomic balance is characterised by responsibility to stabilise the country internally, but also externally, which is determined by the international situation. The matter of macroeconomic stability refers to such values as economic growth, price level, unemployment rate and balance of payments balance. The possibility of crises is one of the main consequences of macroeconomic instability. Contemporary institutional connections mean that entities operating in a given environment are exposed to the possibility of danger and risk. The appropriate level of financial development of an economy is the basis for the growth of the real sphere. As M. Lament and S. Bukowski (Lament, Bukowski, 2022) point out, insurance companies and banks are the main pillars of entities belonging to the financial market. By providing insurance protection, insurance companies influence the stabilisation of the entity architecture of a given economy. The development of insurance markets is therefore an important issue from the point of view of a country's socio-economic development. The development of insurance markets is influenced by a variety of factors of an economic, demographic, social, cultural or structural character.

The aim of the research carried out was to identify the relationship between macroeconomic stabilisation and the development of the Visegrad Group's non-life insurance markets between 2004 and 2020. The study presents a critical review of the literature analysis on the subject and creates a synthetic indicator on the development of the non-life insurance market. This required us to find answers to the following research questions:

- Which V4 country has the most developed non-life insurance market?
- Which V4 country is characterized by the highest macroeconomic stabilisation?
- How does macroeconomic stabilisation affect the non-life insurance markets of the V4 countries?

The research used the Zeroed Unitarisation Method, the Macroeconomic Stabilisation Pentagon Model and the Reciprocal Correlogram. The article uses data from the following databases Insurance Europe and OECD Statistics. The paper is divided into three parts. The first presents the results of a literature review on the determinants of insurance market development. The second part presents the methodology of the study, while the third part presents the results of our own research.

2. Determinants of the development of insurance markets – literature review

The subject of the factors shaping the development of insurance markets is an important issue that is being analysed by many researchers from the academic world. There are numerous reasons for the relevance of this topic. First and foremost, insurance companies and banks are the backbone of the financial market (in relation to the number of institutions and the level of assets). In addition, insurance companies have a significant share of GDP, exceeding 10% in countries with a high level of economic development (Bukowski, Lament, 2020). Research conducted in the literature on the subject indicates that the development of insurance markets influences the economic growth and development of a given country. In a changing environment, the tremendous impact of insurance in suppressing unforeseen events that slow down a country's economic development becomes visible. The constant changes in the world, which affect the development and role of technology in the economy, mean that the insurance sector and its entities must seek new solutions adapted to the requirements of the environment. A constant analysis of the environment is therefore an important condition for the stability of a company (Śliwiński, 2016).

The development of insurance markets in individual countries is influenced by many factors. In the literature on the subject, the most frequently mentioned categories of determinants influencing the insurance market include: economic (e.g. GDP, inflation, unemployment rate, interest rates), demographic (e.g. age structure, gender, population size), social and cultural (e.g. education, religion, risk aversion) and structural (e.g. financial development, legal system, political risk). This is confirmed by studies by T. Beck and I. Webb (2003), T.H. Bednarczyk (2011), S. Sen, S. Madheswaran (2013), M. Curak, I. Dzaja, S. Pepur (2013), J. Phutkaradze (2014), M. Ertl, (2017), T.H. Bednarczyk, K. Bielawska, B. Jackowska, E. Wycinka (2020), K. Ortyński and J. Wołoszyn (2021), M. Lament and S. Bukowski (2022), M.P. Segodi, A.B. Sibindi. The determinants influencing the insurance market can be both negative and positive, which is confirmed in the literature by the studies presented in Table 1. Contemporary factors are influencing the booming insurance market. The insurance sector is characterised by a high potential, which is significantly influenced by technological and socio-economic development making insurance companies more attractive. M. Balcerowicz-Szkutnik and W. Szkutnik argue that the development of the world economy is determined by increasing economic integration. The integration processes, in a broad sense, refer to all aspects of economic life that lead to the integration of economic entities and the creation of uniform business conditions and normative acts. These developments affect all segments of the financial sector, including the insurance market. Internal insurance markets operate according to a specific model, which is determined by the level of economic development and a given organisation.

Table 1.
Factors influencing the development of life and non-life insurance

Type of factors	Estimated effect	Author										Brokesova et al. (2014)	Results			
		Browne, Kim (1933)	Outreville (1996)	Beck, Webb (2003)	Li et al. (2007)	Fayen et al. (2011)	Christophersen, Jakubik (2014)	Alhassan, Biekpe (2016)	Fayen et al. (2011)	Christophersen, Jakubik (2014)	Brokesova et al. (2014)					
Economic	Income (GDP)	+	+	+	+	+	+	+	+	+	+	-	+	+	+	
	Inflation rate	-	-	-	-	+	-	-	-	-	-	-	-	+	NS	NS
	Interest rate		NS	+	-									+	+	+
Demographic	Life expectancy	NS	+	NS	-	-	-	-	-	-	-	-	-	-	-	+
	Age dependency ratio	+	NS	MIXED	NS	MIXED	NS	MIXED				-				-
	Population size								+				MIXED			+
Social and	Education	NS	NS	NS	+	NS	+	NS	NS	NS		MIXED		+		
	Religion	-	NS	-		-		-	-	-				-		
	Social security		NS	NS	-	-	-	-	-	-				-		NS
Structural	Financial development		+	+	+							+				
	Legal environment			+					+			MIXED		+		
	Market concentration		-						+					-		-

Source: own analysis based on Hodula, Janků, Částa, Kučera, 2023.

Gross premiums written and growth rate, insurance density ratio and insurance penetration rate are the most commonly used measures of the importance of insurance development. Confirmation studies have been carried out by, among others: N.S. Erbas, C.L. Sayers (2006), Li and others (2007), T.P. Kramaric, F. Galetic (2013), Sajid Mohy Ul Din and others (2017), S.I. Bukowski, M. Lament (2019). Insurance density ratios illustrate the ratio of premiums to the population of a given country. As T.H. Bednarczyk points out, the most appropriate comparative indicators of the development of insurance markets in different countries include density and insurance penetration ratios. The density ratio shows the actual level of insurance market growth, while the penetration ratio shows the importance of the insurance market in a given economy.

3. Research methodology

The research constructed synthetic indicators of the development of non-life insurance markets in the V4 countries. For this purpose, the Zeroed Unitarization Method was used. It was decided to examine the created indicators in comparison with an important economic category, which is macroeconomic stabilisation. The analysis of macroeconomic stabilisation was carried out using the Macroeconomic Stabilisation Pentagon Model (PSM). The relations between the development of the non-life insurance market and the macroeconomic stabilisation of a given V4 country were examined using a mutual correlogram. The sequence of procedures is presented in Figure 1.

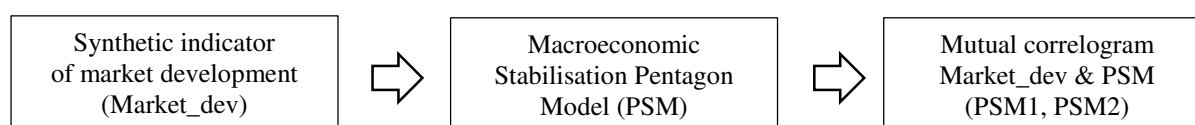


Figure 1. Sequence of research.

Source: Own study.

The development process of the insurance market is a phenomenon determined by many different variables. Adopting only one of them to represent this phenomenon may be a significant simplification and make its comprehensive analysis impossible. Therefore, it was decided to build a synthetic indicator of the development of the Polish non-life insurance market, consisting of the most important values most often used in the literature to describe this issue, i.e. the value of gross written premium, density index, penetration index and the number of insurance companies. The Zeroed Unitarization Method was used for this purpose. The operation diagram is shown in Figure 2.

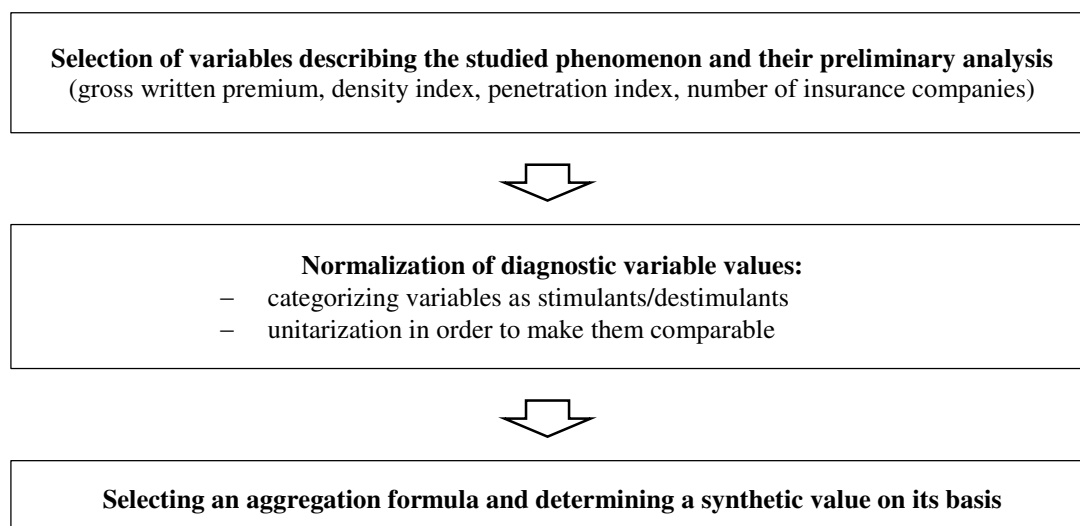


Figure 2. The process of creating a synthetic indicator of the development of the non-life insurance market - Zeroed Unitarization Method.

Source: Own study.

Then, the Pentagon Macroeconomic Stabilisation Model (PSM) was constructed. As part of the selected method, observations were made of basic economic values changing over time, such as (Misala, 2011; Siek, 2015):

- gross domestic product growth rate (Δ GDP),
- registered unemployment rate (U),
- inflation rate (CPI),
- ratio of the state budget balance to GDP (G),
- ratio of current account balance to GDP (CA).

The higher the PSM value, the more favorable the situation in terms of macroeconomic stabilisation. In the optimal case, this value is 1. PSM is the sum of the values of the areas of the five triangles. These include triangle "a" (the real sphere triangle), triangle "b" (the stagflation triangle), triangle "c" (the budget and inflation triangle), triangle "d" (the financial balance triangle) and triangle "e" (the triangle external sector) (Rojek, 2022). This division is presented in Figure 3.

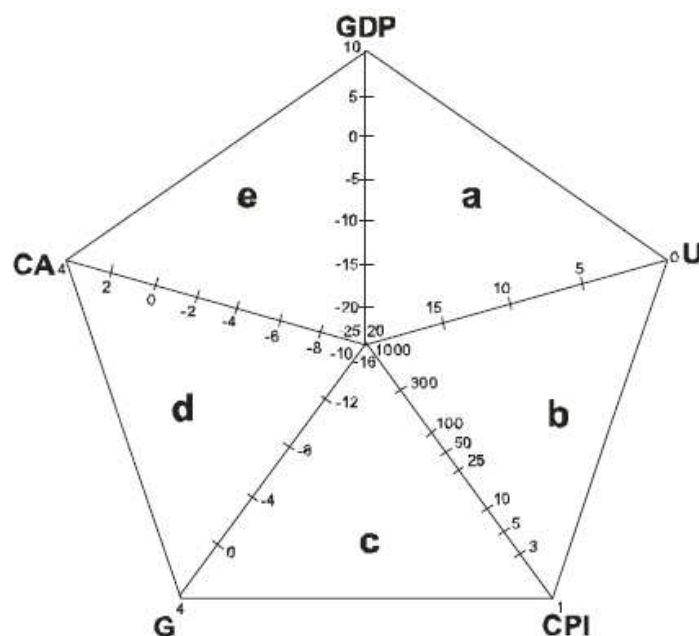


Figure 3. The Pentagon Macroeconomic Stabilisation Model.

Source: Siek, 2015.

The Pentagon Macroeconomic Stabilisation Model also allows for the separation of macroeconomic stabilisation indicators that depend primarily on internal and external factors. In the first case, it is PSM1 consisting of triangles a, b and c. In the second case, PSM2 is the sum of triangles d and e (Rojek, 2022).

The relations between the development of the non-life insurance market and the macroeconomic stabilisation of a given V4 country were examined using a mutual correlogram - i.e. a function of the value of the Pearson correlation coefficient of two time series shifted by Δt relative to each other depending on the value of Δt .

4. Findings

For the vast majority of the period under study, the Czech Republic was the leader in terms of the level of development of the insurance market (measured by a constructed synthetic indicator). Only since 2016 has the Polish market gained an advantage. However, a year after achieving the leadership position, there was a downward trend. In 2020, the difference between both markets was insignificant. Moreover, taking into account the emerging trends, it can be assumed that the Czech Republic will return to first place. The third market of the Visegrad Group is Hungary. Slovakia came in last place. The positions of these countries remained unchanged throughout the period under study. The development of the discussed phenomenon is shown in Figure 4.

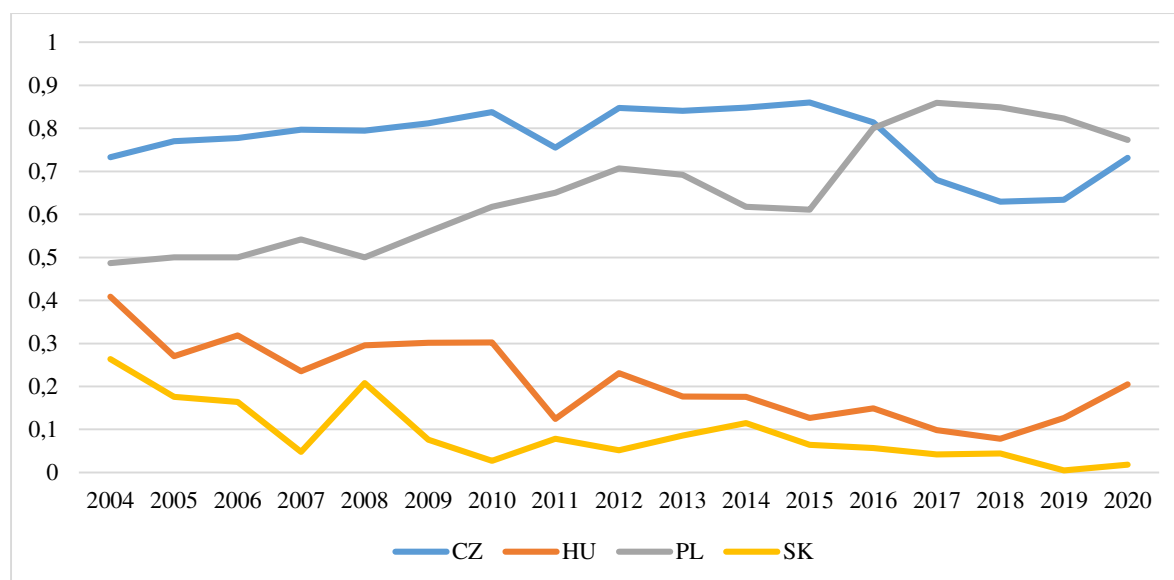


Figure 4. Synthetic indicator of the development of the non-life insurance market of V4 countries.

Source: Own study.

The largest increase in the synthetic indicator occurred in Poland. This applies to both the total increase (since the beginning of the analyzed period) and the average annual growth rate. On this basis, it can be concluded that the Polish non-life insurance market has developed the most intensively among the V4 countries. Detailed data in this regard are presented in Table 1.

Table 2.

Classification of V4 countries in terms of the pace of development of the non-life insurance market

Criterion	Average annual growth rate [%]	Total growth in 2004-2020 [%]
Synthetic indicator of market development	1. Poland 2. Czech Republic 3. Hungary 4. Slovakia	1. Poland 2. Czech Republic 3. Hungary 4. Slovakia
Gross written premium	1. Czech Republic 2. Poland 3. Slovakia 4. Hungary	1. Poland 2. Czech Republic 3. Slovakia 4. Hungary
Density index	1. Czech Republic 2. Poland 3. Slovakia 4. Hungary	1. Poland 2. Czech Republic 3. Slovakia 4. Hungary
Penetration rate	1. Czech Republic 2. Hungary 3. Poland, Slovakia	1. Poland 2. Hungary 3. Czech Republic 4. Slovakia
Number of enterprises	1. Slovakia 2. Czech Republic 3. Poland 4. Hungary	1. Slovakia 2. Czech Republic 3. Poland 4. Hungary

Source: Own study.

Discussing the components of the synthetic indicator of the development of insurance markets in individual V4 countries, it can be concluded that Poland is the leader in the case of gross written premium. This applies to both the last year and the entire period. An assessment of market development based on the density index would place the Czech Republic in first place (both time perspectives). The Czech Republic was also a leader in terms of penetration rate. In turn, the Polish market has an advantage in terms of the number of insurance companies. Table 2 presents the classification of the V4 countries in this respect.

Table 3.

Classification of V4 countries in terms of the development of the non-life insurance market

Criterion	Classification 2004-2020	Classification 2020
Synthetic indicator of market development	1. Czech Republic 2. Poland 3. Hungary Slovakia	1. Poland 2. Czech Republic 3. Hungary Slovakia
Gross written premium	1. Poland 2. Czech Republic 3. Hungary Slovakia	1. Poland 2. Czech Republic 3. Hungary Slovakia
Density index	1. Czech Republic 2. Slovakia 3. Poland Hungary	1. Czech Republic 2. Poland 3. Slovakia Hungary
Penetration rate	1. Czech Republic 2. Poland 3. Hungary Slovakia	1. Czech Republic 2. Poland 3. Hungary Slovakia
Number of enterprises	1. Poland 2. Czech Republic 3. Hungary Slovakia	1. Poland 2. Czech Republic 3. Hungary Slovakia

Source: Own study.

Based on the value of the Macroeconomic Stabilisation Pentagon, it can be concluded that the most favorable situation in this respect was in the case of Poland (0.518) at the end of the analyzed period. A slightly lower PSM value was recorded in our southern neighbor - the Czech Republic (0.511). The next places were taken by Slovakia (0.473) and Hungary (0.420). The development of PSM in the analyzed period is shown in Figure 5.

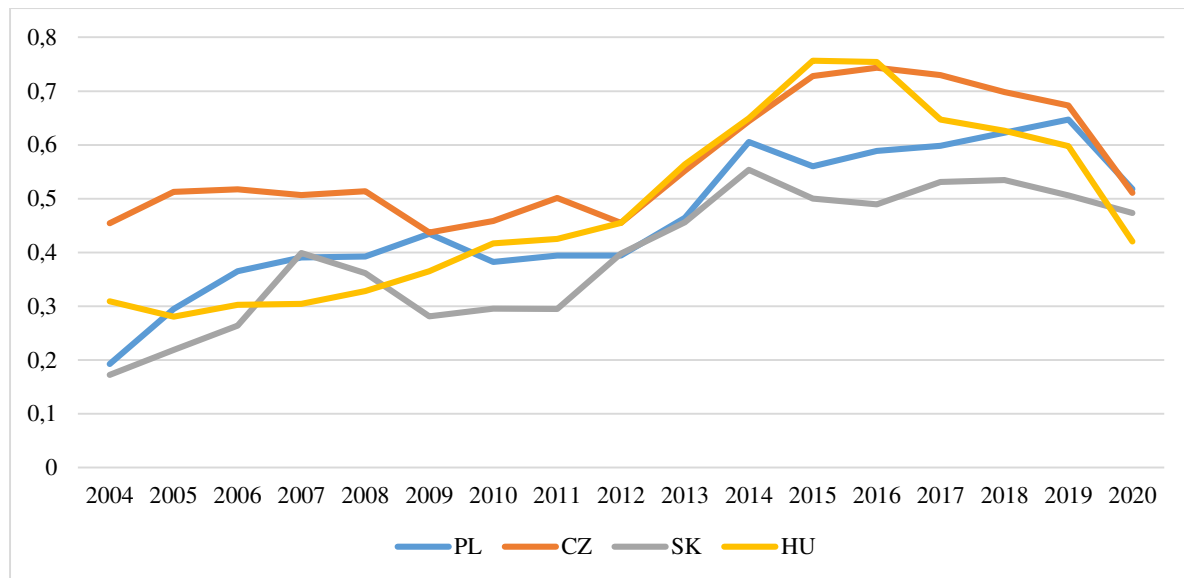


Figure 5. PSM of V4 countries.

Source: Own study.

As for PSM1, this time the Czech Republic (0.328) turned out to be slightly better than Poland (0.322). It can therefore be concluded that internal conditions have a similar impact on the macroeconomic stabilisation of these countries. Slovakia again took 3rd place (0.299), ahead of Hungary (0.292). The development of PSM1 throughout the studied period is shown in Figure 6.

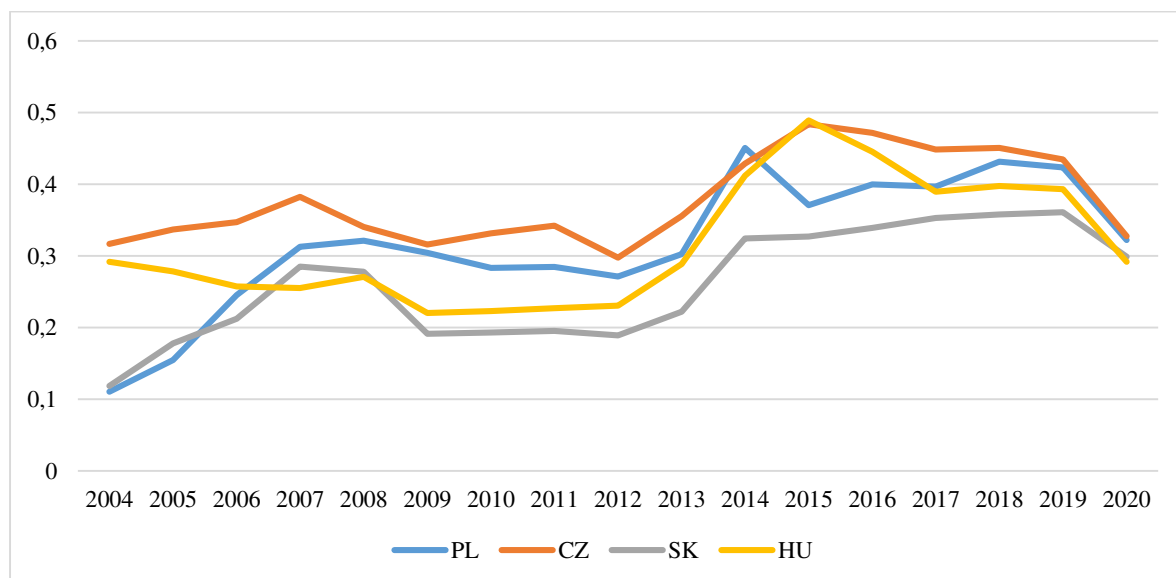


Figure 6. PSM1 of V4 countries.

Source: Own study.

However, in the case of the impact of external factors on macroeconomic stabilisation, Poland turned out to be the leader in the last analyzed period, whose PSM2 was 0.196 in 2020. The next places were taken by the Czech Republic (0.183), Slovakia (0.174) and Hungary (0.129), which were the leaders in this respect for a significant part of the analyzed time period. This is shown in Figure 7.

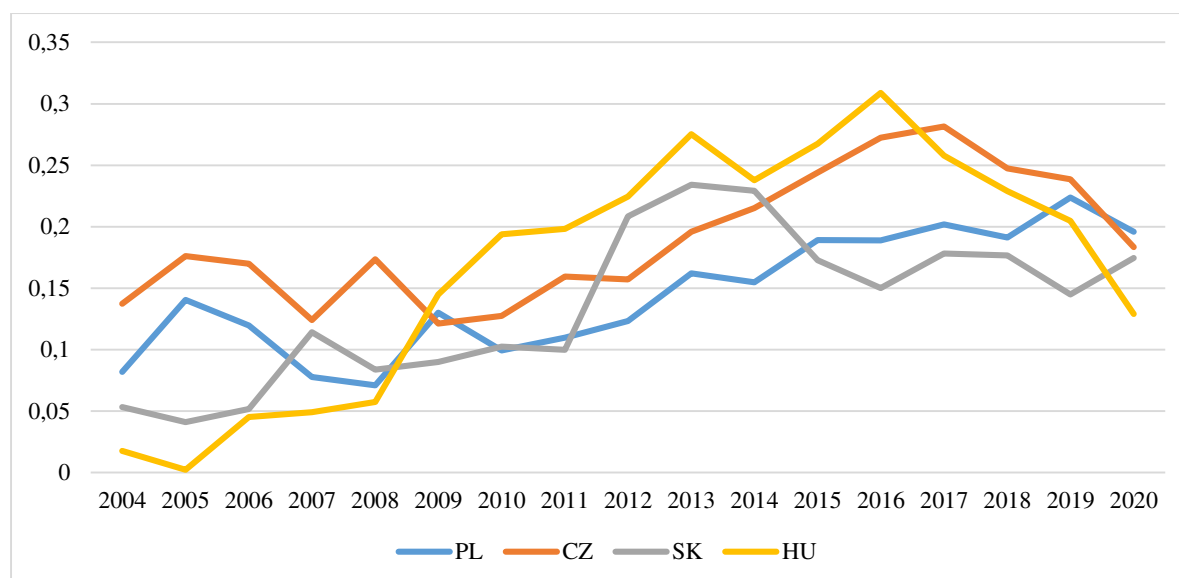


Figure 7. PSM2 of V4 countries.

Source: Own study.

The conducted research showed that there are statistically significant relationships between changes in the constructed synthetic indicator of the development of the non-life insurance market and the values of the PSM, PSM1 and PSM2 indicators, describing the macroeconomic stabilisation of the economies of Poland, Slovakia and Hungary. In the case of the Czech Republic, a statistically significant correlation was recorded for delays of 1-4. This proves that the Czech non-life insurance market reacts with the greatest delay (in the V4 group) to changes in macroeconomic stabilisation. For the rest of the countries, the highest correlation and statistical significance occurred, in most cases, in period 0. The exact results in this respect are presented in Table 3.

Table 4.

Correlogram for the synthetic indicator of the development of the non-life insurance market and PSM, PSM1 and PSM2

Delays		-4	-3	-2	-1	0	1	2	3	4
Poland	PSM	0.176	0.333	0.506 **	0.638 ***	0.793 ***	0.747 ***	0.699 ***	0.576 **	0.4152 *
	PSM1	0.07	0.159	0.342	0.520 **	0.682 ***	0.668 ***	0.694 ***	0.595 **	0.449 *
	PSM2	0.336	0.584 **	0.693 ***	0.704 ***	0.804 ***	0.708 ***	0.532 **	0.394	0.245
Czech Republic	PSM	0.317	0.382	0.272	0.08	-0.297	-0.581 **	-0.739 ***	-0.807 ***	-0.605 **
	PSM1	0.277	0.355	0.302	0.137	-0.229	-0.526 **	-0.712 ***	-0.793 ***	-0.639 ***
	PSM2	0.343	0.384	0.216	0.006	-0.354	-0.602 **	-0.713 ***	-0.761 ***	-0.519 **
Slovakia	PSM	-0.26	-0.255	-0.373	-0.509 **	-0.631 ***	-0.356	-0.388	-0.28	-0.282
	PSM1	-0.252	-0.108	-0.191	-0.386	-0.544 **	-0.385	-0.396	-0.226	-0.264
	PSM2	-0.198	-0.368	-0.497 **	-0.522 **	-0.568 **	-0.225	-0.272	-0.27	-0.228

Cont. table 4.

Hungary	PSM	-0.256	-0.396	-0.536 **	-0.683 ***	-0.786 ***	-0.700 ***	-0.643 ***	-0.494 **	-0.327
	PSM1	-0.396	-0.515 **	-0.540 **	-0.614 **	-0.627 ***	-0.510 **	-0.411 *	-0.331	-0.093
	PSM2	-0.079	-0.206	-0.414 *	-0.593 **	-0.752 ***	-0.712 ***	-0.703 ***	-0.527 **	-0.460 *

* - significance at the 10% level, ** - significance at the 5% level, *** - significance at the 1% level.

Source: Own study.

Moreover, only in the case of the Polish non-life insurance market there was a positive and the highest correlation with PSM and its components (including delays). This proves that it is positively stimulated by the macroeconomic stabilisation of the economy and reacts most strongly almost immediately. This applies to both the entire macroeconomic stabilisation (PSM) and its components determined by both internal and external factors (PSM1, PSM2). The strength of this correlation (tested with the Pearson correlation index) can be described as being on the border between medium and high². The smallest associations in period 0 were recorded in the case of the Czech Republic.

Conclusion

Insurance companies are entities that operate in market conditions that are subject to change as a result of various factors. The insurance sector is shaped by the impact of determinants related to the functioning of insurance and reinsurance companies, banks and other financial institutions, but also by macroeconomic and social factors, which include, in particular: human behaviour, demographic changes, trends and specific features related to other markets, the economic situation and the development of the global economy. The variety of factors influences the determinants of the modern insurance market. The constant changes in the insurance market are mainly due to changes in regulation (both at the level of national and grouping-specific laws) and technological changes that are used by market players. The literature research carried out shows that economic factors play a very important role in non-life insurance. The importance of these factors is determined by the level of economic development. In turn, the conditions for economic development should be considered as a corresponding configuration of economic indicators, which is known as macroeconomic stability. A critical review of the scientific literature and analysis of the results of the authors' research into the insurance markets of the Visegrad Group countries in 2004-2020 have helped to answer the research questions.

² The assessment was made on the basis of a comparison of various scales of correlations between two variables most frequently found in the literature.

Which V4 country has the most developed non-life insurance market?

The highest value of the synthetic indicator of the development of the non-life insurance market in the last period included in the analysis (2020) was recorded in Poland. The Czech market took second place, followed by the Hungarian and Slovak markets. It should be mentioned, however, that for the vast majority of the analyzed time period, the Czech Republic was the leader. However, the Polish market was developing more intensively. This applies to both the increase over the entire period and partial annual increases.

Which V4 country is characterized by the highest macroeconomic stabilisation?

The most favorable situation in terms of macroeconomic stabilisation was recorded in the case of Poland (0.518) at the end of the analyzed period. A slightly lower PSM value occurred in the Czech economy (0.511). The next places were taken by Slovakia (0.473) and Hungary (0.420).

How does macroeconomic stabilisation affect the non-life insurance markets of the V4 countries?

The non-life insurance markets of Poland, Slovakia and Hungary are shaped most strongly and with the greatest statistical significance by the macroeconomic stabilisation of their economies in period 0 - they respond immediately to ongoing economic changes (exception - Polish PSM1). The Czech market reacts with a delay, because the greatest strength of correlation and its greatest statistical significance were recorded at a lag of order 4.

It should also be noted that only in the case of the Polish non-life insurance market a positive correlation was recorded.

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SOCIO-ECONOMIC DEVELOPMENT AND URBANIZATION IN THE ORGANIZATION OF AFRICAN, CARIBBEAN AND PACIFIC STATES

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Purpose: The aim of the paper was to evaluate the level of development in selected OACPS countries and to evaluate the relationship between the level of development in selected OACPS countries and the level of urbanization.

Design/methodology/approach: The TOPSIS method was used to rank countries in terms of socio-economic phenomena in African countries covered by the OACPS. The paper focused on aspects of the labor market, demographics and economic structure, among others.

Findings: It refers to the basic concepts and significance of urbanization in international terms and theories related to it. Moreover, it presents the link between urbanization and the level of development of countries in the context of socio-economic transition. At the same time, it presents the process of social and economic transformations that have taken place in OACPS countries since the 1990s.

Research limitations/implications: The text discusses problems related to the developing countries, urbanization and socio-economic development in the region.

Practical implications: The manuscript concerns on the development of OACPS countries and the urbanization processes taking place in them. The text may be of interest to the government sector at large. Social implications: the research carried out can provide a basis for working off international and national development strategies from the point of view of improving the well-being of their populations, pointing out the direction of transformations and providing the possibility of comparability of the transformations taking place between developing countries, including primarily African countries.

Originality/value: The originality of the article is the use of the TOPSIS method, which is necessary to classify countries and determine their level of development from the point of view of socio-economic phenomena in the context of urbanization.

Keywords: urbanization, OACPS, TOPSIS, level of development, socio-economic aspect.

Category of the paper: own research and review.

1. Introduction

Cities are considered one of the basic elements of the world's spatial system, but they are also a component of the socio-economic development processes of highly and underdeveloped countries (Ichimura, 2003). Szymańska (2007) points out that they are the place where more than half of the world's population lives and urbanization itself is a phenomenon of modern civilization. Paluch (1975) argues that cities are the center of the most advanced processes of change, and their importance in the context of development has changed significantly over the ages.

In literature, urbanization is considered a natural consequence of the development of countries, associated with the shift of labor from agriculture to the production of urban goods. It also represents a process of modernization of traditional societies and transformation of economies. The concept of urbanization is heterogeneous and has multifaceted aspects (e.g., economic, social, environmental or legal). Müller (1975) argues that urbanization is both a process and a state, which allows it to be understood in two aspects. In the context of process, urbanization should be identified with socio-economic changes or changes in human activities, while from the point of view of the state, it means the result of change.

According to Henderson et al. (2002) and Henderson and Wang (2003), the growth of cities and the economies themselves is due to three primary factors. The first factor relates to population growth, the second relates to migration from rural areas to urban zones while the third relates to technological change driving the growth rate of existing cities. The reasons for the migration of people from rural to urban areas are most often related to the difference in expected income (Todaro, 1978; 1980). Often, however, the rapid influx of people and growth of cities outpaces their economic development. This results in increased unemployment, poverty and overcrowding, as well as infrastructure deficiencies (Kuddus et al., 2020).

Africa is considered the "Continent of the Future" with development prospects, but also with challenges. This is influenced by positive demographics - a relatively young population, significant natural resources (including 80% of the world's platinum) or the world's lowest default rate (African Development Bank, 2022b). Urbanization is considered one of the key transformation processes that will take place on the continent in the 21st century (OECD, 2022). In 1960, the percentage of urban population in African countries was less than 20%, in 1990 it was 39% (African Development Bank, 2014), and in 2020 it will be just over 40%. Projections indicate that in 2050 the urban population is expected to make up 60% of Africa's population. As the United Nations (2008) report indicates, cities in Africa generate 55% of the continent's GDP. In some places, urbanization will result in improved quality of life, in others in increased poverty. These phenomena are occurring simultaneously with varying degrees of intensity (Rana, 2011; Aliyu, Amadu, 2017).

Urbanization processes in African countries were not always aimed at sustainable development, the reasons for which can be found in the colonial period. As Fuseini and Kemp, (2015) point out that after independence, these economies did not implement effective development plans, due in large part to a number of factors including rapid urban growth, insufficient manpower, low capacity, lack of institutional coordination, increased political interference in planning or the complexity of land tenure.

The result has been that urban centers in African countries struggle with adverse environmental conditions, poor infrastructure and low-quality services, as well as uncontrolled growth.

Many authors suggest that urbanization can be the driving force behind socioeconomic development in developing countries, meaning that the higher the share of urban population (urban population (% of total population)), the higher the level of socioeconomic development of the country (Pugh, 1995; Kojima, 1996; Kowalewski, 2005; Cohen, 2006; Henderson, Wang, 2007; Szamańska, Biegańska, 2011; Yuan, Guanghua, 2015; Gu, 2019; Fan et al., 2019; Henderson, Turner, 2020). Özden and Enwere (2012), Zhong and Chen (2022) and Zheng and Walsh (2019), argue that an increase in the level of economic development determines the influx of people to cities, where there are greater opportunities for social or professional development of the population. However, in the context of African countries, it becomes crucial for national and local governments to effectively shape policies to stimulate economic growth and reduce poverty, as a natural effect of the increased influx of people from rural areas to cities (Bertinelli, Duncan, 2004).

The aim of the paper was to evaluate the level of development in selected OACPS countries and to evaluate the relationship between the level of development in selected OACPS countries and the level of urbanization. The time range was 1990-1999, 2000-2009 and 2010-2019 to compare changes over the long term. The first period represented a time of diminished interest in developing countries due to global political and economic instability. Period two refers to the millennium years, when the Millennium Declaration for the Development of Developing Countries was created. Period three presented the current situation, and is supported by available data.

Developing countries often form groupings to provide a source of cooperation and mutual support for social and economic development. One example of cooperation is the Organization of African, Caribbean and Pacific States (OACPS), which was formed under the 1975 Georgetown Agreement. The purpose of the agreement was to protect local markets and external support. The group is composed of low- and middle-income per capita countries with varying rates of urbanization. On this basis, 29 African countries included in the OACPS were analyzed and sourced materials collected from World Bank data was used to achieve the purpose of the paper.

The outline of the paper is as follows. First, a review of the literature on urbanization in developing countries and its importance from the point of view of the socio-economic development of countries is presented. Second, the method of the study is described. Third, the TOPSIS method was used to classify countries in terms of selected indicators in African countries, part of the OACPS. Finally, the classification of countries in terms of the level of socio-economic development in the three periods studied is presented, and the relationships that exist between the level of development and urbanization are described. The article closes with a discussion on the importance of urbanization in terms of socioeconomic development in the countries studied.

2. Material and Method

The first stage of the research was a literature study and the aggregation of the necessary data to diagnose the socio-economic situation of OACPS countries. The literature study dealt with both theoretical issues, related to the problems of developing countries, the TOPSIS method and how to use it. Preliminary analysis of data describing the characteristics of the economies of OACPS countries presented significant gaps in public statistics, hence on this basis the focus was on 29 African countries (fig. 1).



Figure. 1. Geographic distribution of OACPS countries included in the analysis

Source: own study.

The next step was to select indicators to evaluate the socio-economic situation of OACPS countries. A set of 15 indicators, defining the socioeconomic situation, was collected for the analyzed group of countries (Table 1). Their selection was based on merit and data availability.

The selection of development indicators is always associated with subjectivity. Different authors (Stec, 2004; Glodowska, 2008) qualify the activities in different ways in order to achieve the set goals and assign them appropriate measures. To study the level of development of countries, similar variables as used by Stec (2004) and Cieslik (2017) were considered in this paper.

The extensive range of this study concerning development of countries made it possible to select characteristics and the structure of a synthetic measure. The material for analysis included information from the World Bank database. Due to the availability of data the conducted analysis covered three years, i.e. 1990-1999, 2000-2009 and 2010-2019, thus facilitating observations of changes in the discussed phenomenon over time.

The diversified level of development in the OACPS countries was investigated using a synthetic measure of development based on the classical TOPSIS method.

Classic TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution), a method for structuring a synthetic metric, was used in assessing the level of development of OACPS countries. Yoon and Hwang developed the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) based on the concept that the chosen alternative should have the shortest distance from the ideal solution and the farthest from the negative-ideal solution (Hwang, Yoon, 1981).

Step 1. Selecting the simple characteristics of countries development levels

Table 1.

Diagnostic variables proposed to be used in measuring the development of OACPS countries

No.	Diagnostic variables	Nature of variables
X1	Population growth (annual %)	S
X2	Fertility rate, total (births per woman)	S
X3	Life expectancy at birth	S
X4	Age dependency ratio (% of working-age population)	D
X5	Mortality rate, infant (per 1,000 live births)	D
X6	Population ages 15-64 (% of total population)	S
X7	GDP per capita (USD per capita)	S
X8	GDP growth (annual %)	S
X9	Exports of goods and services (% of GDP)	S
X10	Industry (% of GDP)	S
X11	Agriculture (% of GDP)	D
X12	Employment in industry (% of total employment)	S
X13	Employment in services (% of total employment)	S
X14	Unemployment, total (% of total labor force)	D
X15	Labor force participation rate, total (% of total population ages 15-64)	S

D – destimulant, S – stimulant.

Source: own study based on the World Bank data.worldbank.org/, 20.02.2023.

An important part of selecting the simple characteristics to be covered by the study is to assess their variation and correlation with one another. It is necessary to remove the ones at very low levels of variation (with a coefficient of variation below 10%) and those highly correlated with other simple characteristics (values largely above 10). The characteristics x6

(coefficient of variation below 10%) and x2 (values largely above 10) were removed from the set of diagnostic variables (Wysocki, 2010).

Step 2. Normalization of simple characteristics

As indicated by Wysocki (2010), this step consists in unifying the simple characteristics, making them mutually comparable, eliminating non-positive values and replacing different ranges of variability of particular characteristics with a constant range. This study relied on an approach based on linear normalization, referred to as zero unitarization.

Hence, the values of simple characteristics were normalized using the following formulas (Wysocki, 2010):

- for variables with a stimulating effect:

$$z_{ij} = \frac{x_{ij} - \min_i\{x_{ij}\}}{\max_i\{x_{ij}\} - \min_i\{x_{ij}\}} \quad (1)$$

- for variables with an inhibiting effect:

$$z_{ij} = \frac{\max_i\{x_{ij}\} - x_{ij}}{\max_i\{x_{ij}\} - \min_i\{x_{ij}\}} \quad (2)$$

The normalization of simple characteristics was performed for a total of two periods under analysis (referred to as object-years) based on average values of simple characteristics recorded in these periods. This was done in order to ensure comparability of results between the periods and to capture the development trend affecting the phenomenon process under consideration.

Step 3. Determining the coordinates of ideal units for normalized characteristics: the positive ideal (A+) solution and the negative ideal solution (A-) as per the following formulas

$$A^+ = (\max_i(z_{i1}^*), \max_i(z_{i2}^*), \dots, \max_i(z_{iK}^*)) = (z_1^+, z_2^+, \dots, z_K^+) \quad (3)$$

$$A^- = (\min_i(z_{i1}^*), \min_i(z_{i2}^*), \dots, \min_i(z_{iK}^*)) = (z_1^-, z_2^-, \dots, z_K^-) \quad (4)$$

Step 4. Calculating the Euclidean distances of each object (country) under consideration from the positive and negative ideal development

$$d_i^+ = \sqrt{\sum_{k=1}^K (z_{ik}^* - z_k^+)^2} \quad (5)$$

$$d_i^- = \sqrt{\sum_{k=1}^K (z_{ik}^* - z_k^-)^2}, \quad (6)$$

where: $i = 1, 2, \dots, N$.

Step 5. Using TOPSIS to calculate the value of the synthetic characteristics of country development

$$S_i = \frac{d_i^-}{d_i^+ + d_i^-} \quad (7)$$

with $0 \leq S_i \leq 1$, where $i = 1, 2, \dots, N$.

The values of the synthetic metric calculated using TOPSIS vary in the range of 0 to 1. The closer the town to the ideal unit (development model), the more distant it is from the negative ideal solution, and the greater the value of its synthetic metric. At the same time, it indicates a higher development level of the country.

Step 6: Based on the values of the synthetic metric, the countries covered by this study were linearly ordered by level of development. The study then identified a distinct typological group of countries based on quartile 1 (Q1), quartile 2 (Q2), quartile 3 (Q3), calculated for the synthetic metric

Group I: above Q_3 (countries at high levels of the development).

Group II: Q_2 - Q_3 (countries at medium-high levels of the development).

Group III: Q_1 - Q_2 (countries at medium-low levels of the development).

Group IV: below Q_1 (countries at low levels of the development).

3. Results

Differentiation of development levels in OACPS countries

In the analyzed OACPS countries, low variation in the level of development was observed in the years studied (coefficient of variation in the range of 10.99-13.93% in 1990-1999, 2000-2009 and 2010-2019) (Table 2). The study revealed a rise in the level of development in the countries examined, as exemplified by the average (0.4511, 0.4847, 0.5260) or the spread of the synthetic measure (0.2820, 0.2054, 0.2294) (Table 2). There was a significant change in the minimum value of the synthetic measure in 2000-2009 compared to 1990-1999. This may indicate an enhancement in the level of development in nations where a low level of development was observed during the period of 1990-1999.

Table 2.

Selected descriptive statistics for the value of the synthetic measure for the OACPS countries in 1990-1999, 2000-2009 and 2010-2019

List	1990-1999	2000-2009	2010-2019
Max	0.5997	0.6103	0.6423
Min	0.3177	0.4049	0.4128
Mean	0.4511	0.4847	0.5260
Med.	0.4374	0.4708	0.5243
Range	0.2820	0.2054	0.2294
coefficient of variation (%)	13.93	11.41	10.99

Max – maximum, Min. – minimum, Med. – median, Mean – arithmetic mean.

Source: own study based on the World Bank data.worldbank.org/, 20.02.2023.

The countries surveyed were divided into four typological groups of development levels. 75% of the OACPS countries experienced an improvement in the level of development compared to the previous period, while one third did not change their ordered group (Table 4). Between 1990 and 1999, half of the countries observed a low level of development (group IV - 51.7% of countries) (Table 3). Subsequent periods witnessed a shift towards higher levels. In 2000-2009, the number of countries in Group IV more than halved (20.7%), and 41.4% of countries were characterized by medium-low levels of development. More than 75% of the countries analyzed high or medium-high levels of development during the period 2010-2019. In contrast, only one country belonged to Group IV (low level of development) (Table 3).

Table 3.

Typological classes for the levels of development of OACPS countries

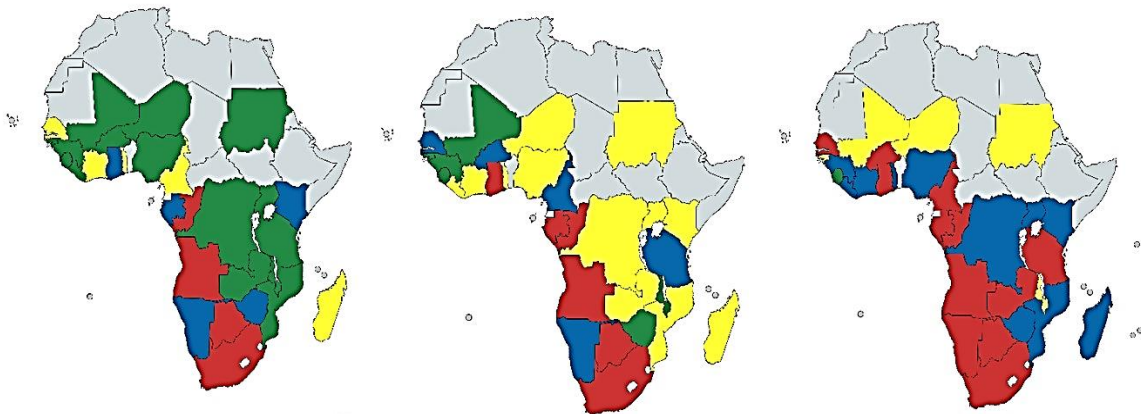
Level of development		Values of the metric	1990-1999		2000-2009		2010-2019	
			N	%	N	%	N	%
I	<i>high</i>	above 0.5285	4	13.8	6	20.7	12	41.4
II	<i>medium-high</i>	0.4817 to 0.5285	5	17.2	5	17.2	11	37.9
III	<i>medium-low</i>	0.4377 to 0.4817	5	17.2	12	41.4	5	17.2
IV	<i>low</i>	below 0.4377	15	51.7	6	20.7	1	3.4

N – the number of countries in a group.

Source: own study based on the World Bank data.worldbank.org/, 20.02.2023.

Group I included OACPS countries with a high level of development. In 2010-2019, compared to 2000-2009, the percentage of countries in this group has increased twofold (Table 3). During the period under review, a significant level of progress has been observed in Botswana, Angola, South Africa, and Republic of Congo, all of which are distinguished by a plethora of natural resources, such as oil, diamonds, gold, or platinum. In subsequent years, advancement was observed in countries that were in Group II in the earlier study period. It is noteworthy that significant advancements were observed in predominantly countries, with the exception of the Republic of Congo, which have moderate to low levels of corruption (African Development Bank, 2022a). Furthermore, countries that are achieving significant progress in the fight against hunger and possess oil-rich resources, such as Angola and Ghana, were classified into this group (African Development Bank, 2014), as well as those whose governments have implemented open market policies (Namibia) (table 4).

Group II consisted of countries with a medium-high level of development. During the period under review, there was a significant variance in the composition of nations, which were categorized into Group II (Table 3). Despite the consistent increase in the percentage of countries with a medium-high level of development between 1990-1999 and 2000-2009, Namibia was the sole country to be ranked in Group II during the indicated periods (Table 4, fig. 2). In 2010-2019, an medium-high level of development was recorded in countries that were ranked in Group III in 2000-2009.



Legend: group I – color red, group II – color blue, group III – color yellow, group IV – color green.

Figure 2. Development level of OACPS countries according to the designated development index in 1990-1999, 2000-2009 and 2010-2019.

Source: own study based on the World Bank data.worldbank.org/, 20.02.2023.

OACPS countries with medium-low levels of development were ordered in Group III. The significant enhancement in the level of development during the period 2000-2009 in comparison to 1990-1999 resulted in the classification of a significant group of countries within this group (Table 3). With the exception of Cote d'Ivoire, the medium-low level of development was identified in countries that were included in Group IV during the period of 1990-1999 (Table 4). In 2010-2019, Niger and Sudan, countries that were afflicted by religious and political conflicts and poverty, experienced a lack of notable advancement in their development, resulting in a medium-low level of development.

Group IV included countries with low levels of development. The proportion of nations within this group underwent significant fluctuations throughout the durations under study. Only Sierra Leone, recognized by the UN as a country in the Least Developed Countries (LDC) group (DAC, 2021), observed a low level of development in all the years examined (Table 4). Furthermore, Group IV included countries with a low share of industry in GDP or exports of goods and services, and a high share of agriculture.

Most of the East African countries recorded an improvement in position in each period. In contrast, countries that were part of Southern Africa had some of the highest values of the development index. The further north one went, the lower the level of development changed (fig. 2).

Table 4.

Values of synthetic measure of development level in OACPS countries in 1990-1999, 2000-2009, 2010-2019

1990-1999			2000-2009			2010-2019		
Group	Country		Group	Country		Group	Country	
I	Botswana	0,5997	I	Congo, Rep.	0,6103	I	Ghana	0,6423
	Angola	0,5526		Angola	0,6021		Botswana	0,6368
	South Africa	0,5524		Botswana	0,5923		Congo, Rep.	0,6103
	Congo, Rep.	0,5383		South Africa	0,5646		Burkina Faso	0,6088
II	Ghana	0,5111	II	Ghana	0,5621	I	South Africa	0,5944
	Gabon	0,5099		Gabon	0,5321		Gabon	0,5883
	Zimbabwe	0,4933		Cameroon	0,4999		Angola	0,5680
	Kenya	0,4924		Namibia	0,4976		Zambia	0,5551
III	Namibia	0,4862	II	Burkina Faso	0,4914	I	Cameroon	0,5360
	Cote d'Ivoire	0,4750		Tanzania	0,4902		Namibia	0,5352
	Senegal	0,4562		Senegal	0,4859		Senegal	0,5301
	Cameroon	0,4498		Madagascar	0,4817		Tanzania	0,5299
IV	Madagascar	0,4487	III	Kenya	0,4776	II	Madagascar	0,5271
	Togo	0,4428		Nigeria	0,4714		Togo	0,5244
	Burkina Faso	0,4374		Zambia	0,4708		Congo, Dem. Rep.	0,5243
	Nigeria	0,4345		Mozambique	0,4689		Cote d'Ivoire	0,5171
	Niger	0,4321		Congo, Dem. Rep.	0,4667		Nigeria	0,5148
	Tanzania	0,4310		Niger	0,4666		Kenya	0,5144
	Zambia	0,4281		Uganda	0,4640		Zimbabwe	0,5103
	Mozambique	0,4231		Liberia	0,4640		Liberia	0,5083
	Guinea	0,4209		Togo	0,4612		Uganda	0,4975
	Liberia	0,4183		Cote d'Ivoire	0,4577		Guinea	0,4968
	Uganda	0,4162		Sudan	0,4487		Mozambique	0,4933
	Sudan	0,3959		Mali	0,4323		Malawi	0,4783
Congo, Dem. Rep.	0,3926	Guinea	0,4311	Niger	0,4654			
Malawi	0,3919	Zimbabwe	0,4288	Guinea-Bissau	0,4495			
Mali	0,3800	Malawi	0,4211	Mali	0,4459			
Guinea-Bissau	0,3546	Sierra Leone	0,4108	Sudan	0,4381			
Sierra Leone	0,3177	Guinea-Bissau	0,4049	Sierra Leone	0,4128			

Source: own study based on the World Bank data.worldbank.org/, 20.02.2023.

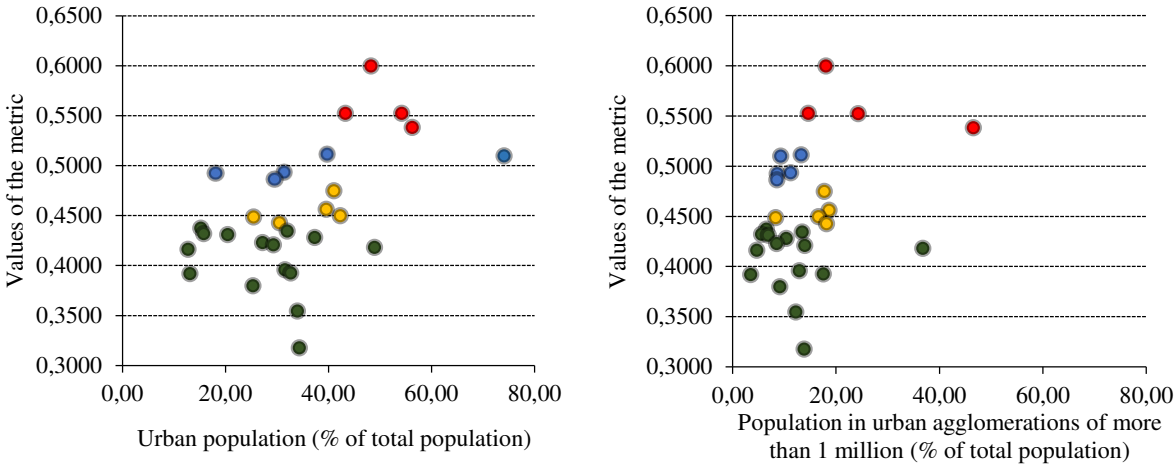
Development level vs. urbanization in OACPS countries

It is acknowledged that cities are the driving force behind the socio-economic development of countries. Furthermore, it has been posited that the expansion of urban populations is associated with the advancement of a nation (Angelopulo, 2021). To assess the relationship between the level of development in OACPS countries and urbanization, two indicators were used: the share of urban population in the total population and the share of urban population in agglomerations with more than one million inhabitants in the total population.

In the period of 1990-1999, a consistent correlation was observed between the values of the synthetic measure of the level of development in OACPS countries and the proportion of urban population in the total population, with Pearson's linear correlation coefficient being 0.51. Countries with high levels of development were 40-60% urbanized. There was no significant

difference between countries in Groups II, III, and IV. In Gabon, where the share of urban population was the highest (almost 80%), the country was ordered into Group II from 1990-1999.

A low correlation was observed between the level of development and the proportion of agglomeration population in the total population. In 1990-1999, there was a correlation of 0.31. Regardless of the development group, the population of agglomerations over one million inhabitants was not exceeding 30% in most countries.



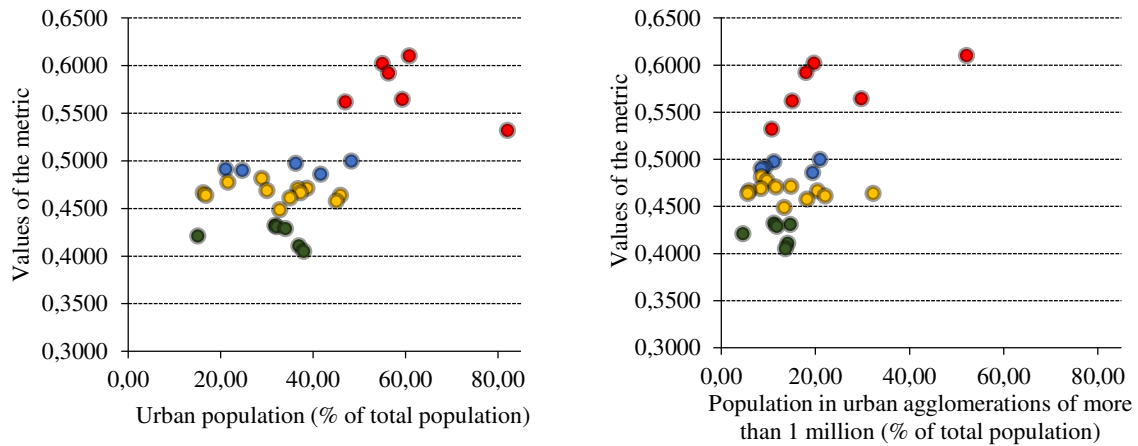
Legend: group I – color red, group II – color blue, group III – color yellow, group IV – color green.

Figure 3. Development level versus urbanization rate and urbanization rate in cities with more than one million inhabitants in 1990-1999 in selected OACPS countries.

Source: own study based on the World Bank data.worldbank.org/, 20.02.2023.

During the period of 2000-2009, it was observed that there was a significant increase in the correlation between the proportion of urban population and the classification for the development group. The Pearson’s correlation coefficient was 0.63. This relationship is evident in the group of countries with a high level of development (group I). These countries experienced an increase in the percentage of urban population. Furthermore, a higher rate of urbanization was observed in some of the OACPS countries with a medium-high or medium-low urbanization rate (groups II and III).

The relationship between the level of development and the share of population in agglomerations with more than one million inhabitants was also increased. The correlation coefficient was 0.51. The percentage of population in agglomerations remained relatively constant during the period of 1990-1999, with the majority of countries achieving a population density of less than 20%.

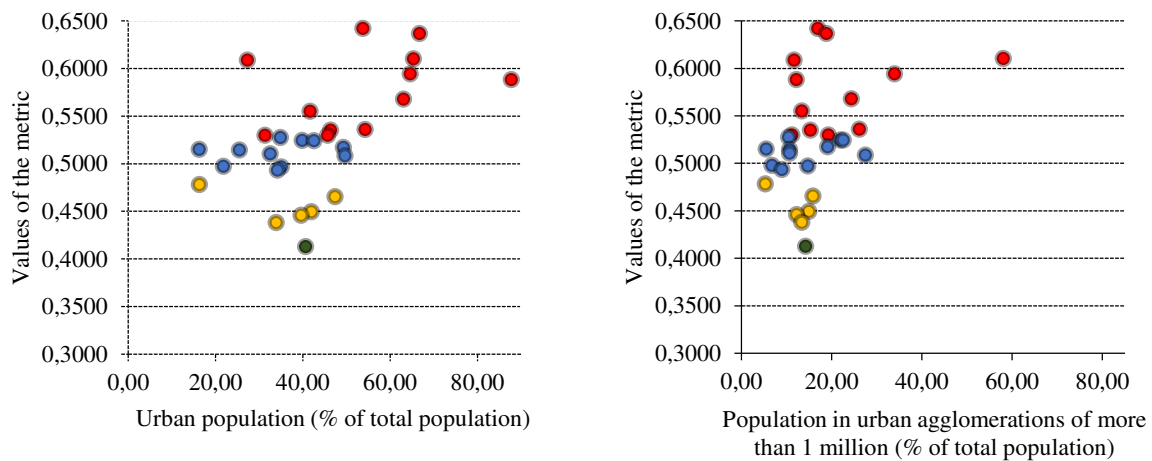


Legend: group I – color red, group II – color blue, group III – color yellow, group IV – color green.

Figure 4. Development level versus urbanization rate and urbanization rate in cities with more than one million inhabitants in 2000-2009 in selected OACPS countries.

Source: own study based on the World Bank data.worldbank.org/, 20.02.2023.

In the period 2010-2019, a decrease in the correlation between the level of development and the urbanization indicators in question was observed compared to 2000-2009. Between the level of development in OACPS countries and the percentage of urban population in these countries was 0.52, while the difference between the percentage of population in agglomerations with more than one million inhabitants was 0.41. In 2010-2019, a decrease in the average growth rate of urban population in the total population was observed, which was 11.8% lower in comparison to the period of 2000-2009.



Legend: group I – color red, group II – color blue, group III – color yellow, group IV – color green.

Figure 5. Development level versus urbanization rate and urbanization rate in cities with more than one million inhabitants in 2010-2019 in selected OACPS countries

Source: own study based on the World Bank data.worldbank.org/ [accessed: 20.02.2023].

The linkage assessment observed that the level of development in the OACPS countries studied is not significantly influenced by urban agglomerations versus all cities. It is also important to note that the improvement in development did not occur simultaneously with urban

population growth. It can be emphasized that a decrease in the rate of urban population growth was accompanied by a decrease in the rate of development.

4. Conclusion

The countries of the OACPS are a group of countries that exhibit a wide range of socio-economic characteristics. Based on the synthetic measure of socioeconomic development created in the study, four typological groups were identified. Improvements in the level of development were observed in the OACPS countries. It can be ascertained that the advancement was of a recurrent nature, i.e., the analyzed nations altered the level of development by a particular group over successive periods. Nonetheless, it is imperative to bear in mind that despite the elevated values of the assessment, the countries analyzed remain among the impoverished regions of the globe. As stated by Muhammad Awais Baloch et al. (2020), it is projected that by 2030, sub-Saharan African nations will not be capable of alleviating poverty, as 45% of the countries still face a problem of extreme poverty among their populace.

The results of the analysis by Li et al. (2021) on sustainable development in African countries are partially consistent with the results of the research conducted. The OACPS countries were ranked high in the sustainability of development in African countries, with a high ranking in Group I and Group II.

The group of countries with high or medium-high levels of development (Group I or II) encompassed resource-rich nations with high HDI values, such as South Africa, Botswana, and Gabon, as reported by the World Bank. In contrast, nations with low levels of development were also characterized by low HDI values. According to the international statistics conducted by the United Nations, they are categorized as the world's poorest (LDC) countries, such as Guinea-Bissau and Sierra Leone. They often have a high share of agriculture in GDP and a high share of agricultural employment.

An assessment of the relationship between the level of development in OACPS countries and urbanization indicators revealed a medium association between the value of the synthetic measure and the share of urban population. A smaller association was observed between the constructed measure and the percentage of urban population in agglomerations with a population of over 1 million. Ngouanet et al. (2016) arrived at similar conclusions, stating that Africa is experiencing a dynamic migration of population from rural to urban areas. However, due to the large diversity of countries, the process may take on a distinct shape in each country, and a higher level of development may not necessarily imply a society's increased urbanization.

It should be noted that in the studies of other authors, the correlation became apparent between economic development and the degree of urbanization of countries (Henderson 2003; 2005; Annez and Buckley 2009). This is a rationale for continuing the research, however this time setting aside the social aspect, which may have introduced variations in the results obtained.

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POST-IPO INNOVATIVE FIRM PERFORMANCE

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Purpose: The aim of the work was to present the impact of IPO on the innovation and economic results of companies debuting on the Warsaw Stock Exchange.

Design/methodology/approach: The aim of the work was achieved by analyzing the literature and conducting research on companies debuting on the WSE. Descriptive statistics, the Shapiro-Wilk normality test and the Student's t-test or Wilcoxon test were used for the study.

Findings: The obtained results confirm that IPO has a negative impact on the economic results of companies debuting on the WSE. It is noted that innovative activities by companies mitigate the negative effect of IPO.

Originality/value: The presented problem is of great practical importance. The research results may prove useful for people managing enterprises and responsible for shaping the innovative activities of enterprises and the methods of financing them.

Keywords: innovation, IPO, firm performance.

Category of the paper: Research paper.

1. Introduction

Dynamically developing companies, especially those conducting innovative activities, may have problems with obtaining the necessary capital. Therefore, these entities decide to debut on the stock exchange. The literature indicates that after an IPO, innovation decreases, and the economic results of enterprises deteriorate. The aim of the article was to examine how a stock exchange debut affects the economic situation of innovative and non-innovative companies debuting on the Polish stock exchange. The presented problem is of great practical importance. The research results may prove useful for people managing enterprises and responsible for shaping the innovative activities of enterprises and the methods of financing them.

2. Innovation and IPO

The company's development increases its financial needs, and one of the possibilities of obtaining capital is offered by the public market through the issue of shares. A skillful issue and the possibility of offering your securities to an unlimited circle of potential buyers allows for a significant improvement in the company's market position.

The initial public offering of shares on the Polish stock exchange can be carried out in three ways: through public subscription of new issue shares, through public sale of existing shares, and through a combination of a public sale offer and public subscription. In the literature, the IPO is treated generally and interpreted in various ways, but most often it is presented in a narrow approach, i.e., the issue of new shares (Sosnowski, 2013). This approach to IPO was used in this work.

Going public of an innovative company is associated with several consequences that depend on many factors. However, the impact of IPO on the level of innovation is not clear. Innovative entities are usually difficult to value by potential shareholders, which makes them susceptible to mispricing during the IPO. Often, company managers may try to increase the IPO price by excessively investing in research and development, signaling to investors the prospect of growth. On the other hand, they may reduce R&D spending to increase reported results. Managers are more willing to reduce R&D expenses because the presented financial results are a stronger incentive for investors (Darroug, Rangan, 2005). Revaluation of a company during an IPO may affect innovation in two ways. The first view refers to the short-sightedness of managers caused by enormous market pressure resulting in involvement in short-term projects. The revaluation of the company creates the need to maintain it. To this end, managers can adopt ready-made innovations from the market to help justify and maintain high valuations. Due to risk and fear of negative impact on the action, managers are less willing to implement their own innovation projects. It should therefore be emphasized that the revaluation of company shares during the IPO inhibits the development of internal innovation. On the other hand, overvaluation of shares may prompt managers to satisfy investors' excessive optimism. Innovation may prove to be a confirmation of the high valuation (Shen et al., 2021).

Private ownership creates incentives for innovation, while public ownership discourages it. Private companies often take greater risks, invest in new products and technologies, and undertake more radical innovation activities. They implement complex and untested projects and are more likely to make organizational changes. Public companies, on the other hand, usually choose more conventional projects, which is why entities go public after introducing breakthrough innovations (Ferreira et al., 2014). On the other hand, public entities invest more, especially in research and development, than private entities. The stock exchange facilitates larger investments, especially in risky projects, by accessing capital and spreading risk among a larger number of shareholders. A major disadvantage of public ownership is the

pressure from shareholders and their short-sightedness, which results in giving up long-term investment opportunities (Feldman et al., 2018; Wang et al., 2022). Post-IPO, companies are expected to introduce innovations with greater diversity (different flavors, colors, package sizes, etc.). However, these are not breakthrough innovations. There is also a decline in the quality of innovation (Aggarwal, Hsu, 2014; Wies, Moorman, 2015; Jiang, 2019). The overall reduction in the level of innovation after the IPO may be due to the use of new capital to purchase technologies already existing on the market rather than investing in internal innovations (Tseng, Tseng, 2016).

The IPO contributes to a change in implemented projects consisting in reduced internal innovation, employee turnover and a decline in the productivity of other inventors, as well as an increase in the acquisition of external technologies (Bernstein, 2015; Dambra, Gustafson, 2021). Despite the general decline in innovation after the IPO, it is possible to maintain the level of innovation before the IPO. The source of success for such companies is developing appropriate innovative behavior much earlier than the stock exchange debut (Wies et al., 2023).

The decision to take a company public may have various impacts on its innovation activities. Most studies find a reduction in innovation after an IPO, largely due to the company's exposure to strong capital market pressures for short-term returns. On the other hand, investors expect long-term growth, and investments in research and development are a clear signal of growth for them.

3. Economic effect of the company after the IPO

The impact of IPO on company results is not clear, but most economists indicate that almost all companies experience declines after going public. This is visible in operational results, sales levels, and overall productivity, and related to companies being less responsive to investment opportunities after they go public (Lerner, 2011). This is visible in operational results, sales levels, and overall productivity. This is related to companies being less responsive to investment opportunities after they go public (Wies, Moorman, 2015).

Research conducted on a sample of 682 companies debuting on the American market in the years 1978-1998 showed that operating profit in relation to total assets decreased both in the year of debut and three years after it. Similar results were obtained on a sample of Thai (1987-1993), Malaysian (1990-2000), European (1995-2006), and Turkish (2003-2011) companies. It can therefore be concluded that the IPO is statistically significant and has a negative impact on the company's results. Different research results were obtained when analyzing 79 companies debuting in 21 developing countries in the years 1987-1993. Both operating margin, ROA and ROE increased after the IPO (Mhagama, Topak, 2019).

A study conducted on a group of companies listed on the Thai stock exchange in 2009-2013 allowed the conclusion that after the IPO, both the ROA and ROE tend to decrease, but the ROA increases if the company is supported by Venture Capital funds. These results are seen up to five years after the IPO (Chalarat, 2018). An analysis of the post-IPO performance of Malaysian companies shows a decline in the year of IPO and three years thereafter. However, the company experiences the greatest declines in the year immediately after the IPO. N.A. Ahmad Zaluki (2005) justified this by aggressively shaping the financial result. J.L. Kao et al. (2009) found that companies with better pre-valuation accounting performance have greater post-IPO profitability declines, lower first-day stock returns, and worse long-term post-IPO stock performance. Profitability declines because companies are unable to maintain their current manipulation of earnings, which in turn results in poor stock performance after the IPO. N. Boubakri and J.C. Cosset (1998), obtained different results on a group of companies debuting on developing markets noticed the positive impact of the IPO on the company's results in later years. Similarly, B. Larrain et al. (2021) they noticed an increase in ROA after the debut. It is indicated that companies that are perceived by IPO market participants as more innovative achieve better results after the IPO compared to the year preceding the debut (Chemmanur et al., 2020).

Based on the above analysis, it can be concluded that the IPO negatively affects the company's results. Typically, performance is lower in the debut year and the short period after the IPO. It is worth noting, however, that innovations are a factor mitigating the above relationship. Sometimes they can completely change this direction.

Based on the literature review, a research hypothesis was formulated:

H: The economic situation of an innovative company after its debut deteriorates to a lesser extent than that of a non-innovative company.

4. Database and methodology

The study covered Polish companies debuting on the WSE in 2007-2018 to provide a seven-year time frame (3 years before, the year of IPO and 3 years after it). Financial institutions were excluded from the group of debutants due to the specificity of their activities and the specificity of the indicator assessment. For the purposes of this study, it was decided to separate entities from the group that offered sale only of new shares. Moreover, the company's transfer from the alternative market to the main market was not considered a debut. Ultimately, less than 29% of companies debuting on the WSE (98 entities) in 2007-2018 were analyzed, of which 22 companies were innovative.

For the purposes of the research, all enterprises that were granted at least one patent or applied for one in the years preceding their debut were considered innovative enterprises. The research and its analyses were carried out based on available economic and financial data contained in financial statements, issue prospectuses, stock exchange information of companies debuting on the WSE and in patent statistics.

Because the companies debuted throughout the year, data from the year of the IPO were excluded from the analysis to ensure data comparability and equality of ranks necessary to conduct the Wilcoxon test. "Pre-IPO" indicators were calculated for data from three years before the IPO, while "post-IPO" indicators were calculated for data from three years after the debut. To draw basic conclusions, descriptive statistics were used, i.e., arithmetic mean, median, minimum value, maximum value, and standard deviation. Differences were compared using the Shapiro-Wilk normality test. Based on its result, a test was selected between the Student's t-test and the Wilcoxon test.

5. Results

The results obtained are presented in tables divided into innovative and non-innovative companies. Three categories of indicators were included: general information, profitability, and financial liquidity of companies.

5.1. General information – innovative companies

In order to verify the hypothesis, first the number of patents, total employment (FTE), total assets and the size of the company (logarithm total assets) were compared.

Table 1.

General information on innovative companies debuting on the WSE before and after the IPO

Index	X	Arithmetic average	Median	Min	Max	SD
Numbers of patents (pcs)	before IPO	0,61	0	0	6,00	1,11
	after IPO	0,39	0	0	5,00	0,93
Total employment (FTE)	before IPO	2 794,00	176,00	27,00	47 734,00	10 106,10
	after IPO	2 873,34	272,00	38,00	45 383,00	9 427,86
Total assets (PLN)	before IPO	2 476 478,04	82 591,39	31,00	54 987 902,00	10 396 328,45
	after IPO	3 067 603,72	249 966,50	18 865,00	58 762 631,00	11 781 941,44
Size (ln total assets)	before IPO	11,47	11,32	3,43	17,82	2,17
	after IPO	12,55	12,43	9,85	17,89	1,72

Source: own study based on data obtained from financial documents of companies debuting on the WSE.

Table 2.

Comparison of general data on innovative companies debuting on the WSE before and after the IPO

Index	Shapiro-Wilk test			Difference test		
	Statistics	df	Test significance	Test selection	Result of the test	Test significance
Numbers of patents	0,547	132	0,000	Wilcoxon	-1,260	0,208
Total employment	0,293	125	0,000	Wilcoxon	-4,595	0,000
Total assets	0,250	131	0,000	Wilcoxon	-6,362	0,000
Size (ln total assets)	0,916	131	0,000	Wilcoxon	-6,839	0,000

Source: own study based on data obtained from financial documents of companies debuting on the WSE.

The above results indicate that among innovative companies debuting on the WSE after the IPO, innovation measured by the number of patents decreases. The size of the company is increasing, measured both by total employment (by 80 positions on average) and in total assets (Table 1).

Conducting a test of the significance of differences allowed us to notice that among innovative companies there are statistically significant differences in the results achieved before and after the IPO in the categories of total employment, total assets, and total assets (Table 2).

5.2. General information – non-innovative companies

The same indicators regarding general characteristics were compared among non-innovative companies debuting on the WSE.

Table 3.

General information on non-innovative companies debuting on the WSE before and after the IPO

Index	X	Arithmetic average	Median	Min	Max	SD
Numbers of patents (pcs)	before IPO	0	0	0	0	0
	after IPO	0,09	0	0	8,00	0,58
Total employment (FTE)	before IPO	386,52	102,00	1,00	11 174,00	1 373,61
	after IPO	415,50	179,00	3,00	10 358,00	1 232,84
Total assets (PLN)	before IPO	242 145,22	64 043,00	1 396,00	9 816 186,00	891 683,16
	after IPO	478 805,27	140 780,00	4 606,00	14 162 151,00	1 521 745,86
Size (ln total assets)	before IPO	11,01	11,07	7,24	16,10	1,54
	after IPO	11,94	11,85	8,44	16,47	1,38

Source: own study based on data obtained from financial documents of companies debuting on the WSE.

Table 4.

Comparison of general data on non-innovative companies debuting on the WSE before and after the IPO

Index	Shapiro-Wilk test			Difference test		
	Statistics	df	Test significance	Test selection	Result of the test	Test significance
Numbers of patents	0,079	462	0,000	Wilcoxon	-3,274	0,001
Total employment	0,237	401	0,000	Wilcoxon	-6,907	0,000
Total assets	0,234	451	0,000	Wilcoxon	-11,828	0,000
Size (ln total assets)	0,994	451	0,055	t-Student	-16,908	0,000

Source: own study based on data obtained from financial documents of companies debuting on the WSE.

The obtained results show that making non-innovative companies public on the WSE leads to a slight increase in their innovativeness measured by the number of patents. Total employment increases (by approximately 30 positions on average), average total assets almost double, and therefore total assets increase (Table 3).

Similarly, to the results of innovative companies, also for non-innovative ones, the differences in results between the situation before and after the IPO are statistically significant in the case of indicators regarding the size of the enterprise, and additionally also in the case of the number of patents (Table 4). Raising capital on the stock exchange opens up new development prospects for companies. It is indicated that public enterprises often invest in assets, mainly intangible ones, which would confirm the increase in their size obtained in the research. the status of public companies helps attract new employees. Increasing production capabilities and growing sales force an increase in the company's labor resources (Chemmanur et al, 2020). At the same time, there is often an exodus of key innovators after an IPO, which is why companies need to develop incentives and provide a favorable working environment (Bernstein, 2015). This research is limited to examining the amount of total employment, ignoring the education of employees, which is often significant for the implementation of innovative processes.

5.3. Profitability - innovative companies

In the next stage, the profitability achieved before and after the IPO by companies conducting innovative activities was compared. For this purpose, changes in ROA, ROE and ROS indicators were examined.

With respect to innovative companies, the IPO had a negative impact on ROA and ROE indicators. There was a noticeable positive impact on the ROS index, improvement from -13.73 to -0.21. However, sales among innovative companies remained unprofitable (Table 5).

Table 5.*Profitability of innovative companies debuting on the WSE before and after the IPO*

Index	X	Arithmetic average	Median	Min	Max	SD
Net ROA	before IPO	0,07	0,08	-1,90	0,50	0,27
	after IPO	0,01	0,05	-1,33	0,43	0,21
Net ROE	before IPO	0,15	0,14	-3,28	0,75	0,47
	after IPO	0,07	0,08	-1,24	1,72	0,29
Net ROS	before IPO	-13,73	0,07	-400,06	0,53	68,84
	after IPO	-0,21	0,06	- 11,68	0,54	1,56

Source: own study based on data obtained from financial documents of companies debuting on the WSE.

Table 6.*Comparison of the profitability of innovative companies debuting on the WSE before and after the IPO*

Index	Shapiro-Wilk test			Difference test		
	Statistics	df	Test significance	Test selection	Result of the test	Test significance
Net ROA	0,464	131	0,000	Wilcoxon	-3,865	0,000
Net ROE	0,517	131	0,000	Wilcoxon	-4,336	0,000
Net ROS	0,127	129	0,000	Wilcoxon	-2,068	0,039

Source: own study based on data obtained from financial documents of companies debuting on the WSE.

Among innovative companies, there are statistically significant differences in the results achieved before and after the IPO in relation to all profitable indicators (Table 6).

5.4. Profitability – non-innovative companies

Then, changes in profitability among non-innovative companies were examined.

Table 7.*Profitability of non-innovative companies debuting on the WSE before and after the IPO*

Index	X	Arithmetic average	Median	Min	Max	SD
Net ROA	before IPO	0,09	0,07	-0,14	0,63	0,11
	after IPO	-0,03	0,03	-1,67	0,25	0,24
Net ROE	before IPO	0,24	0,18	-4,76	3,20	0,48
	after IPO	-0,08	0,06	-7,76	3,17	0,95
Net ROS	before IPO	-0,23	0,04	-58,01	2,43	4,00
	after IPO	-0,29	0,03	- 24,58	0,90	1,89

Source: own study based on data obtained from financial documents of companies debuting on the WSE.

Table 8.*Comparison of the profitability of non-innovative companies debuting on the WSE before and after the IPO*

Index	Shapiro-Wilk test			Difference test		
	Statistics	df	Test significance	Test selection	Result of the test	Test significance
Net ROA	0,649	451	0,000	Wilcoxon	-7,848	0,000
Net ROE	0,454	451	0,000	Wilcoxon	-8,334	0,000
Net ROS	0,108	449	0,000	Wilcoxon	-5,018	0,000

Source: own study based on data obtained from financial documents of companies debuting on the WSE.

Companies not conducting innovative activities recorded a deterioration in all profitability indicators, the largest drop was noticeable in the case of ROE. It is worth emphasizing that the post-IPO metrics were negative, which confirms the unfavorable situation of companies after their stock exchange debut. Additionally, after the debut, the average profit per share decreased and non-innovative entities showed a loss (Table 7).

The above table (Table 8) indicates the existence of statistically significant differences between the profitability of non-innovative companies before and after the IPO.

The obtained results confirm that the profitability of companies after IPO decreases, but the decreases are smaller for companies conducting innovative activities. A decrease in profitability ratios (ROA and ROE) among companies listed on the Thai stock exchange in 2009-2013 was also noticed by A. Chalarat (2018). Other researchers also pointed to the deterioration of profitability indicators, emphasizing the role of shaping the financial result before the IPO (Ahmad Zaluki, 2005). However, this issue was omitted in this study. However, it can be assumed that entities debuting on the WSE influence the financial result to some extent, as the decline in profitability is often explained by problems with maintaining the current results (Kao et al., 2009).

5.5. Financial liquidity - innovative companies

The next step focused on changes in financial liquidity and debt of innovative companies.

In the case of financial liquidity ratios, their average values increased after the IPO, exceeding the standards accepted in the literature, which proves the financial surplus of companies after the debut. At the same time, the total debt ratio (from 0.47 to 0.36) and the equity debt ratio (from 1.33 to 0.61) decreased, which may indicate the implementation of an appropriate innovation strategy using the optimal capital structure (Table 9).

Table 9.

Financial liquidity and debt of innovative companies debuting on the WSE before and after the IPO

Index	X	Arithmetic average	Median	Min	Max	SD
Current ratio	before IPO	1,79	1,51	0,32	7,27	1,21
	after IPO	3,25	1,75	0,16	20,23	3,64
Quick ratio	before IPO	1,35	1,11	0,16	7,27	1,12
	after IPO	2,61	1,36	0,14	20,23	3,62
Cash ratio	before IPO	0,49	0,15	0,00	6,12	0,96
	after IPO	1,38	0,30	0,01	18,22	3,34
Total debt ratio	before IPO	0,47	0,41	0,07	0,87	0,20
	after IPO	0,36	0,30	0,06	1,77	0,25
Debt equity ratio	before IPO	1,33	0,75	0,07	6,50	1,33
	after IPO	0,61	0,44	-2,29	3,16	0,72

Source: own study based on data obtained from financial documents of companies debuting on the WSE.

Table 10.

Comparison of financial liquidity and debt of innovative companies debuting on the WSE before and after the IPO

Index	Shapiro-Wilk test			Difference test		
	Statistics	df	Test significance	Test selection	Result of the test	Test significance
Current ratio	0,559	131	0,000	Wilcoxon	-4,454	0,000
Quick ratio	0,484	131	0,000	Wilcoxon	-4,173	0,000
Cash ratio	0,366	129	0,000	Wilcoxon	-3,355	0,001
Total debt ratio	0,888	126	0,000	Wilcoxon	-4,939	0,000
Debt equity ratio	0,740	126	0,000	Wilcoxon	-5,157	0,000

Source: own study based on data obtained from financial documents of companies debuting on the WSE.

The results of the Wilcoxon test comparing differences in financial liquidity and debt of innovative companies debuting on the WSE confirm that these differences are statistically significant (Table 10).

5.6. Financial liquidity – non-innovative companies

Financial liquidity and debt ratios behave similarly to indicators for innovative entities but are similar to the standards adopted in the literature. The only indicator with a different tendency of change is the debt-to-equity ratio. In the case of non-innovative companies, it increases after the IPO (from -3.82 to 1.27), which indicates a very high burden of external capital on equity capital (Table 11).

Table 11.

Financial liquidity and debt of non-innovative companies debuting on the WSE before and after the IPO

Index	X	Arithmetic average	Median	Min	Max	SD
Current ratio	before IPO	2,06	1,32	0,03	33,09	2,91
	after IPO	2,30	1,54	0,05	17,82	2,45
Quick ratio	before IPO	1,36	0,86	0,03	33,09	2,65
	after IPO	1,58	0,95	0,03	15,86	2,10
Cash ratio	before IPO	0,46	0,10	0,00	31,97	2,25
	after IPO	0,55	0,16	0,00	13,19	1,22
Total debt ratio	before IPO	0,57	0,62	0,06	1,09	0,21
	after IPO	0,53	0,50	0,06	6,49	0,51
Debt equity ratio	before IPO	-3,82	1,71	-1 186,56	35,14	79,88
	after IPO	1,27	0,95	-6,89	22,21	2,49

Source: own study based on data obtained from financial documents of companies debuting on the WSE.

Table 12.

Comparison of financial liquidity and debt of non-innovative companies debuting on the WSE before and after the IPO

Index	Shapiro-Wilk test			Difference test		
	Statistics	df	Test significance	Test selection	Result of the test	Test significance
Current ratio	0,533	451	0,000	Wilcoxon	-2,858	0,004
Quick ratio	0,433	451	0,000	Wilcoxon	-3,462	0,001
Cash ratio	0,224	444	0,000	Wilcoxon	-3,301	0,001
Total debt ratio	0,537	451	0,000	Wilcoxon	-5,352	0,000
Debt equity ratio	0,039	451	0,000	Wilcoxon	-7,058	0,000

Source: own study based on data obtained from financial documents of companies debuting on the WSE.

The results of the Wilcoxon test comparing differences in financial liquidity and debt of non-innovative companies debuting on the WSE confirm that these differences are statistically significant (Table 12).

Obtaining the status of a public company increases the possibilities of obtaining external financing. Public companies often receive bank loans on preferential terms. Moreover, it is confirmed that innovative companies may encounter problems in obtaining external funds necessary to finance innovative projects, which is also reflected in the total debt ratio. An interesting phenomenon is the financial excess shown by innovative companies. These entities deliberately maintain a high level of cash, and the financial surplus is the result of the implemented innovation strategy (Gryko, 2008). Companies conducting innovative activities must therefore maintain high cash levels to be able to finance the next stage of the innovation process at any time.

The above analysis concerned the verification of the hypothesis assuming that the economic situation of an innovative company after its debut deteriorates to a lesser extent than that of a non-innovative company. The hypothesis was confirmed using descriptive statistics and significance tests. Profitability indicators achieved by companies debuting on the WSE decrease after the IPO, but in the case of innovative companies, these decreases are smaller. Additionally, it was confirmed that innovative companies burden the company's assets much more with external capital.

6. Summary

An IPO is one of the ways to raise capital for developing enterprises, especially those that conduct innovative activities. An IPO carries both many benefits and risks. First of all, it is an opportunity to obtain large capital, improves credibility and creates the opportunity to improve the company's economic situation. From the point of view of innovative activity, it allows risk to be spread over a larger number of shareholders and to attract new innovators to the company. On the other hand, carrying out the process is very expensive and time-

consuming, and also results in capital dilution. Moreover, innovative entities may face pressure from shareholders who will demand that they give up long-term innovative projects in favor of short-term profits. Moreover, economists have noticed that going public is associated with a deterioration of its economic situation after the debut. The results of our own research allowed us to notice that the IPO affects the deterioration of the economic situation of companies debuting on the WSE. The hypothesis was confirmed using descriptive statistics and significance tests. This is visible primarily in the deteriorating profitability indicators. However, conducting innovative activities before the debut protects the company against deterioration of indicators. Therefore, the company's managers should analyze the benefits and negative aspects resulting from the IPO in order to make the optimal decision for the company's economic situation and innovative activities.

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DISSIMILAR WELDING OF FERRITIC STEEL H17 WITH DOCOL 1100 FOR THE AUTOMOTIVE APPLICATION

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Purpose: The main novelty and the goal of the paper is to develop the possibility of dissimilar welding for automotive resort. The welding automotive structure is connected with two various grades of steel with different structure.

Design/methodology/approach: Two dissimilar metals were checked in welding process in order to get a high-quality joint for automotive industry. The properties of the joint were checked by non-destructives and destructive tests.

Findings: Relations between welding parameters and the quality of welds.

Research limitations/implications: In the future, it can be suggested to investigate the effect of modern shielding gas mixtures for the MAG welding.

Practical implications: The proposed process innovation will not cause problems in the production.

Social implications: Modifying the shielding gas mixtures will not affect the environment and production management methods. Producing dissimilar welds translates into savings.

Originality/value: It is to propose a new solution in automotive resort with modern welding process and scientific justification. The article is especially addressed to manufacturers of dissimilar material for automotive industry and other means of transport.

Keywords: automotive, dissimilar, welding, H17, DOCOL 1100 M, transport, shielding gas mixture, production savings.

Category of the paper: Research paper.

1. Introduction

The article shows the results of various MAG (metal active gas) welding tests for dissimilar welds. Two various materials were joined with totally dissimilar structure. Ferritic steel H17 (1.4016, X6Cr17) with martensitic steel DOCOL 1100 M were welded by MAG process with various gas mixtures. These dissimilar grades of steels were dedicated into automotive industry, however many applications in other sectors might be possible. The dissimilar welds are recommended for automotive industry because it corresponds with economic savings (Jaewson et al., 2011; Darabi et al., 2016; Hadryś, 2015). Dissimilar welding in this case is difficult because of completely different structures: delta ferrite and martensite (Golański et al., 2018, pp. 53-63; Skowrońska et al., 2017, pp. 104-111). The popular H17 steel was selected as an example of ferritic steel for the application in the automotive industry, while the high-strength DOCOL 1100 M steel was selected as a martensitic steel. In this type of welds, there are often observed welding defects and incompatibilities, mainly cracks in the HAZ (heat affected zone). The quality of connections depends on correctly selected parameters (Silva et al., 2019; Krupicz et al., 2020). The main MAG welding parameters are:

- composition of gas mixtures in MAG welding,
- type of electrode wires,
- pre-heating temperature.

Dissimilar welding of ferritic (delta) steel with martensitic steel is complicated because of different mechanical properties (Fydrych, Łabanowski et al., 2013; Shwachko et al., 2000). Preheating is sometimes recommended for some dissimilar welds (Szymczak, 2020). In the paper, it was mainly decided to check the influence of various amount of nitrogen added to the shielding gas mixture and the pre-heating temperature. In the case usage of H17 steel, nitrogen is treated as an austenite former, and in the case of DOCOL 1100 M steel, nitrogen taken from shielding gas forms nitride inclusions that strengthen the base material and the weld. However, there is a rule, that nitrogen content in the weld metal deposit cannot be too high, because it leads to cracks (Szymczak, 2020).

2. Materials

For dissimilar MAG welding of austenitic H17 steel with martensitic DOCOL 1100 M steel two austenitic electrode wires were chosen: Lincoln IMT 307Si and 309LSi (both with austenitic structure). Attempts were also made to weld this dissimilar joint with non-alloy steel wires, but these tests did not give good results. There were various types of welding defects, mainly in the form of cracks. The main direction of research was the modification of gas

mixtures in the MAG process containing Ar and CO₂, to which it was decided to introduce different nitrogen contents.

Before the welding process, it was realized the drying preheating at three different temperatures of 115°C, 125°C and 135°C. A thickness of both grades of steel was 4 mm. Table 1 shows the mechanical properties of both materials.

Table 1.

Tensile strength of tested dissimilar grades of steel

Steel grade	YS, MPa	UTS, MPa
H17	280	590
DOCOL 1100 M	920	1080

The data from tab. 1 indicates that both grade of steel have completely different properties. Martensitic DOCOL 1100 M steel has much higher strength (UTS) and elevated yield strength (YS) than delta ferritic steel H17. These dissimilar mechanical properties result from various composition of tested materials (Table 2).

Table 2.

Chemical composition of tested grades of steel

Steel	C	Si	Mn	P	S	Al	Cr	Mo	Nb	Ni	Ti
H17	0.08	0.9	1.1	0.035	0.02	0.01	17.5	-	-	-	-
DOCOL 1100 M	0.1	0.12	0.22	0.01	0.002	0.03	0.02	0.04	0.11	0.02	0.21

The table shows that both steel grades differ mainly in their chromium content. Both steels do not have good plastic properties, so it was decided to weld them with authentic wire. It was decided to weld both materials with two different wires (Tab. 3). The wires were selected to differ significantly in their chromium content.

Table 3.

Electrode wire UNION-X90 –composition

Wire	C%	Si%	Mn%	P%	Cr%	Mo%	Ni%	Ti%	P	S
307Si	0.19	0.8	3	0.010	14	0.1	10	0.005	0.015	0.01
309LSi	0.02	0.85	1.8		24	0.2	14	0.001	0.02	0.02

It was tried to make a 2 mm thick joint without chamfering. The electrode wire diameter in both cases (307Si and 307LSi) had 1 mm. The weld was only made as single-pass. At the beginning of weldin process, the voltage and current parameters were determined:

- arc voltage: 20 V.
- welding current: 117 A,

After that, other welding parameters were determined as follow:

- welding speed: 320 mm/min,
- shielding gas flow: 14.5 dm³/min.

The joints were made with few variants. The most important analyzes included checking the preheating temperature and selecting wire with different chromium content (14% and 24% Cr). MAG welding process was realized with a shield of two gas mixtures containing:

- Ar-18%-CO₂,
- Ar-18%-CO₂-1% N₂.

A very important point of the research was to determine the most appropriate preheating temperature:

- pre-heating to the temperature of 115°C,
- pre-heating to the temperature of 125°C,
- pre-heating to the temperature of 135°C.

3. Methods

After welding process with various parameters non-destructive tests (NDT) and also (DT) destructive tests were realized to assess the quality of the joint.

As NDT testing was proposed:

- VT – visual test → PN-EN ISO:17638.
- MT- magnetic particle test → PN-EN ISO:17638 standard.

As destructive testing was proposed:

- nitrogen measurements in metal deposit (was realized on the LECO ONH836 analyzer),
- tensile strength → PN-EN ISO 527-1 standard,
- bending test → PN-EN ISO 7438 standard.

4. Results and discussion

The dissimilar ferritic-martensitic joints were made using two different electrode wires, two different variants of shielding gases and with three different pre-heating temperature. In total, 12 different joints were made, marked with samples from D1 to D-12 (tab. 4).

Table 4.
Samples designations

Sample	Wire	Shielding gas mixture	Pre-heating temperature, °C
D1	307Si	Ar-18%-CO ₂	115
D2	307Si	Ar-18%-CO ₂	125
D3	307Si	Ar-18%-CO ₂	135
D4	307Si	Ar-18%-CO ₂ -1% N ₂	115
D5	307Si	Ar-18%-CO ₂ -1% N ₂	125
D6	307Si	Ar-18%-CO ₂ -1% N ₂	135
D7	309LSi	Ar-18%-CO ₂	115
D8	309LSi	Ar-18%-CO ₂	125
D9	309LSi	Ar-18%-CO ₂	135
D10	309LSi	Ar-18%-CO ₂ -1% N ₂	115
D11	309LSi	Ar-18%-CO ₂ -1% N ₂	125
D12	309LSi	Ar-18%-CO ₂ -1% N ₂	135

After welding, NDT tests were performed. It was found that a significant part of the joints made were free from welding defects and inconsistencies (marked in green colour), but there were also joints made incorrectly (marked in pink colour). The NDT results with comments during inspection are presented in Table 5.

Table 5.
NDT results for tested dissimilar welds

Sample	Observation
D1	Small cracking in HAZ from the H17 steel side
D2	Correct joint
D3	Small cracking in HAZ from the H17 steel side
D4	Small cracking in HAZ from the DOCOL 1100 M steel side
D5	Correct joint
D6	Small cracking in HAZ from both sides
D7	Small cracking in HAZ from the DOCOL 1100M steel side
D8	Correct joint
D9	Small cracking in HAZ from both sides
D10	Correct joint
D11	Correct joint
D12	Small cracking in HAZ from both sides

It was observed that the main factor for the good quality of the weld is proper preheating temperature. The selection of the correct gas mixture and electrode wires was less important. In next part of the investigation it was decided to test all joints that did not have defects (marked with green colour in the Table 5). The first part of the destructive test corresponded with counting the nitrogen amount the weld in terms of main welding parameters. All analysis were realized on the analyzer LECO-ONH-836. The nitrogen amount in the weld is presented in Table 6.

Table 6.*Nitrogen amount in dissimilar weld metal (WMD)*

Sample	Nitrogen in WMD, ppm
D2	55
D5	60
D6	60
D8	50
D10	60
D11	60

It was noted that in all tested joints made with shielding gas A, the nitrogen in the weld was at a lower level of 55 ppm. It was observed that in all tested joints made with shielding gas B, the nitrogen in the weld was at a higher level of 55 ppm.

The next step of the investigation was to realize tensile strength of the selected samples free from welding defects (horizontal rows marked in green colour in tables 4 and 5). The tests were performed at a temperature of 20° C. The mechanical properties of the tested joints are presented in Table 7.

Table 7 shows the tensile strength (UTS) of the tested welds.

Table 7.*Tensile strength of joints*

Sample	UTS [MPa]
D2	486
D5	499
D6	498
D8	511
D10	527
D11	513

The data from the tab. 7 indicate that it is possible to achieve high tensile strength of the dissimilar delta ferrite-martensite joint over the 500 MPa (horizontal rows marked in blue colour). Such good results were achieved only when simultaneously:

- pre-heating temperature is 125°C,
- austenitic wire with higher amount of Cr is chosen (24% Cr),
- amount of 1% N₂ is added to Ar-18%CO₂ gas mixture,

As the next part of the project a bending tests was realized. Measurements were done from the face and ridge sides of the weld The obserwation of bending test are put in Table 8.

Table 8.*Bending test of dissimilar weld*

Sample	Face side	Ridge side
D2	No cracks	No cracks
D5	small cracks	No cracks
D6	No cracks	small cracks
D8	No cracks	No cracks
D10	small cracks	No cracks
D11	No cracks	No cracks

In a half of the samples tested, the results were positive. Bending tests indicate that the pre-heat temperature must be 125°C.

5. Summary

The paper was devoted to the development of appropriate welding parameters for a dissimilar steel joint with two completely different structures: delta ferrite and martensite. Such joints are very difficult to make and require extensive material knowledge and welding experience. Initially, attempts were made to weld the joints with various electrode wires, but it was noticed that the best results were achieved with a wire with an austenitic structure. A large number of tests (initially 12) were performed with various combinations of process parameters, which included 2 different electrode wires, two different shielding gas mixtures, and three different preheating temperatures. The results of NDT tests, and then gradually implemented results of destructive tests, successively allowed for narrowing down the joints with the unsatisfactory mechanical properties and quality. The nitrogen content in the joints was checked and they did not show any cracks. It was found that the addition of 1% N₂ to the standard Ar-18% CO₂ shielding mixture slightly increases the nitrogen content in the weld from 55 ppm to 60 ppm. Therefore, the strength of the joints increased to a very satisfactory level of over 500 MPa.

Based on the research conducted, the following conclusions were proposed:

1. The ability to make dissimilar joints allows for significant process savings.
2. Dissimilar steel joints dominated by delta ferrite in first material and martensite in the second material are difficult to produce.
3. The process parameters should be selected very carefully.
4. The most important parameters of the process are the preheating temperature, the chemical composition of the shielding gas mixture and the type of electrode wire.
5. The best welding results were obtained when:
 - the preheating temperature was 125°C,
 - the shielding gas mixture contained Ar-18% CO₂-1%N₂,
 - an electrode wire with 24% Cr was used.

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THE ESSENCE OF PROCESS MANAGEMENT THROUGH THE METHODS AND TECHNIQUES USED IN IT

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Purpose: The article aims to identify and systematize the current scientific achievements in the area of methods and techniques used in process management.

Design/methodology/approach: The article is a review, in which the method of exploratory research of existing materials is used, including a systematic review of the literature and the desk research method. The obtained results were subjected to qualitative comparative and critical analysis.

Findings: The results of the analysis showed that some methods and techniques can be difficult to implement or resource-intensive. Therefore, organizations need to be aware of these challenges and plan accordingly, paying attention to employee training, change management, and ensuring adequate resources are provided.

Research limitations/implications: The concepts, methods, and techniques of process management mentioned in this publication are not exhaustive. Many other actions should be carefully examined.

Originality/value: The study attempts to organize the methods and techniques used in process management so far. It can be an interesting reference material for other researchers and managers responsible for the area of process management in organizations.

Keywords: Process Management, Organization Management, Process Mapping.

Category of the paper: Literature review.

1. Introduction

In traditional structures found in an organization, the overall processes are divided into fragments, and each of them can be carried out by different organizational units. The classic improvement of the organization, which consists of the improvement of the activities of employees within a specific organizational unit, does not include the perspective of the entire

process in which this unit participates. As a result, employees can perfectly perform their work within their duties, in their organizational unit, and yet the overall process (in which this unit participates) may be inefficient, e.g. due to too long (time-consuming) flow of documentation between different departments of the organization. The main reason for this state of affairs is considered to be the problems of coordinating the flow of processes between different organizational units. This means that by analyzing the overall processes in the organization and then making appropriate changes in the processes and organizational structure, it is possible to ensure more effective and effective cooperation between the organization's employees and the proper fluidity of processes between different departments (e.g. by eliminating downtime or duplication of activities).

Changing an organization's more ubiquitous functional management habits to process management requires knowledge and skills in several areas. Many subdisciplines of management are involved in process management, which according to Burlton (2001) is its strength, not its weakness. Effective and efficient process management is an essential element of success in any organization (Fischbacher-Smith, 2017). In today's fast-paced world, organizations need to be able to quickly and effectively adapt their processes to changing conditions. In this context, various process management methods and techniques such as 5S (Patra et al., 2005), Just in Time (Zatar, 2022), Ishikawa chart (Bose, 2012), Pareto analysis (Alecu, 2010), Balanced Scorecard (Alsyouf, 2006) and many others are essential for effective process management (Ubaid, Dweiri, 2020).

The authors attempted to conduct a comparative analysis of management methods and techniques, verifying their strengths and weaknesses. In addition, it discusses how these methods and techniques are applied in the context of selected management concepts, such as Benchmarking (Holloway et al., 1997), Reengineering (Kubicová, 2015), Lean (Reynders, Kumar, Found, 2022), Six Sigma (Patel, Chudgar, 2020), Total Quality Management (Jasti et al., 2022) and others.

Methods and techniques of process management in the scientific literature are often discussed in the context of their practical application. However, it is worth noting that achieving the desired results through the use of different process management methods and techniques depends on the specifics of the organization and the context in which they are used. Therefore, an organization needs to have a general understanding of what goals and processes make it up before implementing specific actions.

2. Research methodology

The exploratory method and the so-called desk research were used in the study. Methods. The identification of research gaps was preceded by a systematic review of the literature on the issue of process management in research organizations. There are still few studies in the literature devoted to a comprehensive approach to methods and techniques used in process management. In addition, few sources indicate how individual management concepts use developed and proven process management mechanisms. Therefore, the aim of the paper is m.in to systematize the current scientific achievements in the context of methods and techniques used in process management, but also for the needs of other management concepts.

From several available databases, a targeted selection was made and the resources collected in the Scopus and Web of Science databases were subjected to a deeper analysis (Figure 1). To systematize the search, a list of criteria was created according to which data mining was carried out.

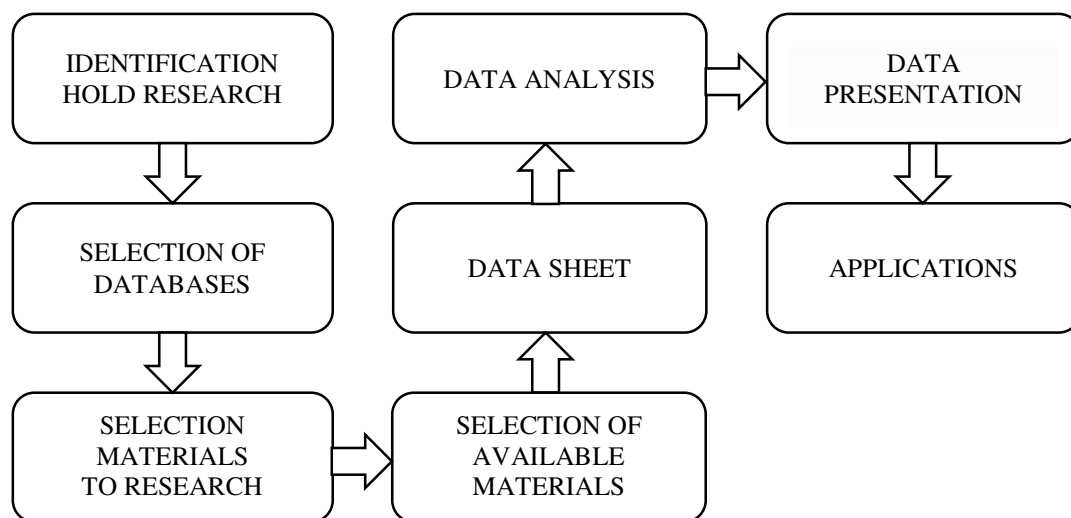


Figure1. Systematic literature review.

Source: own elaboration.

The type of publication was used as the first criterion and the search was limited to scientific articles and review articles only. Then, the phrases (phrases) that best reflected the context and subject of consideration were determined, i.e. "process management methods" and "process management techniques". As a result of narrowing down the search area, 78 entries for the phrase "process management methods" and 76 entries for the phrase "process management techniques" were obtained in the Scopus database (Table 1). On the other hand, in the case of the Web of Science database, the number of these items was much higher and amounted to 656 items for the first return, and 42,108 items for the second return, respectively.

Table 1.*Summary of the results of the review of selected databases*

Database Criteria	Scopus		Web of science	
	Process Management Methods	Process Management Techniques	Process Management Methods	Process Management Techniques
no restrictions	78	76	656	42,108
English only	64	71	623	40,132
type of materials	61	68	619	39,939
Open access	17	14	202	12,890
only articles	11	7	81	170

Source: own elaboration.

In the next stage of the selection of the collected publication database, further exclusion criteria were applied, publications in English were qualified for further analysis, and all publications in other languages were rejected. As a result of this procedure, publications in the Scopus database were limited to 64 items for the term "process management methods" and 71 items for the term "process management techniques". Accordingly, in the Web of Science database, 623 entries were obtained for the first term and 40,132 for the second term. Another exclusion criteria was the type of source materials, which means that only book chapters, articles, and conference proceedings were allowed to be analyzed. All other available forms of source material have been excluded. This criterion did not result in a significant decrease in the number of items to be tested.

For the term "process management methods" in the Scopus database, 17 and 11 items were obtained, respectively, for the following exclusion criteria, i.e. open access and article only. On the other hand, in the same database, 14 and 7 items were obtained for the term 'process management techniques' and using the same exclusion criteria respectively.

The same process of applying the exclusion criteria was applied to both terms in the Web of Science database, resulting in a final score of 81 entries for the term "process management methods" and 170 entries for the term "process management techniques". At this stage, the database of publications has been further filtered using the inclusion of phrases in the text and abstracts, and not only in the titles of scientific publications. As a result of this operation, the final analysis was based on 94 publications.

3. Process management in selected management concepts

The essence of management is to effectively direct an organization's resources to achieve specific goals. Process management is a structured and systematic approach to the analysis and continuous improvement of processes (Biazzo, Bernardi, 2003). Hellström and Eriksson (2013) see process management as a set of many methods, techniques, and tools that, when properly applied, enable the staff of an organization to improve its functioning and improve internal

processes. In addition, the essence of process management is both purely technical aspects and the human factor (Snell, Dean, 1992). When talking about process management, we should refer directly to the aspects related to processes, which include identifying, planning, organizing, conducting, and controlling the flow of work, performing tasks, and optimizing results. In other words, it's administration and continuous improvement of processes in the organization.

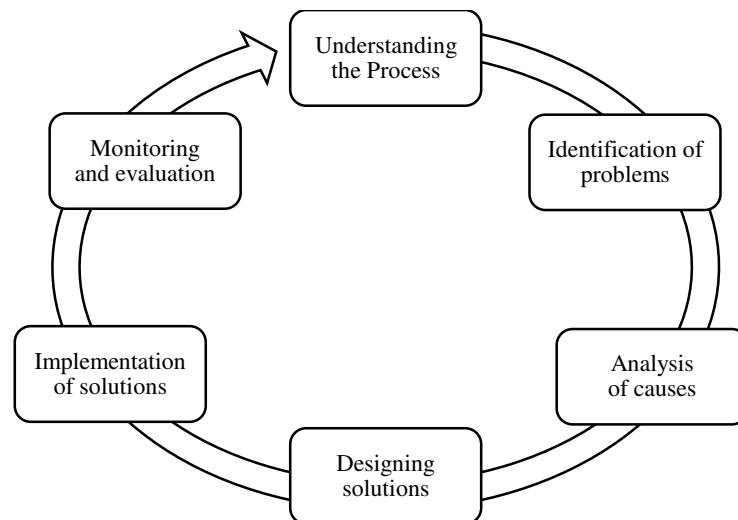


Figure 2. Essential elements of process management in an organization.

Source: own elaboration.

An organization whose decision-makers want to use process management must be aware that this is a time-consuming process and requires the support of both senior management and all employees (Aguilar-Saven, 2003). At the same time, the indicated way of carrying out tasks must be understandable to all participants, as it is difficult to identify areas for improvement or understand how the changes introduced will affect overall performance without knowing them (Brocke et al., 2015). In process management, all the elements indicated in Figure 1 are closely interrelated. If you do not know and understand the processes implemented in the organization, you cannot expect that the identification of problems will be effective, focusing the attention of decision-makers on their solution (Åslund, Bäckström, 2017). In addition, the lack of understanding of processes makes it impossible to determine where inconsistencies occur and does not allow us to understand their causes (Dei, van der Walt, 2020). On the other hand, understanding the causes of problems allows the organization to direct its actions toward their elimination, not just dealing with their effects (Arantes et al., 2023; Benner, Tushman, 2003; Danilova, 2019; Kohlbacher, Gruenwald, 2011; Lee, Dale, 1998; Navarro, 2021; Ponsignon, Smart, Maull, 2012; Saravia-Vergara et al., 2023; Segatto et al., 2013; Sonteya, Seymour, 2012).

Another key element in process management is the ability to develop valuable solutions to eliminate the causes of non-compliance (Silva et al., 2012). The proposed actions may include changing the process, modifying its components, using other methods and techniques, or systematically improving existing processes that also require their implementation

(Draulans, deMan, Volberda, 2003). At this point, once again, all stakeholders must understand the processes, as it requires them to be fully involved in, m.in, for example, change management, training delivery, and monitoring the impact of changes on their performance (Rolinek et al., 2014). Any change or modification made to existing processes cannot go unchecked and cared for by the staff, as the management of the organization must be aware of whether the expected benefits have been achieved (Macdonald et al., 2016; Susa Vugec et al., 2018). When talking about process management, it should be borne in mind that they cover various areas of knowledge, from economics, engineering and marketing, to psychology and human behavior (Bachmann, Jodlbauer, 2023).

There are many different management concepts, and the choice of the one best suited to the specifics of the organization depends on the management of the organization (Bloom et al., 2012). In the era of constant change, management concepts implement some of the elements of process management to streamline them and improve both the efficiency and effectiveness of their results (Abd Rahman et al., 2013). In this context, the organization should be seen as a system of processes that should be mapped, improved, and kept under control (Aparecida da Silva et al., 2012; Armistead, Pritchard, Machin, 1999). In the literature on the subject, it is possible to distinguish various management concepts, which in their assumptions refer to selected elements of process management. Interesting conclusions can be drawn when comparing the concepts of management and the elements of process management used in them (Table 2).

Table 2.

Selected management concepts using elements of process management

Concept	Elements of Process Management
Total quality management (TQM)	<ul style="list-style-type: none"> • using processes to improve the quality of products and services, • process improvement is one of the main objectives of the concept, • flattened hierarchical structure, • focus on process thinking constant monitoring of the course of processes, • teamwork in process improvement.
Lean management	<ul style="list-style-type: none"> • minimizing waste in processes, • emphasis on improving the flow in processes by eliminating unnecessary activities, • flattening of hierarchical structures processes are key elements of the organization, • constant monitoring of the course of processes, • teamwork in process improvement.
Business Process Reengineering (BPR)	<ul style="list-style-type: none"> • radical change of processes to improve quality, • analysis of processes for the client's needs and elimination of low-value work, • flattening of hierarchical structures, • processes are key elements of the organization, • constant monitoring of the course of processes, • group work in the reorganization or reconstruction of processes, • simplification and standardization of overly complicated work, as well as automation of repetitive work, • enabling processes with modern systems and data.

Cont. table 2.

Six sigma	<ul style="list-style-type: none"> • minimizing errors is one of the key goals, • processes are key elements of the organization, • improvement of processes focused on customer and organizational satisfaction, • strong emphasis on constant monitoring and measurement of various aspects of the process, • continuous quality improvement based on statistical analysis of processes, • teamwork in process improvement.
Benchmarking	<ul style="list-style-type: none"> • thorough needs assessment comparing your processes to the best processes in the organization's industry, • analysis and use of the experience of others, • strives to improve the efficiency of processes, • focuses more on processes than on statically understood properties, features, values, effective planning, • management and measurement of changes, • teamwork in process improvement.
Outsourcing	<ul style="list-style-type: none"> • sourcing goods and services needed by the organization from outside, • concentrating processes on the essential goals and key competencies of the organization, • improves the elasticity of the structure, • continuous monitoring, • focus on optimizing and improving process efficiency.

Source: own elaboration on the base on: Agus, 2004; Armistead, Pritchard, Machin, 1999; Andersson, et al., 2006; Antony et al., 2021; Ballard, Howell, 2003; Bandyopadhyay, Lichtman, 2007; Bañuelas, Antony, Brace, 2005; Brilman, 2002; Ciptono, 2007; Erdil, Erbiyik, 2019; Hellström, Eriksson, 2013; Holloway et al., 1997; Jarvenpaa, Stoddard, 1998; Kadarova, Demecko, 2016; Lee, 2020; Macintosh, Maclean, 1999; Parkes, 2015; Prajogo, Sohal, 2003; Sweeney, 1994; Tayauova, 2012; Zitkiene, Dude, 2018.

The most frequently mentioned management concepts include Total Quality Management Lean Management (Parkes, 2015), Business Process Reengineering (Ciptono, 2007), Six Sigma (Bañuelas, Antony, Brace, 2005), Benchmarking (Sweeney, 1994), and Outsourcing (Lee, 2020). Total Quality Management focuses on quality, where the organization is seen as a network of systems and connections existing between them (Prajogo, Sohal, 2003). Using this concept, management focuses on the evolutionary approach to managing an organization, i.e. managing individual processes in all its aspects (Agus, 2004). Another of these management concepts emphasizes the improvement of flow in processes (Andersson et al. 2006). Lean management is a concept of an approach to restructuring an organization (Kadarova, Demecko, 2016). Management should strive to re-examine the tasks performed as part of processes or entire processes and possibly eliminate unnecessary activities (Ballard, Howell, 2003). Rationalization and elimination of waste introduced by the management of the organization should comprehensively cover all areas of its functioning (Douglas, Antony, Douglas, 2015).

The concept of change-oriented in an organization was presented by Hammer (1996), who recognized a focus on processes as an essential ingredient of successful reengineering (Macintosh, Maclean, 1999). The distinguishing feature of reengineering is rapid and radical changes, which must be implemented with the constant participation and support of the entire management of the organization (Jarvenpaa, Stoddard, 1998).

On the other hand, in Six Sigma, i.e. a quality-oriented concept, the involvement of all employees and teamwork are the key to achieving the intended goals (Laureani, Antony, 2019). The basic task carried out by all people who make up organizations is to reduce the variability of both individual processes and their entire groups (Antony, 2021). Therefore, organizational culture and management commitment have a significant impact on the implementation of Six Sigma effectively and efficiently (Bandyopadhyay, Lichtman, 2007).

Another management concept focused on change is benchmarking, the implementation of which assumes comparing one's organization to those that are the best in a given area (Erdil, Erbiyik, 2019). Another key element of this concept is the pursuit of the best possible quality of manufactured products or services (Holloway et al., 1997). It is based on the search for patterns, i.e. ways of proceeding based on the analysis and use of competitors' experience, leading to the success of the entire organization.

Outsourcing, on the other hand, involves purchasing goods and services needed by the organization from external suppliers based on previously concluded contracts and agreements (Tayauova, 2012). In an outsourcing relationship, the contract between the client and the supplier can be of a variety of nature (Damanpour, Magelssen, Walker, 2020). Outsourcing, compared to the usual relationship between the supplier and the customer, is associated with a much greater flow of information and building trust between the parties to the contract (Zitkiene, Dude, 2018). Many of the goals that organizations set for themselves require interdepartmental communication, cooperation, and commitment. Individual workplaces are becoming a thing of the past, or at least they should (Lee et al., 2019). Process management as a concept has its roots in the quality movement and shifting the focus from product characteristics to process characteristics (Hellström, Eriksson, 2013). It should be stated that process management is a broader, more mature concept that is suitable not only for times of revolutionary change but also for times of evolutionary development of organizations (Chromjakova, Trentesaux, Kwarteng, 2021), which is of great importance for both current and future organizations.

4. Methods and techniques used in process management

The purpose of using available methods and techniques in the organization by the management is to improve and improve the effectiveness, efficiency, quality, but also the efficiency of the processes implemented in the organization (Hidalgo, Albors, 2008). In the context of process management, a method is a way of proceeding that allows you to achieve your process-related goals. Technique, on the other hand, is a tool used as part of processes to implement the assumptions of a specific method (Linderman, Schroeder, Sanders, 2010). In the literature as well as in practice, there is a wide range of methods and techniques used for the implementation of process management (Table 3).

Table 3.*Selected techniques and methods used in process management*

Method/Technique	Selected features
5S	<ul style="list-style-type: none"> • increasing the efficiency of processes m.in. removing waste from processes, • organize a work environment that is safe and productive for your team.
Pareto Diagram	<ul style="list-style-type: none"> • graphical distribution of relative and absolute types of errors or problems along with their causes, • hierarchy of factors influencing the studied phenomenon with emphasis on the elements most influencing the problem.
Value Stream Map	<ul style="list-style-type: none"> • a graphical representation of the flow of materials and information that is needed to deliver a product or service to the customer, • identify waste within and between processes, • gain insight into decision-making and process flows.
Single Minute Exchange of Die (SMED)	<ul style="list-style-type: none"> • streamlining current processes by finding solutions to problems within processes, • it helps to find out why processes are not working well, • it helps to find long-term solutions to the problem.
Ishikawa Diagram	<ul style="list-style-type: none"> • a way to visually indicate the causes of a given problem or effect, • identifying and analyzing all possible causes of the problem, • introduces brainstorming sessions to solve problems.
SIPOC Analysis	<ul style="list-style-type: none"> • helps to organize data about human and material resources involved in processes, • identification of all relevant elements needed to improve the process, • defining complex processes that are not properly planned.
Process Map/ Process Flow Chart	<ul style="list-style-type: none"> • graphical visualization of processes showing each of its elements, • supports an understanding of how processes work, • supports the identification of areas within processes that require changes, • processes that require change, • useful in the process of process improvement and in identifying areas for improvement.
Activity Based Costing (ABC)	<ul style="list-style-type: none"> • assessment of the costs of implementing activities, resources, facilities and costs, • assign resources to costs based on their consumption
Just in Time (JIT)	<ul style="list-style-type: none"> • consists in the organization of production, • harmonizing the work of all its elements in order to ensure a continuous flow, reduce unnecessary inventory, reduce overall production costs and improve efficiency, • it enables you to manage your organization's inventory effectively.
Kanban	<ul style="list-style-type: none"> • supports production control, • promotes the principle of no shortages, delays, inventories, queues, idleness, unnecessary operations and controls, and relocation, • liquidation of pre-production, interoperable and product warehouses
Balanced Scorecard (BSC)	<ul style="list-style-type: none"> • a picture of the organization based on four perspectives important from the point of view of organizational effectiveness: financial, customer, internal processes, and development (learning and improvement), • prioritization of activities/initiatives, • integration and monitoring of key processes.
Critical Path Method (CPM)	<ul style="list-style-type: none"> • allows you to estimate the duration of a given process based on the analysis of a sequence of events, • determination of the earliest and latest possible completion times of activities.

Source: own elaboration on the base on Agostino, Arnaboldi, 2012; Gavrilova, Andreeva, 2012; Hajdu, Isaac, 2016; Heinrich et al., 2009; Jonsson, Mattsson, 2006; Marria, Williams, Naim, 2016; McCormack, Rauseo 2005; Pavlović et al., 2014; Pun et al., 2007; Raman, Basavaraj, 2019; Schoensleben, 2010.

Some management techniques are largely based on statistics, others on the scientific method or the specific way of thinking of their creator. Some are easy to implement, but there are also those whose use must be preceded by a series of training and practical workshops. Regardless of the mechanism of their action, the results and results of using each of them require time, regularity, and careful action of the people using them (Bier, Lange, Glock, 2020).

For example, 5S is a set of techniques aimed at establishing and maintaining high-quality workplaces (Marria, Williams, Naim, 2016) and is mainly used in the Lean concept. Kanban is used to optimize work and processes to achieve the highest possible efficiency, and reduce waste to a minimum by visualizing work and continuously improving processes (Jonsson, Mattsson, 2006). Another way to graphically represent the flow of a process or an entire set of processes is a process map (Heinrich et al., 2009). Writing out a sequence of actions, it enables the person to identify downtime and optimize individual work items (McCormack, Rauseo 2005). On the other hand, Pareto analysis using statistics gives management a tool to isolate the factors influencing the outcome of a given action (Raman, Basavaraj, 2019). The other tool that is used to identify the cause and effect of a given quality management situation is the Ishikawa diagram (Pavlović et al., 2014). Just-in-time method supports decision-makers in managing inventory so that it is delivered on schedule and on time (Pun et al., 2007).

Balanced ScoreCard is used to planning daily activities and deliveries, and also assigning priorities to products, activities and results (Agostino, Arnaboldi, 2012). On the other hand, Critical Path Method, gives you the opportunity to indicate the implementation time, minimum and maximum, of key activities affecting the completion of the process (Hajdu, Isaac, 2016). To establish the relationship between the costs incurred, the necessary outlays and the results obtained, the management in the organization should use the Activity Based Costing method (Schoensleben, 2010). A management technique is a recognized method for analyzing or solving a recognized type of management problem in a detailed, systematic manner (Gavrilova, Andreeva, 2012). Both management methods and techniques, skillfully used by the employees of the organization, in most cases, can improve its functioning. At the same time, they can and are used both to counteract and to prevent problems.

5. Process Management Methods and Techniques – Strengths and Weaknesses

Process management is a key aspect of any organization's operations. In the technical dimension, it consists of graphically representing specific resources and data and placing them in a specific process (Isaksson, 2006), comparing the value of a given quantity with a unit of measurement of that size, rebuilding and constantly striving to obtain ideal processes (DeToro, McCabe, 1997). Proper process management can lead to increased efficiency, improved quality,

and reduced costs (Armistead, Pritchard, Machin, 1999). There are many different process management methods and techniques that organizations can employ to achieve these goals. Each of these methods and techniques has its strengths and weaknesses, and their effectiveness depends on the context in which they are used.

Table 4.

Strengths and weaknesses of selected management methods and techniques

Method/Technique	Strengths	Weaknesses
5S	It keeps the workplace tidy and clean, which translates into efficiency and safety	It requires constant commitment and discipline to be effective
Just in Time (JIT)	It minimizes inventory and waste	It is sensitive to supply chain disruptions. It requires careful planning and coordination
Ishikawa diagram	An effective tool for identifying the causes of problems	It does not provide solutions. It requires an in-depth understanding of the process.
Pareto analysis	A powerful tool to identify the most important problems to be solved	It can lead to the overlook of smaller issues that can have large cumulative effects
Balanced Scorecard (BSC)	A comprehensive strategic management tool	It can be difficult to implement and requires commitment at all levels of the organization
Critical Path Method (CPM)	An effective method of project planning	It does not take into account uncertainty and risk
Activity Based Costing	Accurate Costing Method	It can be time-consuming and complicated to implement
Process Map	A useful tool for understanding processes	It can be difficult to maintain when processes change
Kanban	An effective method of workflow management	It requires transparency and open communication to be effective

Source: own elaboration on the base on Alaidaros et al.; Anholon et al., 2017; Bose, 2012; Ghosh, 2017; Kannan, Tan, 2005; Lesakova, Dubcova, Gundová, 2017; Mahdiraji et al., 2016; Nuzhna et al., 2019; Parmentier-Cajaiba, Cajaiba-Santana, 2020; Pavlović et al., 2014; Singh, Vikas, Sharma, 2014.

The 5S method is simple to understand and implement, which makes it attractive to many organizations (Singh, Vikas, Sharma, 2014). However, its effectiveness depends on continued commitment and discipline on the part of employees, which can be difficult to achieve in practice (Anholon et al., 2017). Meanwhile, the *Just-in-time* method is an effective method of reducing inventory and waste, but its effectiveness is vulnerable to supply chain disruptions (Kannan, Tan, 2005). It also requires careful planning and coordination, which can be difficult to achieve in some organizations. The Ishikawa diagram is a tool used to identify causes or problems, which requires an in-depth understanding of the process (Ghosh, 2017). Without training and relevant experience, this can be a huge barrier for staff using the Ishikawa diagram (Bose, 2012). At the same time, it does not provide any way to solve them. On the other hand, Pareto analysis can be a powerful tool for identifying the most important problems to be solved in the hands of the staff (Pavlović et al., 2014). On the other hand, focusing only on the key problems can lead to the omission of these smaller problems, the effects of which can be cumulative.

A comprehensive strategic management tool is the Balanced Scorecard, which requires commitment at all levels of the organization (Lesakova, Dubcova, Gundová, 2017). Another method is the Critical Path Method, which, on the one hand, is effective in planning tasks and

processes, but does not take into account uncertainty and risk (Mahdiraji et al., 2016). This can lead to an underestimation of the time and resources needed to complete tasks and less efficient processes in the organization. Activity Based Costing, on the other hand, provides accurate information about costs, but it can also be time-consuming and complicated to implement, which is often a challenge for organizations with limited resources (Nuzhna et al., 2019). A useful tool for understanding the flow of processes is a process map, which in a changing environment can be unreliable when processes are subject to frequent modifications. This generates the need for continuous monitoring and updating of process maps (Parmentier-Cajaiba, Cajaiba-Santana, 2020). Transparency and open communication in the organization is required from its users by Kanban, which is used to manage the workflow (Alaidaros et al., 2021). This can be a challenge in environments where open communication is lacking. Each of the methods and techniques mentioned above has its own strengths and weaknesses. The key to effective and efficient process management is to identify them and choose the right methods and techniques to apply in a given context according to the needs of the organization.

In conclusion, process management is a key component of any organization's success. The choice of appropriate process management methods and techniques depends on the specifics of the organization, its goals and the context in which it operates (Lenning, 2018). When deciding whether to use any of them, the management of the organization must take into account both their advantages and be aware of their limitations. At the same time, regardless of the chosen method or technique, the key to effective process management is the organization's awareness of the need for continuous improvement and adaptation of its processes to changing environmental conditions.

6. Discussion

Process management is a critical component of any organization's success. Regardless of whether one or another management concept is implemented in the organization, individual methods and techniques of process management are used. Their choice is often dictated by the needs of individual organizations. In some organizations, there is a clear need to improve the quality of processes, in others the focus should be on reducing unnecessary resources and costs. Therefore, each time the selection of appropriate methods and techniques of process management should be preceded by an in-depth analysis of the environment in which it is to be applied. For example, 5S, although easy to understand and implement, requires constant commitment and discipline on the part of employees. Similarly, the *Balanced Scorecard* requires its users to be involved at all levels of the organization (Kaplan, Norton, 1992). However, it can be difficult to implement, as an *Activity Based Costing*, which provides accurate information about the costs incurred by organizations during a specific process

(Straub, 2009). *Just-in-time* enables effective reduction of inventory and waste but is sensitive to any disruption in the supply chain (Ahmed, 2019) supports decision-makers in managing inventory so that it is delivered on schedule and on time.

Pareto analysis is effective in identifying the most important problems that occur, either in a task or in a process, (Talib, Rahman, Queresi, 2010). But those who use it can skip those problems that are smaller, and their effects will only be visible later. The Ishikawa diagram is also used to identify the sources of existing problems, both major and minor (Uksw, 2016). However, its use does not provide users with information on how to solve them. Both the Critical Path Method and Kanban are effective in the hands of experienced users. CPM makes it possible to specify in time the deadlines for the completion of key tasks to complete a given process (Lee, Shvetsova, 2019). It also gives the possibility of adopting time variants for the implementation of tasks, as it specifies both the minimum and maximum time needed to complete individual steps. However, in CPM, management is not able to take into account the uncertainty and risks associated with each process (Mahdiraji et al., 2016). Kanban, on the other hand, will not work in an organization whose stakeholders do not emphasize transparency and communication at all levels of management (Alaidaros et al. 2021).

The same applies to the use of a process map, where teamwork, clarity and transparency of activities in the organization are important (Heinrich et al., 2009). In a safe environment, developing a process map allows you to understand them and their dependencies, but in a high-change environment, it can lead to chaos and wrong decisions about how to perform individual tasks. Different methods and techniques are used at different stages of the management process, from problem identification and analysis, to solution planning and implementation, to monitoring and evaluating results (Benner, Tushman, 2003). The diagram below (Fig. 3) illustrates how different methods and techniques of process management are interrelated, i.e. how they can be coordinated and integrated to achieve a set goal in an organization, but also in a single process.

The stages of the management process are the key phases that organizations go through when managing their processes. Each stage has its own unique goals and challenges, and different process management methods and techniques can be used at different stages to help organizations achieve these goals and meet these challenges. The stages are not rigid and can overlap or iterate depending on the specifics of the organization and the context in which they are applied. The key is continuous improvement and adaptation to changing conditions. At the stage of problem identification and analysis, it is possible to use, m.in, Pareto analysis, to identify significant problems that should be solved (Andriani, Mckelvey, 2011).

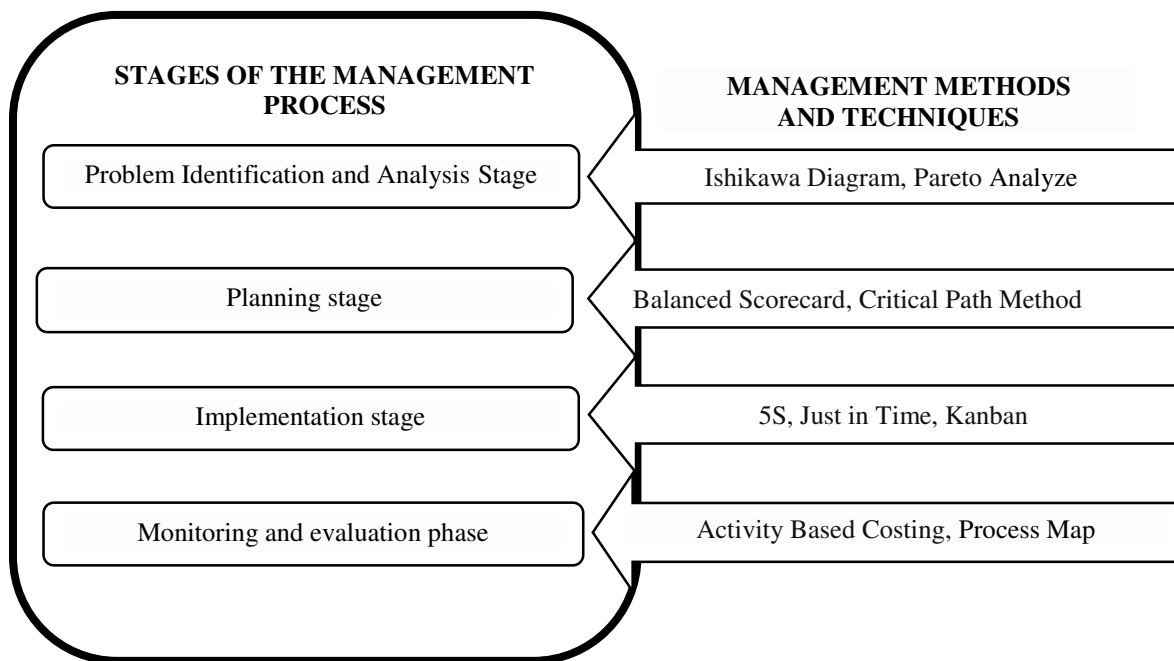


Figure 3. The course of process management with the use of selected methods and techniques.

Source: own elaboration.

On the other hand, the Ishikawa diagram will make it possible to isolate the causes of the problem in the processes carried out in the organization (Coccia, 2017). Moving on to the next stage of planning, you can use BSC for strategic planning in a given organization (Mio, Costantini, Panfilo, 2022), and CPM to determine the timing of individual tasks (Lee, Shvetsova, 2019). During implementation, the 5S technique is a way to maintain order and cleanliness in the workplace (Singh, Vikas, Sharma, 2014), and JIT enables efficient management of necessary resources (Siddiqui, 2022) in parallel with Kanban responsible for workflow control (Dos Santos et al., 2018). In the final stage of monitoring and evaluation within a process, Activity Based Costing can be used (Quesado, Silva, 2021) to accurately estimate costs and a process map to better understand and follow up processes.

These methods and techniques can be used in various combinations and sequences, depending on the specifics and needs of the organization (Lenning, 2018). The literature on the subject does not provide us with a one-size-fits-all scheme of where and how each method or technique is to be used and for which concepts it is most appropriate. What may work within one organization may be undesirable for another, which is why the approach of unambiguously defining what is a method and what is a technique and in what conditions they are applicable is variable.

7. Applications

Process management is a critical component of any organization's success. The essence of process management is to understand how work is done in an organization and then improve those processes to make them more efficient and effective. In this context, various methods and techniques of process management support the achievement of goals in the organization (Lenning, 2018). In different management concepts, different elements of process management play an important role. The key is to understand which methods and techniques are most appropriate for your organization and context, and then implement and apply them effectively.

The conclusions of the analysis suggest that the variables determining the effectiveness of each of the discussed methods and techniques are different. Each of them has its own strengths and weaknesses. In addition, the above considerations suggest that effective process management requires not only the selection of appropriate methods and techniques, but also building a culture of continuous improvement and adaptation to change (Manucharyan, 2021).

This means that organizations must be open to the use of different methods and techniques, they must be ready to support the development of employees, benefit from their experience and continuously improve their processes. Finally, the results of the analysis showed that some methods and techniques can be difficult to implement or resource-intensive. Therefore, it is important for organizations to be aware of these challenges and plan accordingly, paying attention to employee training, change management, and ensuring adequate resources are provided.

8. Recommendations and limitations

Currently, in the practice of management, one can observe a departure from the classic organization, which was based primarily on professional functions and specializations that allow for the accumulation of knowledge, experience and skills (Barkema et al., 2015; David, David, David, 2021). Nor was there a focus on processes whose primary purpose should be to meet customer needs (Barkema et al., 2015). Therefore, organizations, through their human resources, should thoroughly understand the processes and goals they are aiming for before they decide to implement specific methods and techniques of process management. Within the organization, the training of employees in the use of process management should be promoted in order to effectively implement it in the organization using effective methods and techniques. This can also be a challenge for some organizations. At the same time, the authors are aware that the concepts, methods and techniques of process management mentioned in this publication do not exhaust the subject. There are many other actions that should be carefully examined. Nevertheless, the conclusions drawn from the above analysis should be helpful and provide valuable guidance for process management practitioners.

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THE USAGE OF BENCHMARKING IN INDUSTRY 4.0 CONDITIONS

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Purpose: The purpose of this publication is to present the usage of benchmarking approach in Industry 4.0 conditions.

Design/methodology/approach: Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.

Findings: The integration of benchmarking with Industry 4.0 emerges as a strategic imperative for organizations navigating the complexities of the fourth industrial revolution. As Industry 4.0 transforms manufacturing processes through the incorporation of digital technologies, automation, and data exchange, the demand for heightened efficiency, innovation, and adaptability becomes paramount. Benchmarking, evolving from its early roots in efficiency studies, stands as a dynamic and proactive force, playing a pivotal role in helping businesses stay competitive amid the dynamic changes ushered in by digital transformation. From Frederick W. Taylor's early emphasis on best practices to the structured approaches of the late 20th century, benchmarking's historical journey laid the groundwork for its integration with Industry 4.0. The application of benchmarking in this context spans various dimensions, encompassing digital maturity, smart technologies integration, data analytics, supply chain optimization, innovation, cybersecurity, and collaboration. Tables 2, 3, and 4 provide a comprehensive overview, illustrating examples of integration, emphasizing advantages, and addressing challenges. In leveraging benchmarking not only for traditional metrics but also for digital capabilities, organizations position themselves as agile, competitive, and resilient players in the dynamic landscape of Industry 4.0, reflecting a commitment to continuous improvement and competitiveness.

Originality/Value: Detailed analysis of all subjects related to the problems connected with the usage of benchmarking in Industry 4.0 conditions.

Keywords: Industry 4.0, Quality 4.0, quality management; quality methods, QFD, benchmarking.

Category of the paper: literature review.

1. Introduction

In the era of Industry 4.0, benchmarking has emerged as a critical tool for organizations seeking to navigate the complexities of the fourth industrial revolution. Characterized by the integration of digital technologies, automation, and data exchange into manufacturing processes, Industry 4.0 demands a heightened focus on efficiency, innovation, and adaptability. Benchmarking, in this context, plays a pivotal role in helping businesses stay competitive and responsive to the dynamic changes ushered in by the digital transformation. In the Industry 4.0 landscape, benchmarking extends beyond traditional performance metrics to encompass a broader spectrum of factors. Companies now compare not only production efficiency but also the integration of smart technologies, data analytics, and the overall digital maturity of their operations. This expanded scope allows organizations to gain insights into the holistic landscape of Industry 4.0, identifying areas for improvement and innovation (Singh et al., 2023).

The purpose of this publication is to present the usage of benchmarking approach in Industry 4.0 condition.

2. The basics of benchmarking approach

Benchmarking is a strategic management tool that involves the systematic comparison of an organization's processes, products, or performance metrics against those of industry leaders or best-in-class competitors. The primary objective of benchmarking is to identify areas for improvement, enhance organizational performance, and adopt best practices to achieve a competitive advantage. This process goes beyond mere performance measurement; it is a proactive approach to continuous improvement. Benchmarking encompasses various types, including internal, competitive, and strategic benchmarking, each serving distinct purposes. Internal benchmarking involves comparing different departments or units within the same organization, fostering a culture of shared learning and improvement (Gajdzik et al., 2023).

Competitive benchmarking evaluates an organization's performance against direct competitors, allowing for insights into relative strengths and weaknesses. Strategic benchmarking, on the other hand, involves analyzing processes and practices of organizations renowned for their excellence, even if they operate in different industries. Successful benchmarking requires a comprehensive understanding of the industry context, clear identification of performance metrics, and a commitment to implementing the insights gained to drive positive change within the organization. Overall, benchmarking is a dynamic and

adaptive process that plays a pivotal role in fostering a culture of continuous improvement and innovation within organizations (Barsalou, 2023; Maganga, Taifa, 2023).

Benchmarking, as a strategic management tool, has evolved over the years to become an integral aspect of organizational performance improvement. The history of benchmarking can be traced back to the early 20th century when Frederick W. Taylor, a pioneer in scientific management, emphasized the importance of comparing and adopting best practices for efficiency. Taylor's work laid the foundation for the concept of benchmarking by highlighting the significance of studying successful organizations to enhance one's own processes (Jokovic et al., 2023).

In the mid-20th century, Japan played a pivotal role in shaping the benchmarking landscape. After World War II, Japanese industries faced the challenge of rebuilding and competing on a global scale. They embraced benchmarking as a means to learn from Western practices and improve their own methodologies. The success of Japanese companies in industries such as automotive manufacturing demonstrated the effectiveness of benchmarking in achieving operational excellence.

As the global economy became more interconnected, benchmarking gained prominence in the business world during the latter half of the 20th century. The Xerox Corporation is often credited with popularizing formalized benchmarking in the 1970s. Facing challenges in the copier market, Xerox engaged in systematic performance comparisons with other companies to identify areas for improvement. This marked a shift towards a structured and systematic approach to benchmarking (Yanamandra et al., 2023).

Throughout the 1980s and 1990s, benchmarking methodologies continued to evolve. Various frameworks, such as the Malcolm Baldrige National Quality Award and the International Organization for Standardization (ISO) standards, emerged to provide organizations with structured approaches to benchmarking their processes. The emphasis shifted from merely imitating successful practices to understanding the underlying principles and adapting them to suit the unique needs of each organization.

In the 21st century, the digital revolution has further transformed benchmarking. With the advent of big data analytics and advanced technology, organizations can now access vast amounts of data to compare and analyze performance metrics. This has enabled a more dynamic and real-time approach to benchmarking, allowing companies to adapt swiftly to changing market conditions.

Today, benchmarking is not limited to specific industries or sectors; it has become a cross-industry practice, encompassing various aspects such as quality, innovation, and sustainability. Organizations across the globe recognize benchmarking as a strategic tool for continuous improvement and competitiveness in an ever-evolving business landscape. The history of benchmarking reflects its journey from an informal concept rooted in efficiency studies to a sophisticated and integral part of modern management practices.

One of the primary applications of benchmarking in Industry 4.0 is in the realm of digitalization. As organizations embrace technologies like the Internet of Things (IoT), artificial intelligence, and cloud computing, benchmarking enables them to evaluate their digital strategies against industry standards and best practices. This ensures that companies are not only adopting cutting-edge technologies but also leveraging them effectively to enhance overall operational performance. Moreover, benchmarking serves as a strategic compass for organizations navigating the complexities of interconnected supply chains in Industry 4.0. Companies can assess their logistics and supply chain management against industry benchmarks, optimizing processes for increased agility, reduced lead times, and enhanced customer satisfaction. This is particularly crucial in an environment where rapid response to market changes is a competitive necessity.

In the context of innovation, Industry 4.0 benchmarking fosters a culture of continuous improvement. By comparing their research and development efforts, product life cycles, and innovation processes with industry leaders, organizations can identify areas to enhance creativity, shorten time-to-market, and stay ahead of technological disruptions. Furthermore, as cybersecurity becomes a paramount concern in the digital age, benchmarking assists organizations in fortifying their defenses. By benchmarking their cybersecurity protocols against industry standards and peers, companies can ensure the resilience of their digital infrastructure and protect against evolving cyber threats.

The usage of benchmarking in Industry 4.0 conditions reflects a strategic imperative for organizations aiming to thrive in the digital era. By benchmarking not only traditional performance metrics but also digital capabilities, supply chain integration, innovation processes, and cybersecurity measures, businesses can position themselves as agile, competitive, and resilient players in the dynamic landscape of Industry 4.0.

Table 1 contains description of benchmarking key principles.

Table 1.
Key principles of benchmarking

Key principle	Description
Continuous Improvement	Ongoing, incremental changes are prioritized over radical shifts, fostering steady progress.
Employee Involvement	All members of the organization, from top management to frontline workers, contribute ideas.
Gemba (Real Place)	Solutions are sought at the source of the issue, often on the shop floor or in the workspace.
Standardization	Once improvements are made, standardized processes are established to maintain consistency.
Elimination of Waste	Identification and removal of unnecessary processes, movements, and resources to optimize.
Kaizen Events	Time-limited, focused activities to address specific issues and rapidly implement improvements.
Quality Focus	A commitment to producing high-quality products or services is central to the Kaizen philosophy.
Visual Management	Information is presented visually to enhance understanding and facilitate quick decision-making.

Cross-Functional Teams	Collaboration among individuals from different departments to address issues comprehensively.
Data-Driven Decision-Making	Analysis of data guides decision-making, ensuring changes are based on evidence and facts.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

3. How benchmarking method can be integrated with Industry 4.0 and Quality 4.0 concept

The integration of benchmarking with Industry 4.0 encompasses several key aspects critical to the success of organizations navigating the complexities of the fourth industrial revolution. Firstly, the assessment of digital maturity is paramount. This involves a thorough evaluation of an organization's level of digitalization, including the adoption and effective utilization of technologies such as the Internet of Things (IoT), artificial intelligence, and cloud computing. Benchmarking against industry standards ensures that the organization optimally leverages digital tools for enhanced operational efficiency (Bousdekis et al., 2023).

Another crucial aspect is the integration of smart technologies into manufacturing processes. Organizations must assess how well automation, robotics, and sensor networks are incorporated into their operations. Benchmarking strategies in this realm facilitates the identification of best practices, allowing companies to streamline their processes for increased efficiency and responsiveness (Alrabadi et al., 2023).

Data analytics capabilities play a pivotal role in Industry 4.0, and benchmarking helps organizations gauge their proficiency in utilizing data for decision-making. By comparing their data analytics practices against industry benchmarks, companies can ensure effective extraction of insights from big data, contributing to informed and strategic decision-making.

Supply chain optimization is a key consideration in the benchmarking process. Organizations assess their logistics and supply chain management against industry standards, aiming to achieve increased agility, reduced lead times, and heightened customer satisfaction. This aspect acknowledges the interconnected nature of supply chains in the Industry 4.0 landscape.

Innovation processes are also subject to benchmarking scrutiny. Companies compare their research and development efforts, product life cycles, and overall innovation strategies with industry leaders. This facilitates the identification of areas for improvement, fostering a culture of continuous innovation and ensuring a faster time-to-market for new products and solutions (Antony et al., 2023; Escobar et al., 2023; Antony et al., 2023; Salimbeni, Redchuk, 2023).

The integration of benchmarking with Industry 4.0 extends to cybersecurity protocols. In an era where digital threats are prevalent, organizations benchmark their cybersecurity measures against industry standards. This safeguards the integrity and resilience of digital infrastructure, protecting against evolving cyber threats associated with increased connectivity. Furthermore, the integration of interconnected systems is a critical benchmarking aspect. Organizations evaluate how well their systems and platforms are integrated, benchmarking against industry leaders to enhance interoperability and communication between interconnected systems (Maganga, Taifa, 2023).

Collaboration and ecosystem engagement are emphasized in Industry 4.0, and benchmarking helps organizations assess their level of collaboration with external partners. Benchmarking against successful collaboration models enhances innovative and agile practices in a networked environment. Sustainability considerations are also integrated into benchmarking practices. Organizations benchmark their sustainability practices against industry benchmarks, assessing the environmental impact of operations. This aspect aligns with Industry 4.0 principles and identifies opportunities for green initiatives (Maganga, Taifa, 2023).

Lastly, the benchmarking of employee skills and training programs is crucial. Organizations compare their workforce's skills and training programs related to Industry 4.0 technologies against industry standards. This ensures that the workforce is equipped with the necessary skills to effectively contribute to the organization's digital transformation efforts (Jonek-Kowalska, Wolniak, 2021; 2022).

Table 2 is listing examples of integration of benchmarking method with industry 4.0.

Table 2.
Benchmarking integration with industry 4.0

Aspect	Description
Digital Maturity	Evaluate the organization's level of digitalization, including the adoption of IoT, artificial intelligence, and cloud computing. Benchmark against industry standards to ensure optimal utilization of digital technologies.
Smart Technologies Integration	Assess how well smart technologies are integrated into manufacturing processes. Compare strategies for automation, robotics, and sensor networks to enhance efficiency and responsiveness.
Data Analytics Capabilities	Evaluate the organization's proficiency in utilizing data analytics for decision-making. Benchmark against industry best practices to ensure effective extraction of insights from big data.
Supply Chain Optimization	Benchmark logistics and supply chain management practices against industry standards. Optimize processes to achieve increased agility, reduced lead times, and improved customer satisfaction.
Innovation Processes	Compare research and development efforts, product life cycles, and innovation strategies. Identify areas for improvement to foster a culture of continuous innovation and faster time-to-market.
Cybersecurity Protocols	Benchmark cybersecurity measures against industry standards to ensure the resilience of digital infrastructure. Protect against evolving cyber threats in the era of increased connectivity.
Interconnected Systems Integration	Assess how well interconnected systems and platforms are integrated within the organization. Benchmark against industry leaders to enhance interoperability and communication between systems.

Cont. table 2.

Collaboration and Ecosystem Engagement	Evaluate the level of collaboration with external partners and ecosystem engagement. Benchmark against successful models to enhance collaborative innovation and agility in a networked environment.
Sustainability and Environmental Impact	Benchmark sustainability practices against industry benchmarks. Assess the environmental impact of operations and identify opportunities for green initiatives in alignment with Industry 4.0 principles.
Employee Skills and Training	Evaluate the skills and training programs related to Industry 4.0 technologies. Benchmark against industry standards to ensure the workforce is equipped with the necessary skills for digital transformation.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

Table 3 is describe the advantages benchmarking approach usage in industry 4.0. This table provides a brief overview of some of the key advantages associated with integrating benchmarking practices with Industry 4.0.

Table 3.

The advantages of benchmarking integration with industry 4.0

Advantage	Description
Enhanced Operational Efficiency	Benchmarking with Industry 4.0 allows organizations to identify and adopt best practices, leading to improved operational processes and overall efficiency.
Real-time Data Analysis and Decision Making	Integration with Industry 4.0 enables the utilization of real-time data for benchmarking, facilitating quicker and more informed decision-making processes.
Innovation and Technology Adoption	Benchmarking in the context of Industry 4.0 encourages the adoption of innovative technologies and practices, keeping businesses at the forefront of industry trends.
Improved Quality and Productivity	By comparing processes and performance metrics, organizations can identify areas for improvement, leading to enhanced product quality and increased productivity.
Cost Reduction and Resource Optimization	Industry 4.0 benchmarking helps in identifying cost-effective solutions and optimizing the use of resources, contributing to overall cost reduction strategies.
Supply Chain Optimization	Benchmarking integration with Industry 4.0 assists in optimizing supply chain processes, ensuring seamless and efficient coordination among various elements.
Enhanced Customer Satisfaction	Continuous improvement through benchmarking in Industry 4.0 leads to better products and services, ultimately resulting in higher customer satisfaction levels.
Agility in Response to Market Changes	Organizations can become more agile and adaptable to market changes by benchmarking with Industry 4.0, adjusting strategies based on real-time industry standards.
Enhanced Predictive Maintenance	Integration with Industry 4.0 allows for the implementation of predictive maintenance strategies, reducing downtime by identifying potential equipment failures before they occur.
Increased Employee Engagement	Benchmarking fosters a culture of continuous improvement, engaging employees in identifying and implementing best practices, leading to higher job satisfaction.
Sustainable Practices Adoption	Organizations can benchmark sustainable practices within Industry 4.0, promoting eco-friendly initiatives and reducing the environmental impact of operations.
Global Competitiveness	Benchmarking against global industry standards helps organizations stay competitive by aligning their practices with the best in the world.
Accelerated Time-to-Market	Industry 4.0 benchmarking enables faster product development cycles by incorporating efficient processes and technologies employed by industry leaders.
Risk Mitigation and Compliance	Identifying and adopting industry best practices through benchmarking helps mitigate risks and ensures compliance with evolving regulatory standards.

Cont. table 3.

Cross-Functional Collaboration	Benchmarking encourages collaboration among different departments and functions within an organization, breaking down silos and fostering a cohesive working environment.
Improved Cybersecurity Measures	Integrating benchmarking with Industry 4.0 allows organizations to assess and enhance their cybersecurity measures, safeguarding critical digital assets.
Data-driven Decision Validation	Organizations can validate their strategic decisions by benchmarking data-driven insights, ensuring that choices align with industry trends and proven successful approaches.
Enhanced Supplier Relationships	Benchmarking practices extend to suppliers, fostering stronger relationships and collaboration to improve overall supply chain efficiency and product quality.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

Table 4 is describe the problems of benchmarking approach usage in Industry 4.0 and methods to overcome them. Addressing these problems requires a strategic and thoughtful approach, involving a combination of technological solutions, organizational change management, and ongoing adaptation to evolving industry standards and practices.

Table 4.

The problems of benchmarking integration with Industry 4.0

Problems	Description of Problem	Overcoming Strategies
Data Security and Privacy Concerns	Integrating benchmarking with Industry 4.0 involves sharing sensitive operational data, raising concerns about data security and privacy.	Implement robust encryption protocols, establish secure data sharing agreements, and comply with relevant data protection regulations.
Lack of Standardization in Data Formats	Industry 4.0 may involve diverse data formats, making it challenging to compare and benchmark data consistently across different systems and platforms.	Establish industry standards for data formats, invest in interoperable technologies, and utilize data conversion tools to ensure compatibility.
Technological Incompatibility	Varied technological infrastructures among different organizations may hinder seamless integration for benchmarking purposes.	Invest in adaptable technologies, conduct thorough compatibility assessments, and collaborate on developing standardized technology frameworks.
Difficulty in Identifying Comparable Metrics	Identifying comparable metrics for benchmarking purposes in the dynamic environment of Industry 4.0 can be challenging, leading to inaccurate or incomplete comparisons.	Develop industry-specific benchmarking metrics, collaborate with stakeholders to define standardized metrics, and continuously adapt benchmarks to changing industry trends.
Rapidly Evolving Technology Landscape	The fast-paced evolution of Industry 4.0 technologies may result in benchmarks quickly becoming outdated, making it challenging to maintain relevance.	Establish a flexible benchmarking strategy, conduct regular reviews and updates, and foster a culture of continuous learning to stay abreast of technological advancements.
Lack of Collaboration and Knowledge Sharing	In some cases, organizations may be hesitant to share critical insights and best practices, hindering the effectiveness of benchmarking initiatives.	Promote a culture of open collaboration, incentivize knowledge sharing, and establish secure platforms for confidential information exchange to encourage transparency.

Cont. table 4.

Resource Intensity and High Implementation Costs	Implementing Industry 4.0 benchmarking initiatives may require significant resources, making it prohibitive for some organizations, especially smaller ones.	Prioritize cost-effective solutions, collaborate on shared resources, and consider phased implementations to manage costs more efficiently.
Resistance to Change and Cultural Barriers	Employees and leadership may resist changes associated with benchmarking and Industry 4.0, creating cultural barriers that hinder effective integration.	Implement comprehensive change management strategies, provide training and education, and foster a culture that embraces innovation and continuous improvement.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khoureshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

4. Conclusion

The integration of benchmarking with Industry 4.0 represents a strategic imperative for organizations navigating the complexities of the fourth industrial revolution. As Industry 4.0 reshapes manufacturing processes through the integration of digital technologies, automation, and data exchange, the need for heightened efficiency, innovation, and adaptability becomes paramount. Benchmarking emerges as a critical tool in this context, playing a pivotal role in helping businesses stay competitive and responsive to the dynamic changes ushered in by the digital transformation.

The evolution of benchmarking from its early roots in efficiency studies to a sophisticated and integral part of modern management practices reflects its adaptability and relevance in the ever-changing business landscape. The principles of continuous improvement, employee involvement, and data-driven decision-making underscore the dynamic and proactive nature of benchmarking, making it a driving force for innovation and competitiveness. The historical journey of benchmarking, from Frederick W. Taylor's emphasis on best practices in the early 20th century to the structured approaches of the late 20th century, laid the groundwork for its integration with Industry 4.0. The digital revolution of the 21st century further transformed benchmarking, enabling a more dynamic, real-time approach with the advent of big data analytics and advanced technologies.

The application of benchmarking in Industry 4.0 extends across various dimensions, including digital maturity, smart technologies integration, data analytics capabilities, supply chain optimization, innovation processes, cybersecurity protocols, and collaboration. Benchmarking ensures that organizations not only adopt cutting-edge technologies but also leverage them effectively to enhance overall operational performance.

Table 2 illustrates examples of benchmarking integration with Industry 4.0, emphasizing its multifaceted applications. The advantages highlighted in Table 3 underscore the positive impact of benchmarking on operational efficiency, decision-making, innovation, quality, cost reduction, and more. However, as outlined in Table 4, organizations may encounter challenges such as data security concerns, lack of standardization, technological incompatibility, and resistance to change. Overcoming these challenges requires strategic solutions, including robust encryption protocols, standardization efforts, adaptable technologies, and comprehensive change management strategies.

In the era of Industry 4.0, the usage of benchmarking as a strategic management tool reflects a commitment to continuous improvement and competitiveness. By embracing benchmarking not only for traditional performance metrics but also for digital capabilities, supply chain integration, innovation processes, and cybersecurity measures, organizations position themselves as agile, competitive, and resilient players in the dynamic landscape of Industry 4.0.

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THE USAGE OF KAIZEN IN INDUSTRY 4.0 CONDITIONS

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Purpose: The purpose of this publication is to present the usage of Kaizen approach in Industry 4.0 conditions.

Design/methodology/approach: Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.

Findings: The integration of Kaizen principles into the realm of Industry 4.0 signifies a strategic alignment between time-honored doctrines of continuous improvement and the revolutionary technologies characterizing the fourth industrial era. Originating from post-World War II Japanese reconstruction, Kaizen has evolved into a global philosophy guiding organizations toward sustained growth and excellence. In the context of Industry 4.0, marked by automation and artificial intelligence, Kaizen serves as a catalyst, seamlessly aligning with the dynamic nature of continuous improvement. Emphasizing data-driven decision-making and smart manufacturing, Kaizen becomes integral to organizations aspiring for efficiency and excellence in the digital landscape. Beyond methodologies, the integration fosters a cultural evolution, exemplified by virtual Kaizen events, employee empowerment, and digital tool optimization, contributing to a culture of continuous improvement. Tables 2 and 3 illustrate the holistic integration and advantages of Kaizen in Industry 4.0, while Table 4 acknowledges potential challenges and offers strategic solutions. Ultimately, this integration represents a transformative journey from historical recovery to a globally recognized philosophy, guiding organizations toward continuous improvement, adaptability, and excellence in the dynamic landscape of the fourth industrial revolution.

Originality/Value: Detailed analysis of all subjects related to the problems connected with the usage of kaizen in Industry 4.0 conditions.

Keywords: Industry 4.0; Quality 4.0, quality management; quality methods, QFD, Kaizen.

Category of the paper: literature review.

1. Introduction

The integration of Kaizen principles into the context of Industry 4.0 signifies a strategic alignment between a traditional philosophy of continuous improvement and the cutting-edge technologies characterizing the fourth industrial revolution. Industry 4.0, marked by the extensive use of automation, data exchange, the Internet of Things (IoT), and artificial intelligence, has redefined the landscape of manufacturing and production.

In the realm of Industry 4.0, Kaizen serves as a catalyst for maximizing the potential of advanced technologies. The emphasis on continuous improvement aligns seamlessly with the dynamic nature of Industry 4.0, where adaptability and responsiveness to change are paramount (Alrabadi et al., 2023).

The purpose of this publication is to present the usage of Kaizen approach in Industry 4.0 condition.

2. The basics of Kaizen approach

Kaizen, a Japanese term meaning "change for better" or "continuous improvement", has become a guiding philosophy for organizations worldwide seeking excellence and efficiency. Rooted in the principles of incremental progress and a commitment to constant refinement, Kaizen has evolved into a comprehensive methodology that extends far beyond its origins in manufacturing. This text explores the multifaceted nature of Kaizen, breaking down its key components into digestible bullet points to elucidate its significance in various aspects of life (Bousdekis et al., 2023).

The history of Kaizen, a term rooted in Japanese philosophy, can be traced back to the post-World War II era. In the aftermath of the devastating conflict, Japan faced the monumental task of rebuilding its economy. Influenced by American management practices introduced during the occupation, Japanese industrial leaders sought innovative approaches to enhance productivity and quality.

The concept of Kaizen began to take shape in the 1950s as a response to the pressing need for economic recovery. It gained momentum in the subsequent decades with the introduction of Quality Circles, small groups of workers who convened regularly to discuss ways to improve processes and address quality issues. Notably, the principles of Kaizen found a prominent application in the Toyota Production System (TPS), where continuous improvement became a cornerstone of manufacturing practices (Antony et al., 2023; Escobar et al., 2023; Antony et al., 2023; Salimbeni, Redchuk, 2023).

As Japanese companies like Toyota started to dominate global markets, interest in their management methodologies, including Kaizen, surged. The philosophy expanded beyond manufacturing and made inroads into various industries, such as healthcare, education, and services. In the 1990s, Kaizen became closely associated with the principles of lean manufacturing, emphasizing efficiency, waste reduction, and value creation. Organizations began to conduct "Kaizen events", focused, time-limited efforts to address specific problems and improve processes (Liu et al., 2023).

The 21st century witnessed the continued evolution of Kaizen, adapting to the digital age and incorporating technology into continuous improvement efforts. Beyond specific methodologies, Kaizen became synonymous with a mindset of continuous improvement woven into the fabric of an organization's culture.

Today, the history of Kaizen reflects its journey from post-war recovery efforts to a globally recognized management philosophy. Its enduring principles continue to guide organizations of all sizes, emphasizing the value of a culture that fosters constant learning, employee involvement, and adaptation in the pursuit of sustainable growth and excellence.

One significant aspect of the integration lies in leveraging data-driven decision-making. Kaizen, with its commitment to incremental progress based on data analysis, complements the vast amounts of data generated by interconnected devices in Industry 4.0. Organizations adopting Kaizen principles in this context harness the power of real-time information to identify areas for improvement, optimize processes, and enhance overall efficiency (Maganga, Taifa, 2023).

Furthermore, the application of Kaizen in Industry 4.0 extends to the concept of smart manufacturing. By incorporating the philosophy into smart factories, organizations can create an environment where continuous improvement is embedded in the very fabric of automated and interconnected systems. This extends beyond traditional manufacturing processes to include the optimization of supply chains, logistics, and product lifecycle management. The advent of Industry 4.0 has also seen the evolution of Kaizen events. In the current landscape, these events may involve not only physical spaces but also virtual environments where teams collaborate using digital tools and platforms. This allows for a more global and interconnected approach to problem-solving and improvement initiatives (Maganga, Taifa, 2023).

In essence, the usage of Kaizen in Industry 4.0 conditions represents a strategic evolution of a time-tested philosophy. By seamlessly integrating with advanced technologies, Kaizen becomes a driving force behind the continuous improvement efforts necessary for thriving in the rapidly evolving and interconnected industrial landscape of the fourth industrial revolution (Jonek-Kowalska, Wolniak, 2021; 2022).

Table 1 contains description of Kaizen key principles. These principles collectively form the foundation of Kaizen, promoting a culture of continuous improvement, employee engagement, and efficiency within an organization.

Table 1.
Key principles of Kaizen

Key principle	Description
Continuous Improvement	Ongoing, incremental changes are prioritized over radical shifts, fostering steady progress.
Employee Involvement	All members of the organization, from top management to frontline workers, contribute ideas.
Gemba (Real Place)	Solutions are sought at the source of the issue, often on the shop floor or in the workspace.
Standardization	Once improvements are made, standardized processes are established to maintain consistency.
Elimination of Waste	Identification and removal of unnecessary processes, movements, and resources to optimize.
Kaizen Events	Time-limited, focused activities to address specific issues and rapidly implement improvements.
Quality Focus	A commitment to producing high-quality products or services is central to the Kaizen philosophy.
Visual Management	Information is presented visually to enhance understanding and facilitate quick decision-making.
Cross-Functional Teams	Collaboration among individuals from different departments to address issues comprehensively.
Data-Driven Decision-Making	Analysis of data guides decision-making, ensuring changes are based on evidence and facts.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

3. How Kaizen method can be integrated with Industry 4.0 and Quality 4.0 concept

The integration of the Kaizen method with Industry 4.0 represents a strategic convergence of time-tested principles and cutting-edge technologies. Several crucial aspects define this integration, shaping the way organizations optimize processes, engage their workforce, and leverage advanced digital tools. In the realm of Industry 4.0, data-driven decision-making takes center stage. The Kaizen method seamlessly aligns with this paradigm, where the abundance of data from interconnected devices informs real-time decision-making. Incremental progress, a core tenet of Kaizen, aligns with the dynamic nature of Industry 4.0, emphasizing the continuous refinement of processes (Singh et al., 2023).

Smart manufacturing, an integral component of Industry 4.0, sees the application of Kaizen principles. Beyond the shop floor, organizations extend continuous improvement efforts to encompass the entire value chain, integrating supply chains, logistics, and product lifecycle management within a holistic framework. The integration fosters a culture of continuous improvement within the digital landscape. Kaizen serves as a guiding philosophy, encouraging adaptability and responsiveness to change. This aspect ensures that employees are not only participants in the digital transformation but active contributors to the ongoing improvement initiatives (Gajdzik et al., 2023).

Virtual Kaizen events mark a shift in problem-solving dynamics. These events, traditionally conducted in physical spaces, evolve to include virtual environments. Teams collaborate using digital tools and platforms, reflecting the need for flexibility in addressing challenges and implementing improvement initiatives in a digital context (Yanamandra et al., 2023). Employee empowerment is a cornerstone of the integration. As Industry 4.0 introduces advanced technologies, Kaizen principles emphasize that employees' insights and expertise are indispensable. The method ensures that the human element remains central in leveraging these technologies effectively to achieve excellence (Jokovic et al., 2023).

Optimizing digital tools becomes a continuous process. Kaizen principles are applied to refine the use of digital technologies within Industry 4.0 actively. The focus is on enhancing efficiency, minimizing waste, and extracting maximum value from digital tools as part of the broader pursuit of continuous improvement. Adaptability is crucial in Industry 4.0, and Kaizen's agile approach aligns perfectly with this requirement. Organizations embracing the integration respond quickly to changes in the technological landscape, adopting an open mindset for experimentation, learning from experiences, and continuously refining strategies and processes (Barsalou, 2023; Maganga, Taifa, 2023).

Table 2 is listing examples of integration of Kaizen method with industry 4.0. These aspects collectively illustrate how the integration of Kaizen with Industry 4.0 is a holistic approach that addresses various facets of modern manufacturing and production in the digital era.

Table 2.

Kaizen integration with Industry 4.0

Aspect	Description
Data-Driven Decision-Making	Utilizing the vast amounts of data generated by interconnected devices and systems to inform decision-making processes. Kaizen's commitment to incremental progress aligns with the dynamic nature of Industry 4.0 and its reliance on real-time data.
Smart Manufacturing	Applying Kaizen principles to optimize automated and interconnected manufacturing processes within smart factories. This extends to the entire value chain, incorporating supply chains, logistics, and product lifecycle management.
Continuous Improvement Culture	Embedding a culture of continuous improvement into the fabric of automated and digital systems. Kaizen serves as a guiding philosophy, encouraging adaptability and responsiveness to change in the rapidly evolving landscape of Industry 4.0.
Virtual Kaizen Events	Evolving traditional Kaizen events to include virtual environments, where teams collaborate using digital tools and platforms. This global and interconnected approach enhances problem-solving and improvement initiatives in the digital era.
Employee Empowerment	Empowering employees to actively contribute to improvement initiatives in the digital age. With Industry 4.0, workers may engage with advanced technologies, and Kaizen ensures that their insights and expertise are valued in the pursuit of excellence.
Optimization of Digital Tools	Applying Kaizen principles to optimize the use of digital tools and technologies within Industry 4.0. This involves ensuring that the technologies in place are continuously refined to enhance efficiency, minimize waste, and improve overall performance.

Cont. table 2.

Agile and Adaptive Strategies	Embracing Kaizen's agile approach to adaptability, allowing organizations to respond quickly to changes in the Industry 4.0 landscape. This includes being open to experimentation, learning from experiences, and continuously refining strategies and processes.
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Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

Table 3 is describe the advantages Kaizen approach usage in industry 4.0. These advantages collectively illustrate how the Kaizen approach enhances the adaptability, efficiency, and overall performance of organizations in the context of Industry 4.0.

Table 3.

The advantages of Kaizen integration with industry 4.0

Advantage	Description
Continuous Improvement	Kaizen's commitment to incremental progress aligns with the dynamic nature of Industry 4.0, allowing for ongoing optimization of processes.
Adaptability to Change	The agile nature of Kaizen ensures that organizations can readily adapt to the rapidly evolving landscape of Industry 4.0, embracing technological advancements.
Data-Driven Decision-Making	Kaizen leverages the abundance of data in Industry 4.0, facilitating informed decision-making and strategic planning based on real-time insights.
Enhanced Employee Engagement	The Kaizen approach empowers employees to actively contribute to improvement initiatives, fostering a culture of engagement and innovation.
Optimization of Digital Tools	Kaizen principles actively contribute to refining the use of digital technologies, ensuring efficient and effective utilization within Industry 4.0 environments.
Global Collaboration	Virtual Kaizen events enable global collaboration, allowing teams to work seamlessly across borders and leverage diverse expertise for problem-solving.
Human-Centric Approach in Automation	Kaizen ensures that the human element remains central in the integration of advanced technologies, balancing automation with the expertise and insights of the workforce.
Efficiency and Waste Reduction	Industry 4.0, guided by Kaizen principles, focuses on minimizing waste and optimizing efficiency across the entire value chain, from production to logistics.
Cultural Integration of Continuous Improvement	The Kaizen approach seamlessly integrates with the organizational culture, promoting a mindset of continuous improvement that aligns with the principles of Industry 4.0.
Agile and Adaptive Strategies	Kaizen's agile approach supports Industry 4.0 by facilitating quick adjustments to strategies, ensuring organizations remain responsive to technological shifts and market demands.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

Table 4 is describe the problems of Kaizen approach usage in Industry 4.0 and methods to overcome them. Addressing these problems requires a strategic and thoughtful approach, involving a combination of technological solutions, organizational change management, and ongoing adaptation to evolving industry standards and practices.

Table 4.
The problems of Kaizen integration with industry 4.0

Problems	Description of Problem	Overcoming Strategies
Resistance to Change	Employees may resist adopting the Kaizen approach or Industry 4.0 technologies due to fear of job displacement, unfamiliarity, or a reluctance to alter established workflows.	Implement comprehensive change management programs that include communication, training, and involvement of employees in the decision-making process. Highlight the benefits of Kaizen and Industry 4.0, emphasizing skill enhancement and job enrichment.
Lack of Digital Literacy	The successful integration of Industry 4.0 technologies may be hindered by a lack of digital literacy among the workforce, limiting their ability to effectively use and maximize the potential of new tools.	Invest in training programs to enhance digital literacy. Provide ongoing education and support to ensure employees are comfortable and proficient with the technologies involved. Encourage a culture of continuous learning.
Integration Challenges	Integrating Kaizen principles with advanced digital technologies can be complex, especially if existing systems are not designed to seamlessly interact with Industry 4.0 solutions.	Conduct thorough assessments of existing systems, and invest in flexible and interoperable technologies. Implement phased integration plans, allowing for gradual adoption and addressing challenges in smaller, manageable steps.
Data Security Concerns	The increased reliance on data in Industry 4.0 raises concerns about data security and privacy. Organizations may face challenges in ensuring the integrity and confidentiality of sensitive information.	Implement robust cybersecurity measures, including encryption, access controls, and regular security audits. Develop and communicate clear data privacy policies. Involve employees in cybersecurity awareness programs to foster a collective commitment to data security.
Overemphasis on Technology	Organizations might focus too much on the implementation of new technologies without adequately addressing the cultural and human aspects essential for the success of Kaizen and Industry 4.0.	Maintain a balance between technological advancements and cultural integration. Prioritize a people-centric approach by emphasizing employee involvement, collaboration, and a culture of continuous improvement alongside technological upgrades.
Lack of Standardization	Inconsistencies in processes and practices can emerge if standardization is not adequately addressed, leading to challenges in maintaining quality and efficiency across different facets of the organization.	Establish clear standardization protocols and procedures. Regularly review and update standards to ensure relevance. Implement a robust communication system to disseminate standardized practices and encourage adherence across all levels of the organization.
High Implementation Costs	The integration of Industry 4.0 technologies can incur substantial upfront costs, including investments in hardware, software, and employee training. Managing these costs can be a significant challenge.	Develop comprehensive cost-benefit analyses before implementation. Explore phased implementation approaches to distribute costs over time. Seek partnerships and collaborations to share resources and expenses. Prioritize technologies that provide long-term value and align with organizational goals.
Data Overload and Analysis Paralysis	The abundance of data in Industry 4.0 can overwhelm organizations, leading to challenges in effectively analyzing and interpreting information. This can result in delayed decision-making and missed improvement opportunities.	Implement advanced analytics tools to streamline data analysis. Focus on actionable insights and prioritize key performance indicators. Invest in employee training to enhance data interpretation skills. Establish clear data governance policies to ensure data relevance and accuracy.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

4. Conclusion

The integration of Kaizen principles into the context of Industry 4.0 represents a powerful and strategic alignment between traditional philosophies of continuous improvement and the transformative technologies of the fourth industrial revolution. Industry 4.0, characterized by automation, data exchange, and artificial intelligence, has redefined manufacturing and production, making the incorporation of Kaizen principles a timely and valuable endeavor. The journey of Kaizen, rooted in post-World War II Japanese recovery efforts, has evolved into a global philosophy of continuous improvement. From its application in manufacturing, particularly in the Toyota Production System, to its expansion into diverse industries and its adaptation to the digital age, Kaizen has demonstrated enduring principles that guide organizations toward sustainable growth and excellence.

As Industry 4.0 unfolds, Kaizen serves as a catalyst for maximizing the potential of advanced technologies. The philosophy's emphasis on continuous improvement seamlessly aligns with the dynamic nature of Industry 4.0, where adaptability and responsiveness to change are paramount. Leveraging data-driven decision-making and embracing smart manufacturing, Kaizen becomes an integral part of organizations striving for efficiency and excellence in the digital landscape. The integration of Kaizen with Industry 4.0 goes beyond methodologies; it becomes a cultural evolution. Virtual Kaizen events, employee empowerment, and the optimization of digital tools exemplify the dynamic ways in which Kaizen principles adapt to the modern industrial environment. The approach fosters a culture of continuous improvement, ensuring that employees are not only participants in the digital transformation but active contributors to ongoing improvement initiatives.

Table 2 illustrates how Kaizen seamlessly integrates with Industry 4.0 across various aspects, such as data-driven decision-making, smart manufacturing, and continuous improvement culture. These aspects collectively showcase a holistic approach that addresses the multifaceted challenges of modern manufacturing and production. Furthermore, Table 3 outlines the advantages of employing the Kaizen approach in Industry 4.0 conditions. From continuous improvement to enhanced employee engagement, the benefits demonstrate how Kaizen contributes to the adaptability, efficiency, and overall performance of organizations within the rapidly evolving and interconnected industrial landscape.

Despite the evident advantages, Table 4 acknowledges potential challenges in implementing the Kaizen approach in Industry 4.0. Resistance to change, lack of digital literacy, integration challenges, and data security concerns are among the obstacles organizations may face. However, the provided strategies offer practical solutions, emphasizing the importance of comprehensive change management, ongoing education, and the thoughtful integration of technology and human elements.

The integration of Kaizen with Industry 4.0 represents a journey from historical recovery efforts to a globally recognized philosophy. It is a journey that continues to guide organizations towards continuous improvement, adaptability, and excellence in the dynamic and interconnected landscape of the fourth industrial revolution.

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THE USAGE OF SMART CAMERAS IN SMART HOME

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Purpose: The purpose of this publication is to present the usage of smart cameras in smart home.

Design/methodology/approach: Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.

Findings: The integration of smart cameras into the fabric of smart homes signifies a revolutionary advancement in security, convenience, and efficiency. These technologically sophisticated devices, harnessing the power of artificial intelligence and machine learning, transcend traditional surveillance, providing a myriad of functionalities that redefine contemporary living. Primarily excelling in security, smart cameras enable real-time monitoring with features like facial recognition and object detection, empowering homeowners to swiftly identify potential threats and proactively enhance security measures. The seamless integration of smart cameras with other home automation devices establishes an interconnected ecosystem, enabling automated responses based on detected events and synchronized actions with smart door locks, sensors, and lighting systems. Additionally, smart cameras contribute to energy efficiency and resource management by analyzing occupancy patterns, optimizing HVAC systems, and addressing privacy concerns through customizable settings. However, challenges such as privacy and data security issues, false positives, internet connectivity dependency, and upfront costs must be navigated through regulatory frameworks, technological improvements, and user education. Despite these challenges, the substantial advantages of enhanced security, remote monitoring, and seamless integration position smart cameras as pivotal elements in the ongoing evolution of smart homes.

Originality/Value: Detailed analysis of all subjects related to the problems connected with the usage of smart cameras in smart home.

Keywords: Smart City, energy efficiency, smart home, smart house, digitalization, smart cameras

Category of the paper: literature review.

1. Introduction

Smart cameras play a pivotal role in the contemporary landscape of smart homes, contributing significantly to the evolution of home automation and security. These intelligent devices seamlessly integrate into the fabric of smart homes, offering a range of functionalities that go beyond traditional surveillance. In the realm of security, smart cameras provide homeowners with real-time monitoring capabilities, allowing them to keep a watchful eye on their property remotely. The integration of advanced technologies such as facial recognition and object detection enhances their effectiveness, enabling the identification of familiar faces and alerting homeowners to potential security threats (Alsaedi et al., 2023).

Beyond security, smart cameras contribute to the overall convenience and efficiency of smart homes. With features like two-way audio communication, homeowners can remotely communicate with family members, guests, or even delivery personnel. This not only facilitates interactive monitoring but also adds an additional layer of convenience by enabling communication without physical presence. Moreover, the integration of smart cameras with other smart home devices creates a holistic and interconnected ecosystem. For instance, smart cameras can collaborate with smart door locks, sensors, and lighting systems. This integration allows for automated responses based on detected events. For example, a smart camera identifying motion at the front door can trigger the smart door lock to send an alert or initiate a predefined action, enhancing both security and convenience (Chaudhari et al., 2023).

The purpose of this publication is to present the usage of smart cameras in smart home.

2. Smart cameras in smart home

Smart cameras have become an integral component of modern surveillance and security systems, revolutionizing the way we monitor and safeguard our surroundings. These advanced devices leverage cutting-edge technology to provide enhanced functionality and efficiency in diverse applications, ranging from public spaces to private residences. One of the primary advantages of smart cameras lies in their ability to incorporate artificial intelligence (AI) and machine learning algorithms (Wu et al., 2023). These sophisticated algorithms empower smart cameras to not only capture and record video footage but also analyze and interpret the visual data in real-time. This capability enables them to detect and respond to various events, such as intrusions, suspicious activities, or unauthorized access, with a level of accuracy and speed that traditional surveillance systems often struggle to achieve (Huda et al., 2024).

In the realm of public safety, smart cameras contribute significantly to the prevention and investigation of criminal activities. Their advanced analytics can identify anomalies, track individuals, and even recognize specific objects or behaviors. This proactive approach allows law enforcement agencies to respond swiftly to potential threats, enhancing overall security in public spaces such as airports, transportation hubs, and city centers. Moreover, smart cameras play a crucial role in industrial settings, where they can monitor production processes, ensure workplace safety, and identify defects in real-time. By leveraging machine vision, these cameras contribute to quality control efforts, reducing the likelihood of faulty products reaching the market and improving overall production efficiency (Raff et al., 2024).

In the retail sector, smart cameras enable businesses to analyze customer behavior and preferences. Retailers can use this information to optimize store layouts, enhance product placements, and personalize marketing strategies. Additionally, smart cameras assist in the prevention of theft and fraud by detecting suspicious activities and notifying security personnel promptly (Sobhani et al., 2023). In the realm of smart cities, these cameras are instrumental in traffic management, environmental monitoring, and urban planning. They can help alleviate congestion, improve emergency response times, and contribute to the development of sustainable urban environments. By collecting and analyzing data from various sources, smart cameras empower city planners to make informed decisions for the benefit of residents and visitors alike (Ramanujam et al., 2024).

Despite the numerous benefits, the widespread adoption of smart cameras has raised concerns about privacy and data security. As these devices continuously capture and process vast amounts of visual data, it is crucial to establish robust regulations and ethical frameworks to protect individuals' privacy rights and prevent misuse of the gathered information (Douha et al., 2023).

The application of smart cameras in smart homes extends to energy efficiency and resource management. Some smart cameras are equipped with advanced analytics that can identify patterns of occupancy within a home. This information can be utilized to optimize the operation of heating, ventilation, and air conditioning (HVAC) systems, contributing to energy savings and environmental sustainability. Privacy considerations are paramount in the context of smart home surveillance, and manufacturers have responded by incorporating features that prioritize user control. Homeowners can customize privacy settings, define areas that are off-limits for monitoring, and have the ability to disable cameras when desired (Patheja et al., 2023).

The usage of smart cameras in smart homes transcends conventional security measures, offering a holistic approach to modern living. Their integration with advanced technologies, coupled with seamless collaboration with other smart devices, positions them as essential components in the creation of intelligent, secure, and efficient home environments. As smart homes continue to evolve, smart cameras will likely play an increasingly central role in shaping the future of residential living (Afroz et al., 2024).

Table 1 contains descriptions of key features of smart cameras usage. This table provides a concise overview of key features associated with the usage of smart cameras, highlighting their diverse applications and the challenges related to privacy and data security (Ameur et al., 2023).

Table 1.
Key features of smart cameras usage

Key Features of Smart Cameras	Description
AI and Machine Learning	Smart cameras leverage advanced algorithms for real-time analysis of visual data. This enables them to identify and respond to specific events, such as intrusions or suspicious activities.
Real-Time Monitoring	These cameras provide instant monitoring capabilities, allowing for timely detection and response to security threats or unusual occurrences.
Event Recognition	The ability to recognize specific events, behaviors, or objects enhances the camera's functionality, aiding in crime prevention and investigation.
Proactive Security	By actively identifying potential threats, smart cameras contribute to proactive security measures, allowing for quicker response times and improved overall safety.
Industrial Applications	In industrial settings, smart cameras play a role in quality control, monitoring production processes, ensuring workplace safety, and identifying defects in real-time.
Retail Analytics	Smart cameras in retail environments analyze customer behavior, optimize store layouts, and contribute to theft prevention by detecting suspicious activities.
Traffic Management	Contributing to smart city initiatives, these cameras assist in traffic management by monitoring congestion, improving emergency response times, and aiding in urban planning.
Environmental Monitoring	Smart cameras in smart cities also contribute to environmental monitoring, collecting data for air quality, noise levels, and other parameters to support sustainable urban development.
Privacy Concerns	The widespread use of smart cameras has raised privacy concerns. Addressing these concerns requires establishing regulations and ethical frameworks to protect individuals' privacy rights and prevent misuse.
Data Security	With the continuous capture and processing of visual data, ensuring robust data security measures is imperative to prevent unauthorized access or misuse of the gathered information.
Wide-Angle Coverage	Smart cameras often have a wide field of view, allowing for comprehensive coverage and reducing the need for multiple cameras in a single area.
Pan-Tilt-Zoom (PTZ) Control	The capability to pan, tilt, and zoom provides flexibility in adjusting the camera's focus, enabling users to closely monitor specific areas of interest in real-time.
Low Light and Night Vision	Many smart cameras are equipped with low-light and night vision capabilities, ensuring effective surveillance even in challenging lighting conditions.
Cloud Integration	Integration with cloud services allows for remote access to video feeds, storage of footage, and facilitates data analysis and sharing across multiple locations.
Mobile Alerts and Notifications	Users can receive real-time alerts and notifications on their mobile devices, keeping them informed about security events or anomalies, even when they are away from the monitoring site.
Two-Way Audio	Some smart cameras feature two-way audio communication, enabling users to both listen to and speak with individuals within the camera's vicinity. This is useful for interactive monitoring and communication.
Facial Recognition	Advanced facial recognition technology allows smart cameras to identify and categorize individuals, providing an additional layer of security and access control.
License Plate Recognition	In traffic management and law enforcement applications, smart cameras can recognize and log license plate information, aiding in vehicle tracking and monitoring.
Heat Mapping	Retailers use heat mapping features to analyze customer traffic and engagement, helping optimize store layouts and product placements based on popular areas.
Gesture Recognition	Gesture recognition technology enables smart cameras to interpret human gestures, offering interactive control options and enhancing accessibility in certain applications.

Cont. table 1.

Object Tracking	Smart cameras can dynamically track and follow moving objects or individuals within their field of view, maintaining focus and providing continuous monitoring.
Edge Computing	Some smart cameras have onboard processing capabilities (edge computing), allowing them to perform analytics locally and reduce the need for constant data transmission to a centralized server.
Integration with IoT Devices	Integration with Internet of Things (IoT) devices enables smart cameras to collaborate with other smart devices, enhancing automation and control in smart home or industrial settings.
Customizable Analytics	Users can often customize analytics settings based on their specific needs, tailoring the smart camera's functionality to address particular security or monitoring requirements.

Source: (Gøthesen et al., 2023; Alsaedi et al., 2023; Chaudhari et al., 2023; Huda et al., 2024; Husain et al., 2023; Rhode et al., 2023; Bassarir-Orzeł et al., 2023; Tong et al., 2023; Chen et al., 2023; Douha et al., 2023; Sobhani et al., 2023).

3. The advantages and problems of using smart cameras

The integration of smart cameras into smart home environments brings forth a multitude of advantages, elevating the overall functionality, security, and convenience of modern living. One of the foremost benefits is the heightened level of security that smart cameras provide (Dhaou, 2023). Equipped with advanced features such as facial recognition and object detection, these cameras offer real-time monitoring, enabling homeowners to identify and respond promptly to potential threats. Remote monitoring stands as another pivotal advantage, allowing homeowners to keep a vigilant eye on their property from virtually anywhere in the world. This capability not only fosters peace of mind but also empowers users to respond swiftly to security events or emergencies, irrespective of their physical location (Valencia-Arias et al., 2023).

The incorporation of two-way communication in smart cameras further enhances their utility (Hussain et al., 2023). This feature enables homeowners to interact with individuals within the camera's field of view, fostering interactive monitoring. Whether it's communicating with family members, guests, or even delivery personnel, this capability adds a layer of convenience and control to the smart home ecosystem (Chen et al., 2023). Smart cameras truly shine in their ability to seamlessly integrate with other smart devices. This integration facilitates automation and coordination between various components of the smart home, such as smart door locks, sensors, and lighting systems. The result is a synchronized response to events, contributing to both security and convenience in the smart home environment (Gajdzik et al., 2023; Jonek-Kowalska, Wolniak, 2021; 2022).

Energy efficiency is another noteworthy advantage, with some smart cameras utilizing advanced analytics to identify occupancy patterns. This information can be leveraged to optimize the operation of heating, ventilation, and air conditioning (HVAC) systems, reducing energy consumption and promoting sustainability within the smart home. Customizable privacy

settings address concerns related to surveillance in the home (Tong et al., 2023). Homeowners have control over monitoring zones, can disable cameras as needed, and customize privacy preferences. This ensures that smart cameras align with individual privacy preferences, striking a balance between security and personal space (Rhode et al., 2023).

Real-time alerts and notifications keep homeowners informed of specific events detected by smart cameras, offering immediate feedback for proactive responses. Additionally, integration with cloud services ensures secure storage of video footage, remote access to recordings, and seamless data sharing across devices (Olabode et al., 2023). The analytical capabilities of smart cameras provide insights into occupancy patterns, enabling informed decisions about home automation, security settings, and resource management. This contributes to a more intelligent and responsive living environment in the smart home (Bsarir-Orzeł et al., 2023).

Lastly, the user-friendly installation and setup of smart cameras make them accessible to a broad range of users, encouraging widespread adoption and ensuring that the benefits of this technology are attainable for all those seeking to enhance their smart home experience (Hussain et al., 2023).

Table 2 highlighting the advantages of using smart cameras in smart home. This table outlines the diverse advantages associated with the use of smart cameras in smart homes, ranging from enhanced security and remote monitoring to energy efficiency and customizable privacy settings.

Table 2.
Advantages of using smart cameras

Advantage	Description
Enhanced Security	Smart cameras provide real-time monitoring and advanced security features, including facial recognition and object detection, to identify and respond to potential threats. This enhances the overall security of the smart home by offering comprehensive surveillance capabilities.
Remote Monitoring	Homeowners can remotely monitor their property through smart cameras, enabling them to keep an eye on their home, family, and belongings from anywhere in the world. This feature enhances peace of mind and allows for immediate response to security events or emergencies.
Two-Way Communication	Smart cameras with two-way audio capabilities facilitate communication between homeowners and individuals within the camera's vicinity. This feature is valuable for interactive monitoring, such as talking to family members, guests, or delivery personnel, enhancing convenience and control.
Integration with Smart Devices	Smart cameras seamlessly integrate with other smart home devices, allowing for automation and collaboration. Integration with smart door locks, sensors, and lighting systems enables coordinated responses to events, contributing to both security and convenience in the smart home environment.
Energy Efficiency	Some smart cameras use advanced analytics to identify patterns of occupancy, contributing to energy efficiency. This information can optimize the operation of HVAC systems based on actual usage, reducing energy consumption and promoting sustainability in smart home environments.
Customizable Privacy Settings	Homeowners have control over privacy settings, allowing them to define monitoring zones, disable cameras when needed, and customize privacy preferences. This ensures that smart cameras align with individual privacy preferences and address concerns related to surveillance in the home.

Cont. table 2.

Alerts and Notifications	Smart cameras provide real-time alerts and notifications to homeowners' devices when specific events, such as motion detection, are identified. This immediate feedback allows for prompt action in response to potential security breaches or other noteworthy occurrences in the smart home.
Integration with Cloud Services	Integration with cloud services enables secure storage of video footage, remote access to recordings, and the ability to share data across devices. This ensures that homeowners can access and manage their smart camera data conveniently and efficiently, even when away from home.
Occupancy Insights	Analytical capabilities of smart cameras can offer insights into occupancy patterns, helping homeowners make informed decisions about home automation, security settings, and resource management. This contributes to a more intelligent and responsive living environment in the smart home.
Easy Installation and Setup	Smart cameras are designed for user-friendly installation and setup, often allowing homeowners to integrate them into their smart home ecosystem with minimal effort. This ease of use encourages widespread adoption and ensures that the benefits of smart camera technology are accessible to a broad range of users.

Source: (Gøthesen et al., 2023; Alsaedi et al., 2023; Chaudhari et al., 2023; Huda et al., 2024; Husain et al., 2023; Rhode et al., 2023; Bassarir-Orzel et al., 2023; Tong et al., 2023; Chen et al., 2023; Douha et al., 2023; Sobhani et al., 2023).

Table 3 highlighting some of the common problems and challenges associated with the problems of using smart cameras in smart homes. This table outlines various problems associated with the usage of smart cameras in smart homes, along with detailed descriptions of each issue and suggested methods for overcoming or mitigating these challenges.

Table 3.

Problems of using smart cameras

Problem	Description	Methods of Overcoming
Privacy Concerns	The use of smart cameras raises significant privacy concerns, as they continuously capture and process visual data within the home. This can lead to discomfort or opposition from residents who are wary of constant surveillance and potential misuse of their personal information.	<ul style="list-style-type: none"> • Implementing robust privacy settings and features in smart cameras that allow users to control and customize the level of monitoring. • Educating users about the importance of privacy settings and providing clear information about how the collected data will be used.
Security Vulnerabilities	Smart cameras, like any connected device, are susceptible to hacking and security breaches. Unauthorized access to camera feeds can compromise the privacy and security of residents, potentially leading to unauthorized surveillance or data theft.	<ul style="list-style-type: none"> • Regularly updating firmware and software to address security vulnerabilities. • Implementing strong encryption protocols and secure authentication mechanisms. • Choosing reputable brands and manufacturers with a track record of prioritizing security in their smart camera products.
False Positives and Inaccurate Alerts	Smart cameras may generate false positives, triggering alerts for normal activities or irrelevant events. Inaccurate alerts can lead to user frustration and desensitization, diminishing the effectiveness of the smart camera in identifying genuine security threats.	<ul style="list-style-type: none"> • Fine-tuning motion detection algorithms and sensitivity settings to reduce false positives. • Utilizing advanced analytics and machine learning to improve the accuracy of event recognition. • Allowing users to customize alert preferences and thresholds to align with their specific needs.

Cont. table 3.

Dependency on Internet Connectivity	Smart cameras heavily rely on internet connectivity for real-time monitoring, remote access, and data storage in the cloud. Network outages or disruptions can result in the loss of crucial functionality and render the smart camera temporarily ineffective.	<ul style="list-style-type: none"> • Implementing local storage options or onboard memory in smart cameras to ensure continuous recording and functionality during internet outages. • Using redundant internet connections or backup systems to maintain connectivity. • Educating users about the importance of a stable and reliable internet connection.
High Upfront Costs	The initial investment in acquiring and installing smart cameras, along with associated smart home infrastructure, can be relatively high. This may pose a barrier to entry for some users who are deterred by the upfront costs associated with setting up a comprehensive smart home surveillance system.	<ul style="list-style-type: none"> • Offering more affordable smart camera options or bundles for users with budget constraints. • Explaining the long-term cost benefits, including potential savings on security services and insurance premiums. • Providing financing options or subscription plans to spread costs over time.
Compatibility Issues	Interoperability challenges may arise when integrating smart cameras with other devices or smart home platforms. Incompatibility issues can limit the seamless collaboration between different components, reducing the overall efficiency and automation potential of the smart home ecosystem.	<ul style="list-style-type: none"> • Ensuring that smart cameras adhere to industry standards for interoperability. • Choosing devices and platforms that support widely adopted communication protocols, such as Zigbee or Z-Wave. • Regularly updating firmware and software to address compatibility issues and improve integration capabilities.
Limited Field of View	The field of view of smart cameras may be limited, leading to blind spots or gaps in coverage. This limitation can reduce the effectiveness of surveillance, allowing potential security threats or events to go unnoticed if they occur outside the camera's range.	<ul style="list-style-type: none"> • Strategically positioning multiple smart cameras to cover a broader area and eliminate blind spots. • Selecting smart cameras with features like pan, tilt, and zoom (PTZ) for flexible coverage. • Regularly reviewing and adjusting camera placements based on the evolving needs of the smart home environment.
Limited Low-Light Performance	Smart cameras may struggle with capturing clear footage in low-light conditions, impacting their effectiveness during nighttime or in poorly lit areas. This limitation can compromise overall security and surveillance capabilities.	<ul style="list-style-type: none"> • Investing in smart cameras equipped with infrared (IR) or low-light vision capabilities for enhanced visibility in the dark. • Supplementing smart cameras with additional smart lighting solutions in key areas. • Ensuring regular maintenance, cleaning, and positioning of cameras to optimize low-light performance.
Data Privacy Concerns	The storage and transmission of video footage raise concerns about the privacy and security of the collected data. Unauthorized access or breaches could lead to the exposure of sensitive information, posing risks to the residents' privacy.	<ul style="list-style-type: none"> • Implementing end-to-end encryption for video data during storage and transmission. • Providing users with options for local storage to keep video footage within the confines of the home network. • Clearly communicating data privacy policies and compliance with relevant regulations to assure users of their information's security.

Cont. table 3.

Power Source Dependency	Smart cameras typically require a power source, and dependence on wired connections may limit their flexibility in terms of placement. Power outages or disruptions can also impact the continuous operation of smart cameras, leaving blind spots in surveillance coverage.	<ul style="list-style-type: none"> • Exploring battery-powered or solar-powered smart camera options for increased flexibility in placement. • Incorporating uninterruptible power supply (UPS) systems or backup power sources to mitigate the impact of power outages. • Strategically placing smart cameras near power sources while considering their field of view requirements.
Weather Resistance Challenges	Outdoor smart cameras may face challenges related to exposure to the elements, such as rain, snow, or extreme temperatures. These environmental factors can affect the camera's performance and durability over time.	<ul style="list-style-type: none"> • Choosing outdoor smart cameras with weather-resistant or weatherproof ratings. • Regularly maintaining and cleaning outdoor cameras to prevent damage from environmental factors. • Installing additional protective enclosures or housing for smart cameras to shield them from adverse weather conditions.
Complex Installation and Setup	Some users may find the installation and setup process of smart cameras to be complex or intimidating. Complicated procedures may discourage users from adopting smart camera technology or result in improper installations that impact their effectiveness.	<ul style="list-style-type: none"> • Providing user-friendly installation guides and tutorials. • Offering customer support services or professional installation assistance. • Simplifying setup procedures through intuitive mobile applications or software interfaces. • Incorporating plug-and-play features to streamline the initial configuration process.
Limited Facial Recognition Accuracy	While facial recognition technology is advancing, smart cameras may still encounter challenges in accurately identifying individuals, leading to false positives or negatives. This limitation can impact the reliability of facial recognition features for access control or security purposes.	<ul style="list-style-type: none"> • Regularly updating firmware to include improvements in facial recognition algorithms. • Offering customization options for users to fine-tune facial recognition settings based on their preferences. • Integrating additional biometric or multi-factor authentication methods to enhance overall security in conjunction with facial recognition.
Data Storage and Retrieval Issues	The continuous recording of video footage generates large amounts of data, leading to potential challenges in storage and retrieval. Retrieving specific footage quickly or managing storage capacity efficiently can become cumbersome, affecting the user experience.	<ul style="list-style-type: none"> • Providing options for cloud storage with scalable plans based on users' storage needs. • Implementing efficient video compression algorithms to optimize storage space. • Offering local storage solutions with expandable storage capacity. Incorporating intelligent search and retrieval features in smart camera software for streamlined access to specific footage.
Integration with Legacy Systems	Users with existing non-smart surveillance systems may face challenges integrating new smart cameras with legacy systems. Compatibility issues or differences in communication protocols can hinder a seamless transition to a unified and efficient smart home security setup.	<ul style="list-style-type: none"> • Choosing smart cameras and devices with open standards or compatibility with popular communication protocols. • Utilizing intermediary devices or hubs that act as bridges between legacy systems and smart technologies. • Seeking professional assistance or consulting with experts to identify and implement integration solutions based on specific system requirements.

Cont. table 3.

Legal and Regulatory Compliance	The use of smart cameras raises legal and regulatory considerations, such as adherence to data protection laws and privacy regulations. Failure to comply with these requirements can result in legal consequences and potential disputes, impacting the overall adoption and use of smart cameras in smart homes.	<ul style="list-style-type: none"> • Staying informed about and adhering to relevant data protection laws and privacy regulations. • Incorporating features in smart cameras that support compliance with privacy standards, such as privacy mode settings. • Providing clear documentation on legal obligations and privacy practices to educate users and ensure transparent compliance.
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Source: (Gøthesen et al., 2023; Alsaedi et al., 2023; Chaudhari et al., 2023; Huda et al., 2024; Husain et al., 2023; Rhode et al., 2023; Bassarir-Orzeł et al., 2023; Tong et al., 2023; Chen et al., 2023; Douha et al., 2023; Sobhani et al., 2023).

4. Conclusion

The integration of smart cameras into the fabric of smart homes represents a transformative leap in the realms of security, convenience, and efficiency. These intelligent devices, armed with advanced technologies like artificial intelligence and machine learning, have evolved beyond traditional surveillance, offering a spectrum of functionalities that redefine modern living.

Smart cameras excel in the domain of security, providing real-time monitoring with features such as facial recognition and object detection. This not only enhances homeowners' ability to identify potential threats promptly but also fosters proactive security measures. Beyond security, the seamless integration of smart cameras with other smart home devices creates an interconnected ecosystem, allowing for automated responses based on detected events. For instance, collaboration with smart door locks, sensors, and lighting systems results in synchronized actions that enhance both security and convenience. Moreover, the advantages of smart cameras extend to energy efficiency and resource management. The ability to analyze occupancy patterns contributes to optimizing HVAC systems, promoting sustainability within the smart home. Privacy concerns are addressed through customizable settings, giving users control over monitoring zones and ensuring that smart cameras align with individual preferences.

However, the widespread adoption of smart cameras also introduces challenges. Privacy concerns and data security issues are paramount, necessitating the implementation of robust regulations and ethical frameworks. Security vulnerabilities pose risks of unauthorized access, emphasizing the importance of regular updates and strong encryption protocols. False positives, dependency on internet connectivity, and high upfront costs are challenges that require fine-tuning algorithms, alternative storage options, and accessible pricing strategies for broader user adoption. Compatibility issues, limited field of view, and low-light performance limitations underscore the need for industry standards, strategic camera placement, and enhanced hardware

features. The integration of smart cameras into legacy systems necessitates solutions such as open standards, intermediary devices, and professional assistance.

The advantages of smart cameras in smart homes are substantial, offering enhanced security, remote monitoring, and integration with other smart devices. The challenges, while significant, are addressable through technological advancements, user education, and industry collaboration. As smart homes continue to evolve, smart cameras are poised to play an increasingly central role in shaping the future of residential living.

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THE USAGE OF SMART VOICE ASSISTANT IN SMART HOME

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Purpose: The purpose of this publication is to present the usage of smart voice assistant in smart cameras.

Design/methodology/approach: Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.

Findings: The integration of smart voice assistants into smart homes promises a transformative shift in our daily lives, offering unparalleled convenience through hands-free control, efficient task automation, and personalized experiences. Despite these advantages, the evolution of this technology presents challenges, including privacy concerns, security vulnerabilities, and limitations in contextual understanding. Overcoming these obstacles necessitates a comprehensive approach, encompassing robust privacy settings, ongoing improvements in recognition algorithms, and a commitment to addressing biases. As technology advances, solutions such as offline capabilities, improved contextual understanding, and enhanced personalization become crucial for a seamless smart home experience. The need for industry collaboration, standardized practices, and the minimization of false triggers highlights the importance of a collective effort from developers, manufacturers, and users. Transparent communication, ethical considerations, and a focus on addressing challenges are paramount in creating a technologically advanced, secure, user-friendly, and inclusive smart home environment. This journey towards innovation underscores the importance of upholding values of privacy, security, and accessibility to unlock the true potential of smart living.

Originality/Value: Detailed analysis of all subjects related to the problems connected with the usage of smart voice in smart home.

Keywords: Smart City, energy efficiency, smart home, smart house, digitalization, smart voice assistant.

Category of the paper: literature review.

1. Introduction

The utilization of smart voice assistants in smart homes marks a significant leap forward in the realm of home automation, revolutionizing the way individuals interact with and manage their living spaces. These advanced systems, equipped with sophisticated voice recognition and natural language processing capabilities, bring forth a range of transformative applications. One of the central advantages lies in the hands-free convenience they offer. Users can seamlessly control an array of smart devices simply by articulating voice commands, eliminating the need for manual interaction. This streamlined approach enhances overall convenience and accessibility, particularly for individuals with mobility challenges. Efficiency is a cornerstone of smart voice assistant usage in smart homes. These systems excel in automating routine tasks, from setting reminders and creating shopping lists to managing daily schedules. By doing so, they not only save time but also contribute to increased productivity in daily activities (Patheja et al., 2023).

The purpose of this publication is to present the usage of smart voice assistant in smart home.

2. Smart voice assistant in smart home

Smart voice assistants have emerged as revolutionary technologies that seamlessly integrate into our daily lives, transforming the way we interact with and control our devices (Chen et al., 2023). These sophisticated virtual companions, powered by advanced artificial intelligence (AI) algorithms, have evolved from basic voice recognition systems into versatile and intuitive digital assistants (Olabode et al., 2023). At the core of these smart voice assistants is natural language processing (NLP), a branch of AI that enables machines to comprehend and respond to human speech in a manner that feels organic and conversational. This breakthrough technology has paved the way for a more intuitive and user-friendly interaction with devices, eliminating the need for cumbersome interfaces and manual inputs (Afroz et al., 2024).

One of the key features that distinguish smart voice assistants is their ability to perform a diverse range of tasks through voice commands. Whether it's setting reminders, sending messages, making calls, or even controlling smart home devices, these assistants have become virtual personal assistants that cater to our needs with just a spoken word. The seamless integration with various applications and services has made them an indispensable part of our daily routines (Gajdzik et al., 2023; Jonek-Kowalska, Wolniak, 2021; 2022). Moreover, the continuous learning capabilities of smart voice assistants contribute to their adaptability and personalized user experience. Through machine learning, these assistants can understand user

preferences, adapt to speech patterns, and provide increasingly accurate and relevant responses over time (Tong et al., 2023). This dynamic learning process enhances the overall user experience, making the interaction more personalized and efficient (Ameur et al., 2023).

In addition to their role as personal assistants, smart voice technologies have found applications in various industries, ranging from healthcare to education. In healthcare, they can be utilized to provide information, monitor health metrics, and even offer emotional support. In education, these assistants can facilitate learning by answering queries, providing information, and offering interactive lessons (Bsarir-Ozel et al., 2023). Security and privacy concerns have been significant considerations in the development of smart voice assistants (Rhode et al., 2023). Manufacturers have implemented robust security measures to safeguard user data and ensure that voice recordings are handled with the utmost confidentiality. Nevertheless, ongoing discussions and improvements in privacy policies are essential to address the evolving challenges associated with these technologies (Valencia-Arias et al., 2023).

Looking ahead, the future of smart voice assistants holds even more exciting possibilities (Hussain et al., 2023). As technology advances, we can anticipate enhanced contextual understanding, more natural conversations, and increased integration with emerging technologies like augmented reality and the Internet of Things (IoT). The evolution of these assistants is bound to reshape the way we interact with our digital environments, fostering a more connected and efficient lifestyle (Dhaou, 2023).

Table 1 contains descriptions of key features of smart voice assistance usage. This table provides a concise overview of key features associated with the usage of smart cameras, highlighting their diverse applications and the challenges related to privacy and data security.

Table 1.

Key features of smart voice assistance usage

Key Features of Smart Voice Assistance	Description
Voice Recognition	Smart voice assistants utilize advanced voice recognition technology to understand and interpret spoken commands, allowing for hands-free interaction.
Natural Language Processing	These systems can comprehend and respond to natural language, enabling users to communicate with the assistant in a more conversational manner.
Task Automation	Smart voice assistants can perform various tasks on command, such as setting reminders, sending messages, or controlling smart home devices.
Information Retrieval	Users can ask the assistant for information on a wide range of topics, and it will provide relevant and up-to-date information from the internet.
Smart Home Integration	Integration with smart home devices enables users to control lights, thermostats, security systems, and more, using voice commands.
Calendar Management	Users can schedule appointments, set reminders, and check their calendar using voice commands, enhancing productivity and organization.
Multimodal Interaction	Some smart assistants support multimodal interaction, combining voice commands with visual feedback on devices with screens, such as smartphones.
Language Translation	Translation capabilities allow users to ask for translations or have real-time conversations in different languages using the voice assistant.

Cont. table 1.

Personalized Responses	Smart voice assistants can learn user preferences over time, providing personalized responses and recommendations based on individual habits and needs.
Accessibility Features	These features cater to users with disabilities by providing hands-free interaction, dictation, and accessibility settings for a more inclusive experience.
Continuous Learning	Many voice assistants continuously learn and improve their capabilities through machine learning, adapting to user preferences and evolving over time.
Voice Recognition	Advanced technology for accurate and reliable voice input recognition.
Natural Language Processing	Understanding and interpreting natural language, allowing for more intuitive and conversational interactions.
Task Automation	Automating tasks such as setting alarms, creating to-do lists, sending emails, or ordering items online through voice commands.
Information Retrieval	Access to a vast amount of information, providing answers to general knowledge questions, news updates, weather forecasts, and more.
Smart Home Integration	Seamless control of smart home devices like lights, thermostats, locks, and cameras using voice commands.
Calendar Management	Scheduling events, setting reminders, and checking calendar appointments with voice prompts.
Multimodal Interaction	Integration with screens for visual feedback, enabling users to see and interact with information in addition to voice commands.
Language Translation	Translating languages on the fly, facilitating communication across language barriers.
Personalized Responses	Customized interactions based on user preferences, history, and context, providing a more tailored and user-centric experience.
Accessibility Features	Voice assistants offer accessibility options, including voice commands for users with mobility issues and screen-reading capabilities for the visually impaired.
Continuous Learning	Machine learning algorithms allow the voice assistant to adapt and improve over time, learning from user interactions and evolving its capabilities.
Entertainment	Playing music, recommending movies, telling jokes, and engaging in casual conversations to provide entertainment and enhance user experience.
Location-Based Services	Utilizing location data for context-aware assistance, such as finding nearby restaurants, navigating routes, and providing location-specific information.
Integration with Third-Party Apps	Connecting with external applications and services to expand functionality, like ordering food, calling a ride-sharing service, or checking social media.
Security and Privacy Features	Implementing measures to safeguard user data and privacy, including voice recognition profiles and options to control data sharing.
Voice Modulation and Emotion Recognition	Some systems can recognize and respond to changes in voice modulation and emotion, providing a more nuanced and empathetic interaction.

Source: (Gøthesen et al., 2023; Alsaedi et al., 2023; Chaudhari et al., 2023; Huda et al., 2024; Husain et al., 2023; Rhode et al., 2023; Basarir-Ozel et al., 2023; Tong et al., 2023; Chen et al., 2023; Douha et al., 2023; Sobhani et al., 2023).

3. The advantages and problems of using smart voice assistant

Smart voice assistants have ushered in a new era of convenience and efficiency within the realm of smart homes. Their integration offers a myriad of advantages, fundamentally reshaping how individuals interact with and manage their living spaces. Foremost among these benefits is the hands-free convenience that smart voice assistants bring to the table. Users can seamlessly control a spectrum of smart devices, adjusting lighting, thermostats, and other connected elements through effortless voice commands, eliminating the need for physical interaction (Alsaedi et al., 2023).

Efficiency is another hallmark advantage. These assistants excel at automating routine tasks, from setting reminders and creating shopping lists to managing daily schedules. This not only streamlines day-to-day activities but also enhances overall productivity. Instant information retrieval is a key forte, allowing users to quickly access a wealth of information on demand. Whether checking the weather forecast, receiving news updates, or accessing real-time data, users can retrieve information simply by posing a question, eliminating the need for manual device checks (Chaudhari et al., 2023).

Enhanced home security is achieved through seamless integration with security systems, cameras, and smart locks. Voice commands provide quick access to security features, contributing to an enhanced sense of safety and control. The ability to personalize living environments stands out as a distinctive advantage. Users can tailor their spaces based on individual preferences, adjusting the thermostat, changing lighting colors, or setting up personalized routines (Huda et al., 2024).

Seamless device integration characterizes smart voice assistants, as they effortlessly unite with a diverse array of smart devices and platforms. This integration creates a unified ecosystem where users can control and manage various aspects of their homes through a single, voice-activated interface. Accessibility is a key consideration, particularly for individuals with mobility challenges or disabilities. The hands-free nature of voice control ensures inclusivity, allowing everyone in the household to easily interact with and benefit from smart home features (Wu et al., 2023).

Energy efficiency receives a boost through voice commands that enable users to optimize energy consumption. Controlling smart thermostats, lights, and appliances not only contributes to a more eco-friendly home but also aids in reducing energy costs. Remote control and monitoring add an extra layer of convenience and peace of mind. Whether away on vacation or at the office, users can stay connected to their homes through voice commands, enhancing overall control and security (Sobhani et al., 2023).

The intuitive nature of home automation facilitated by natural language commands makes operating complex systems more user-friendly. This ensures that individuals of all technological backgrounds can easily navigate and utilize the smart home environment. Increased productivity is a byproduct of smart voice assistants, allowing users to perform tasks efficiently, such as adding calendar events or creating reminders. This efficiency frees up time to focus on other activities and ultimately boosts overall productivity (Raff et al., 2024).

Multi-user recognition enhances the user experience by allowing smart voice assistants to recognize different users within a household. This feature offers personalized responses and tailored experiences for each family member. Integration with third-party apps extends the functionality of smart voice assistants, offering a broader range of capabilities and services to users (Ramanujam et al., 2024).

Continuous updates and improvements from manufacturers ensure that smart voice assistants remain up-to-date, secure, and capable of meeting evolving user needs. This commitment to innovation ensures that the smart home system continually evolves to enhance the user experience (Douha et al., 2023).

Table 2 highlighting the advantages of using smart voice assistant in smart home. These advantages showcase the transformative impact of smart voice assistants in creating more efficient, convenient, and personalized smart home environments.

Table 2.
Advantages of using smart cameras

Advantage	Description
Hands-Free Control	Users can control smart home devices, such as lights, thermostats, and locks, without the need for physical interaction, enhancing convenience.
Voice-Activated Entertainment	Enjoy seamless control of entertainment systems, including playing music, adjusting volume, or even selecting and streaming content using voice commands.
Efficient Task Automation	Automate routine tasks like setting timers, creating shopping lists, and managing daily schedules, making daily activities more streamlined and efficient.
Quick Information Retrieval	Obtain instant information on weather updates, news, and other real-time data by simply asking the voice assistant, eliminating the need to check devices manually.
Enhanced Home Security	Integrate voice commands to control security systems, cameras, and door locks, allowing users to monitor and secure their homes easily.
Personalized Environment	Adjust smart home settings based on individual preferences, creating a personalized and comfortable living environment for each household member.
Seamless Integration with Devices	Voice assistants seamlessly integrate with a wide range of smart devices, providing a unified platform for controlling and managing various aspects of the home.
Accessibility for All Users	Voice control enhances accessibility for individuals with mobility challenges or disabilities, offering a more inclusive smart home experience.
Energy Efficiency	Optimize energy consumption by controlling smart thermostats, lights, and appliances with voice commands, contributing to a more energy-efficient home.
Remote Control and Monitoring	Monitor and control smart home devices remotely using voice commands, providing convenience and peace of mind, especially when away from home.
Intuitive Home Automation	Simplify the operation of complex home automation systems by using natural language commands, making it more user-friendly and accessible to everyone.
Increased Productivity	Execute tasks efficiently, such as adding calendar events or creating reminders, allowing users to focus on other activities and enhance productivity.
Multi-User Recognition	Voice assistants can recognize different users in a household, providing personalized responses and tailored experiences for each family member.
Integration with Third-Party Apps	Connect with various third-party applications, expanding the capabilities of smart voice assistants and enabling a broader range of functionalities.
Continuous Updates and Improvements	Manufacturers regularly release updates, adding new features and improving performance, ensuring that the smart home system remains up-to-date and secure.

Source: (Gøthesen et al., 2023; Alsaedi et al., 2023; Chaudhari et al., 2023; Huda et al., 2024; Husain et al., 2023; Rhode et al., 2023; Basarir-Ozel et al., 2023; Tong et al., 2023; Chen et al., 2023; Douha et al., 2023; Sobhani et al., 2023).

Table 3 highlighting some of the common problems and challenges associated with the problems of using smart voice assistant in smart homes. This table outlines various problems associated with the usage of smart cameras in smart homes, along with detailed descriptions of each issue and suggested methods for overcoming or mitigating these challenges.

Table 3.
Problems of using smart voice assistant

Problem	Description	Methods of Overcoming
Privacy Concerns	Users may express concerns about the privacy of their personal data, as voice assistants typically process and store voice recordings.	<ul style="list-style-type: none"> - Implement robust privacy settings that allow users to control data sharing preferences. - Regularly update privacy policies and communicate them transparently. - Develop local processing capabilities to limit data sent to the cloud.
Security Vulnerabilities	Smart voice assistants can be susceptible to hacking or unauthorized access, potentially exposing sensitive information or enabling malicious control over connected devices.	<ul style="list-style-type: none"> - Regularly update software and firmware to patch security vulnerabilities. - Implement strong authentication methods, such as voice recognition or biometrics. - Educate users on the importance of strong passwords and security practices.
Inaccuracy in Voice Recognition	Voice assistants may struggle to accurately recognize and interpret user commands, leading to frustration and diminished user experience.	<ul style="list-style-type: none"> - Continuously improve and update voice recognition algorithms through machine learning. - Provide options for users to train the system on their voice for better accuracy. - Incorporate contextual clues to enhance understanding of ambiguous commands.
Limited Understanding of Context	Voice assistants may lack contextual understanding, making it challenging to carry on complex or multi-step conversations. Misinterpretation of context can result in incorrect responses.	<ul style="list-style-type: none"> - Invest in natural language processing advancements to improve contextual understanding. - Implement machine learning models that consider historical user interactions for more accurate context recognition. - Allow users to provide additional context or clarification during interactions.
Dependency on Internet Connectivity	Many voice assistants rely on a stable internet connection for processing voice commands, which can be a limitation in areas with poor connectivity or during internet outages.	<ul style="list-style-type: none"> - Develop offline capabilities to handle basic commands without an internet connection. - Prioritize the use of local processing to reduce dependence on cloud-based services. - Educate users on optimizing their home network for a more reliable connection.
Device Compatibility Issues	Compatibility issues may arise when integrating voice assistants with various smart home devices, especially if they come from different manufacturers or use different communication protocols.	<ul style="list-style-type: none"> - Encourage device manufacturers to adhere to common industry standards for seamless integration. - Regularly update voice assistant software to support new devices and protocols. - Provide comprehensive compatibility lists and user guides for easy setup and troubleshooting.
False Triggers and Unintended Activation	Voice assistants may be triggered unintentionally by background noise or phrases that sound similar to wake words, leading to unintended activation and potential privacy concerns.	<ul style="list-style-type: none"> - Allow users to customize wake words to reduce false triggers. - Implement advanced audio processing algorithms to filter out background noise. - Incorporate contextual analysis to distinguish between intentional and unintentional activation.
Lack of Personalization for Multiple Users	Voice assistants may struggle to differentiate between multiple users, leading to a less personalized experience for each household member.	<ul style="list-style-type: none"> - Invest in robust multi-user recognition systems based on voice, biometrics, or other identifiers. - Allow users to create individual profiles with personalized preferences. - Continuously update algorithms to adapt to changing user patterns and preferences.
Ethical and Bias Concerns	Voice assistants may unintentionally perpetuate biases present in training data, resulting in biased responses or reinforcing stereotypes.	<ul style="list-style-type: none"> - Regularly audit and review training data for biases and diversity. - Implement ethical guidelines for content creation and response generation. - Encourage diverse and inclusive development teams to minimize unintentional biases

Source: (Gøthesen et al., 2023; Alsaedi et al., 2023; Chaudhari et al., 2023; Huda et al., 2024; Husain et al., 2023; Rhode et al., 2023; Basarir-Ozel et al., 2023; Tong et al., 2023; Chen et al., 2023; Douha et al., 2023; Sobhani et al., 2023).

4. Conclusion

The integration of smart voice assistants into smart homes offers a multitude of advantages, transforming the way we interact with and manage our living spaces. The hands-free convenience, efficiency in task automation, and personalized experiences contribute to a more streamlined and enjoyable daily life. However, these advancements come with their set of challenges. Privacy and security concerns, potential inaccuracies in voice recognition, and limitations in contextual understanding represent significant hurdles in the widespread adoption of smart voice assistants. Overcoming these challenges requires a multi-faceted approach, including robust privacy settings, continuous improvement in recognition algorithms, and a commitment to addressing biases and security vulnerabilities.

As technology continues to evolve, solutions such as offline capabilities, improved contextual understanding, and enhanced personalization for multiple users are crucial to ensuring a seamless and reliable smart home experience. Device compatibility and minimizing false triggers further underscore the importance of industry collaboration and standardized practices. In navigating the future of smart homes, it is imperative for developers, manufacturers, and users alike to work together. Transparent communication, ethical considerations, and a dedication to addressing the identified challenges will be essential in fostering a smart home environment that is not only technologically advanced but also secure, user-friendly, and inclusive. As we continue on this technological journey, the pursuit of innovation must be accompanied by a commitment to the values of privacy, security, and accessibility to truly unlock the potential of smart living.

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VOLUNTARY FIRE DEPARTMENTS (VFD) IN POLAND AS AN ENTITY OF THE NON-GOVERNMENTAL SECTOR (NGO) ON THE EXAMPLE OF THE WESTERN POMERANIA VFD

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Purpose: The article's purpose was to explore the usage of and activities to enhance human potential and the socioeconomic impact of the VFD units of the Western Pomerania Voivodship, based on research done among the VFD units of the Western Pomerania Voivodship.

Design/methodology/approach: The study employs literature analysis, tabular comparisons, and conducted questionnaires of bathers. The approach for the research was based on a desktop evaluation of accessible information, statistics, and other data national sources. The qualitative data acquired from self-research was used in the statistical analysis. The research group had 338 firemen from 17 VFD units and the research was scheduled from February and the end of March 2022.

Findings: The study found that membership in the NRFS system had a considerable impact on local governments and firemen. The operation of TSOs in the NRFS system is a factor that promotes the improvement of firefighters' funding on the part of local governments, and on the part of TSO units themselves, it is a factor that raises their competence and confidence in the skills of their own team. Both have a considerable impact on the effectiveness of rescue and firefighting operations, as well as firefighters' attitudes.

Research limitations/implications: The research has limitations, such as its specific timeframe and omitted variables.

Practical implications: The study's findings revealed a progressive professionalization of TSO units in NRFS, as well as an increase in social functions, particularly rescue functions - participation in rescue and firefighting activities, which is reflected in increased receipt of financial support from the municipal to provincial levels. Therefore, reduced activity and self-motivation of TSO firefighters from outside the NRFS system may cause less professionalism during rescue and firefighting operations.

Social implications: Volunteer fire stations perform essential social duties in their region of operation in addition to rescue and firefighting actions. The "extinction" of TSO units' activities outside the KSRG system may result in lower social activity in the locations where the aforementioned units operate, among other reasons.

Originality/value: Study documents a certain stage of development of TSO units, with the long-term goal of professionalizing these structures of units joining the NRFS system. In addition to the components (conclusions) described in the article, this is demonstrated by the decreased participation of firefighters outside the NRFS in various activities aimed at raising funds for TSOs' broadly specified statutory activities.

Keywords: public policy, NGOs, social participation, fire protection, volunteer fire departments, public safety, social capital.

Category of the paper: research paper.

1. Introduction

Non-governmental organizations (NGOs) in Poland operate on the idea of citizen voluntarism and social involvement in the local or regional environment. The Law on Public Benefit Activity and Volunteerism contains the legal definition of a non-governmental organization. According to the legal definition, a non-governmental organization is any entity that is neither an organ or a subordinate unit of public administration (government or local government) and whose operations are not profit-oriented (Act on Public Service, 2023). Non-governmental organizations are referred to in the public sphere as the "third sector", as opposed to the public sector (first sector) and the business sector (second sector). Volunteer fire departments (VFD) and the VFD organization, which operate from the municipal level and has a statewide reach, are unique in terms of legislative activity in Poland and Europe.

The aim of the article was to investigate the use of and activities to strengthen human capability and socio-economics impact of the VFD units of the Western Pomerania Voivodship, based on the research conducted among the VFD units of the West Pomeranian Voivodeship. The study employs literature analysis, tabular comparisons, and conducted questionnaires of bathers. The approach for the research was based on a desktop evaluation of accessible information, statistics, and other data national sources. The qualitative data acquired from self-research was used in the statistical analysis. The research group had 338 firemen from 17 VFD units and the research was scheduled from February and the end of March 2022. The research group was established as the territorial VFD units of the West Pomeranian Voivodeship. The activity of separate districts of the mentioned province in various local government programs served as the guiding rationale for their separation. Counties with low, medium, and high levels of involvement were pointed out from this standpoint. Following that, firefighting units belonging to and not belonging to the CRSG were chosen at random within them. A total of 17 units and 338 firefighters were polled. The survey ran from February to the end of March 2022.

2. Theoretical aspects of voluntary fire departments in Poland and in the west pomeranian region

Volunteer fire departments responded to socioeconomic changes following Poland's political transformation in 1989 and are an example of a non-governmental organization that has been popular in the public eye for years as an organization and its members - volunteer firefighters. The profession of "firefighter" ranks first on the national list of professions, thanks not only to the state fire department's (SFD) standing, but also to the operations of volunteer firefighting groups and departments (VFD). Under the requirements of the Law of April 7, 1989, VFD units became non-governmental organizations - Associations Law (Law on Associations, 1989). The entry into force of the Fire Protection Act of August 24, 2003, as well as the establishment of the national rescue and firefighting system (NRFS) of state security, laid the legal and organizational groundwork for VFD unit job implementation (Dz.U.2022.0.2257). Cooperation within the NRFS is primarily cooperation during rescue operations throughout the country with the participation of specialists, rescue groups, the use of equipment, the preparation of joint training programs on the principles of first aid, the use of basic rescue techniques, the creation of programs informing about disaster risks, natural disasters, fires, and other hazards caused by natural or human activity, and the availability of resources (Ministry of Internal Affairs, 20.07.2023). VSDs have been performing civil protection, fire protection, and rescue operations for almost 30 years. Volunteer fire departments' goals and tasks are based on statutes, with the basis being to carry out activities aimed at preventing fires, participating in rescue operations carried out during fires and other dangerous events and disasters, and informing the population about existing threats. The boards of VFD associations have legal personality and are recognized in the National Court Register (NCR). The distinctive feature of VFD is "to take action to protect life, health, property, or the environment," which distinguishes this organization from others. VFD units conduct large-scale preventive efforts, primarily geared at children and young people (NGO portal, 20.07.2023). The incorporation of VFD units in the national rescue and firefighting system (NRFS) is a critical component in elevating the status of VFDs. In 1995, the inclusion of VFD units in the NRFS was conditional on meeting the requirements set by the Minister responsible for internal affairs and the Chief Commander of the National Fire Service for equipment and training, in accordance with the Minister of Internal Affairs' Regulation of September 15, 2014 on the scope, detailed conditions, and procedure for including fire protection units in the national rescue and firefighting system (Ordinance of the Minister of Internal Affairs of September 15, 2014).

Fire protection units may be included in the NRFS system if their forces and resources are available for use in the district or provincial rescue plan, which is included in the aggregate plan of the network of system entities managed by the State Fire Department. A VFD unit may be included in the NRFS system if it: 1. has: 1.1. at least one medium or heavy rescue and

firefighting vehicle, 1.2. at least 12 trained rescuers, 1.3. an effective notification and alarm system, 1.4. communication facilities on the system's radio network for rescue operations, and 2. remains ready to undertake rescue operations.

VFD units have been continuously absorbed into NRFS's resources during the past 30 years. The NRFS will have 4738 VFDs in 2021. NRFS has 4,929 VFD units at the end of December 2022, with 12,000 rescue, firefighting, and special vehicles. Outside of the NRFS system, there are around 11,000 VFD units whose capabilities are also employed for rescue and firefighting. The total number of VFD units registered with the National Court Register in Poland has surpassed 16 thousand. It is Europe's largest volunteer firefighter rescue group. The VFD phenomenon has been astounding for many decades, on the one hand, while also helping to save life, health, property, or the environment from fire, natural disaster, or other local risk. In 1990-1991, the drafters of the "firefighting laws" extremely efficiently incorporated social and non-governmental potential into the state security apparatus developed after 1989 (Ręclawowicz, 2018).

The social components of VFS activities must be highlighted. In 2012, a detailed research study on the conditions and possibilities of VFDs (Bubak, 2008, Dzieniszewska-Naroska, 2004; Kocowski, 2018; Popis, 2013; Stochmal, 2021) indicated that they are frequently the primary source of social capital in villages and small towns. VFD activity is predominantly concentrated in rural regions, and VFD social engagement is an important component of local social capital, which also creates normative behavior based on trust, reciprocity, obligations, and expectations", contributing to socio-local development. In empirical investigations, social and civic action determines the level of social capital. Common metrics of social activity are those related to social networks and the operation of voluntary associations and social organizations - referred to as a barometer of social involvement by topic researchers (Zakrzewska, 2023).

VFDs employ approximately 700,000 people, with 228,394 firefighters actively involved in rescue and firefighting operations, as well as technical, flood, chemical and ecological, medical, high altitude, water rescue, and search and rescue activities. Within the VFD, there are also various Youth Fire Departments Teams (YFDT), which are naturally centers for training and recruiting young firemen.

VFD activity includes not only programs targeted at direct support to local communities, but also activities promoting culture, sports, relaxation, and environmental protection. The VFD includes almost 800 orchestras, 20,000 musicians, 300 artistic teams, and 600 sports teams. Although the memory of fire history is gathered and made available in over 1000 chambers of tradition, it is worth noting that VFDs are distinguished from other secular NGOs working in rural regions by their professed dedication to tradition and religiosity (Marcysiak, 2021).

As it goes with the West Pomeranian Voivodship, by the end of 2021, the potential of its national rescue and firefighting system included:

- 20 municipal/county SFD commands,
- 26 SFD rescue and firefighting units,
- 4 SFD stations (Darlowo, Debno, Miedzzydroje, Nowogard),
- 200 VFD units included in the NRFS,
- 5 units of military fire protection included in NRFS.

The system is being supported by the following forces and resources (from outside the NRFS):

- 243 VFD units,
- 5 units of Company Fire Service and Company Rescue Service,
- 8 units of military fire protection (Ordinance of the Minister of Internal Affairs of September 15, 2014).

The number of VFD units in the West Pomeranian Voivodeship is as follows:

- Number of VFDs according to the IT SYSTEM of VFDs – 475,
- Number of VFDs registered in the National Court Register – 468,
- Number of VFDs in NRFS – 205.

The number of West Pomeranian VFDs resulting from the IT SYSTEM of VFDs as of 08.12.2021 are:

- members - 14,555 persons, including 11,197 men and 1494 women, including:
 - supporting members - 1026 persons,
 - honorary members - 838 persons,
- 47 Women's Fire Teams with 420 members,
- 237 Youth Fire Brigades Teams with 2794 members, of which 1149 are girls and 1645 are boys.

Analysis the infrastructure potential of VFD in the West Pomeranian Voivodeship, 214 VFD units own light rescue and firefighting vehicles, 97 units own heavy vehicles, and 152 units own other vehicles: 12 hydraulic lifts, 4 mechanical ladders, 12 cars, 46 technical with equipment, 9 trucks, 2 coaches, 1 tractor, 64 boats on trailers, and 60 other vehicles. There were no fire stations in 16 units, and 34 VFDs lacked rescue equipment such as a car or a motor pump.

Thus, taking into account the statistics cited above, it is possible to distinguish three basic areas of firefighter activity:

- fire protection and rescue,
- branch activity, in terms of training, maneuver competitions,
- activities for the local environment.

In turn, the way in which the above-mentioned tasks are fulfilled is determined by many factors among which are economic factors (e.g., the building of the fire station, the equipment owned by the unit, the level of wealth of the municipality in which the unit operates), the condition of the cadre (e.g., its number, age, level of training, etc.), the technical infrastructure of the municipality (e.g., transportation availability, access to water), social conditions (institutions operating in its area).

3. Conducted research – methodology and research group

For the purposes of this study, the analysed region of the West Pomeranian region compared to Poland is identified with each of the sixteen existing regions in accordance with the Nomenclature of Territorial Units for Territorial Statistics (NTS) in force in Poland, prepared based on the European Nomenclature of Territorial Statistics Units (NUTS) (Zalewski, Sikora, Czapiewski, 2021). The region included in the study is of size corresponding in this classification to the NUTS 2 level as a unit of the administrative division of the second-level country, as indicated by many authors (Korenik, 1999; Strahl, 2005; Paradysz, 2012).

According to a review of the literature, the subject of volunteer firemen is studied in three contexts:

1. volunteer firemen (Blaney et al., 2021; Bryant, Harvey, 1995),
2. volunteer firefighters (Hwang et al., 2019),
3. volunteer firemen working as part of a larger group (Henderson, Sowa, 2018; Oliveira, Pinheiro, 2021).

Several subject groups can be defined based on the concerns addressed in the literature. The physical health of firefighters, as well as the elements that influence it, is frequently the focus of investigation (Petruzzello et al., 2016). Firefighters' mental health receives a great deal of attention (Frost et al., 2021; Cramm et al., 2021), which is undoubtedly due to the unique nature of their operations (Kovac et al., 2022), particularly in crisis and traumatic situations (Smith et al., 2022; Schnell et al., 2020). Because the phenomenon "affecting" Volunteer Fire Departments is staffing problems (Malinen, Mankkinen, 2018), much attention has been paid to the motivations for joining TSO units and the factors that encourage long-term activity in them (Gazzale, 2019; Henderson, Sowa, 2018; Huynh et al., 2023). The role of family is frequently emphasized in this context (Cowlshaw et al., 2008; McLennan et al., 2009; Huynh et al., 2013). There have also been research on the effect of rescue and firefighting experience on their responses (Petruzzello et al., 2016; Poh et al., 2014). However, no studies have been found in which firefighter activity toward institutional support or social participation has been studied. Therefore, quantitative study's goal was to inquire into firefighting activity variables

such as: a) attitude toward institutional support, b) opportunities for action, c) social engagement, and d) existing problems in VFD units.

The approach for the research was based on a desktop evaluation of accessible information, statistics, and other data national sources. The qualitative data acquired from self-research was used in the statistical analysis. The research group had 338 firemen from 17 VFD units and the research was scheduled from February and the end of March 2022. The research group was established as the territorial VFD units of the West Pomeranian Voivodeship.

4. Research results considering attitude towards institutional support

Municipalities finance the activities of firemen in VFD units, which is the foundation for their operation. According to the report, the majority of firefighters favor local government assistance. A total of 286 people (84.62%) evaluated their authorities as 3 to 5. The majority, 112 (33.4%), thought the level of subsidies was adequate. 91 respondents (26.92%) gave a good rating, and 83 (24.56%) gave a very high rating. Opinions differ between the two distinct types of VFD units. While opinions among NRFS firefighters are similar with the entire data, firemen who are not participating in the described system have more diverse evaluations. On the one hand, we have two groups of 15 persons who provide evaluations of adequate and excellent. There are also 10 responders who are pleased with the municipality's financial assistance. However, greater than in the NRFS units of individuals 6 (taking the entire category into account). Provide a dismal mark to their local administrations (Table 1).

Table 1.

Level of financial - organizational support provided by municipal authorities to VFDs

Evaluation of support	VFD units in NRFS			VFD units outside NRFS			Total	
	N	% ¹	Location	N	% ²	Location	N	% ³
0	2	0,70	VI	2	3,77	V	4	1,18
1	11	3,86	V	6	11,32	III	17	5,03
2	26	9,12	IV	4	7,55	IV	30	8,88
3	97	34,04	I	15	28,30	I	112	33,14
4	81	28,42	II	10	18,87	II	91	26,92
5	68	23,86	III	15	28,30	I	83	24,56
No data available	-	-		1	1,89		1	0,30
Total:	285	100,00		53	100,00		338	100,00

%¹ - percentage calculated from the size of the NRFS category = 53 people; %² - percentage calculated from the size of the NRFS category = 285 people; %³ - percentage of all respondents = 338 people; Place - options to choose among the distinguished categories of firefighters.

Source: Authors' own research.

5. Research results considering attitude towards opportunities for action

The purchase of new equipment for firefighters, particularly a fire engine, demonstrates the municipality's economic capacity. The capacity of firemen to perform during actions is heavily influenced by the availability of modern equipment. The majority of responders, 174 (51.48%), said their VFD unit has a new fire vehicle. There are discrepancies between the divided categories here, as in the previously stated table. Firefighters from units other than the NRFS are more concerned about a lack of modern equipment (1st place in the selection possibilities) than those from the system (2nd place). Surprisingly, as many as five firefighters outside the NRFS claimed that their unit had received a new truck, despite the fact that the majority of their unit members claimed the reverse. These individuals may have previously belonged to a different VFD than the one they represented on the day of the poll. However, it is possible to deduce that firefighters outside the NRFS have older equipment than those within the system (Table 2).

Table 2.

Acquisition of new rescue and firefighting vehicle by VFD unit in the last 5 years

Selection option	VFD units in NRFS			VFD units outside NRFS			Total	
	N	% ¹	Location	N	% ²	Location	N	% ³
The unit has a new truck	151	52,98	I	23	43,40	II	174	51,48
The unit does not have a new vehicle	129	45,26	II	30	56,60	I	159	47,04
No data available	5	1,75		-	-		5	1,48
Total:	285	100,00		53	100,00		338	100,00

%¹ - percentage calculated from the size of the CRSG category = 53 people; %² - percentage calculated from the size of the CRSG category = 285 people; %³ - percentage of all respondents = 338 people; Place - options to choose among the distinguished categories of firefighters.

Source: Authors' own research.

6. Research results considering respondents' social participation

There are differences in the activity of firemen based on their classification. Firefighters in the NRFS system are undoubtedly more frequently involved in rescue and firefighting operations. Every year, the majority of firefighters here participate in more than 30 actions, with those who are less active (up to 20 actions) coming in second. The opposite is true in the SFD outside of the system. Every year, firemen participate in no more than 20 activities. The most active responses have a small number of responses. The participation of the investigated firefighters' units in the NRFS system appears to be the distinguishing element of their actions. In addition, 37 firefighters (20.95%) do not participate in direct VFD tasks.

These are mostly retired firefighters and a few women. Firefighters' activity is measured by their participation in rescue and firefighting operations (Table 3).

Table 3.

Number of rescue and firefighting operations in which firefighters participated during the year

Selection option	VFD units in NRFS			VFD units outside NRFS			Total	
	N	% ¹	Location	N	% ²	Location	N	% ³
0	30	10,53	IV	7	13,21	III	37	10,95
up to 20	93	32,63	II	28	52,83	I	121	35,80
above 20 to 30	53	18,60	III	11	20,75	II	64	18,93
above 30	109	38,25	I	7	13,21	III	116	34,32
Total:	285	100,00		53	100,00		338	100,00

%¹ - percentage calculated from the size of the CRSG category = 53 people; %² - percentage calculated from the size of the CRSG category = 285 people; %³ - percentage of all respondents = 338 people; Place - options to choose among the distinguished categories of firefighters.

Source: Authors' own research.

The capacity to offer first response is another key indicator of firefighters' social participation (Table 4). With 92 answers (27.22%), firefighters who rate their skills as very good are the most numerous. 86 respondents (25.44%) rate themselves as having a high opinion of themselves. Following that are mediocre 70 firefighters (20.71%), sufficient 54 druhs (15.98%), and insufficient 31 persons (9.17%).

Table 4.

Assessment of first responds skills of firefighters

Selection option	Evaluation	VFD units in NRFS				VFD units outside NRFS				Total	
		N	% ¹	Location	Average	N	% ²	Location	Average	N	% ³
Own skills	0	4	1,40	VI	3,43	-	-	-	3,02	4	1,1
	1	23	8,07	V		8	15,09	III		31	9,17
	2	58	20,35	III		12	22,64	II		70	20,71
	3	42	14,74	IV		12	22,64	II		54	15,98
	4	73	25,61	II		13	24,53	I		86	25,44
	5	84	29,47	I		8	15,09	III		92	27,22
A firefighter's away team for rescue and firefighting operations	0	3	1,05	VI	3,78	2	3,77	IV	3,23	5	1,48
	1	8	2,81	V		5	9,43	III		13	3,85
	2	59	20,70	III		8	15,09	II		67	19,82
	3	29	10,18	IV		8	15,09	II		37	10,95
	4	77	27,02	II		14	26,42	I		91	26,92
	5	111	38,95	I		14	26,4	I		125	36,98
Other firefighters in the VFD unit	0	2	0,70	VI	3,55	-	-	-	3,53	2	0,59
	1	23	8,07	V		8	15,09	IV		31	9,17
	2	48	16,84	III		7	13,21	V		55	16,27
	3	39	13,68	IV		13	24,53	II		52	15,38
	4	85	29,82	II		14	26,42	I		99	29,29
	5	87	30,53	I		11	20,75	III		98	28,99

%¹ - percentage calculated from the size of the CRSG category = 53 people; %² - percentage calculated from the size of the CRSG category = 285 people; %³ - percentage of all respondents = 338 people; Place - options to choose among the distinguished categories of firefighters.

Source: Authors' own research.

When the opinions of the surveyed types of TSO units are compared, those who work in the NRFS system rank their first aid skill much higher, with an average value of 3.43. Druhs from outside VFDs give themselves worse grades. Their average is 3.02 points. The respondents rate their teammates' competence higher than their own. Very good marks are the most common in both separate categories. This is how 125 individuals (36.98%) ranked their team. At the same time, firemen from VFD units in the NRFS assess the companions' skills higher - the average here is 3.78, which is 0.55 higher than among firefighters outside the system. Respondents' ratings of non-team members in the unit are similar in both categories evaluated, at 3.55 for those in the NRFS system and 3.52 for those outside the system. Better belief in teammates, more connection to their own team, and belief in their team's competency fall into the first category, which should convert into increased trust in colleagues and efficacy. Lower self-confidence, admittedly better appraisals of colleagues, but much better, those with whom they do not engage, characterize individuals in the second category of weaker self-assessment. These ratings here are based on the idea that where we are not is better (Table 4).

7. Research results considering challenges and problems in VFD units

Firefighters were also polled on the most prevalent issues they encountered in their VFD unit (Table 5). Insufficient training and the need to invest in the firehouse structure - 121 individuals (35.80%); staff shortages - 110 people (32.54%); lack of money for activities - 107 people (31.66%); and antiquated equipment - 102 people (30.18%).

Table 5.
Firefighters' opinions on problems occurring in their units

Type of problem	VFD units in NRFS			VFD units outside NRFS			Total	
	N	% ¹	Location	N	% ²	Location	N	% ³
Tough working conditions	14	4,91	XIV	3	5,66	VII	17	5,03
Poor interpersonal relations	32	11,23	X	2	3,77	VIII	34	10,06
Poor work organization	36	12,63	VIII	2	3,77	VIII	38	11,24
Frequency of participation in TSO actions and related remuneration	18	6,32	XII	1	1,89	IX	19	5,62
Excessive workload	18	6,32	XII	2	3,77	VIII	20	5,92
Conflicts	37	12,98	VII	1	1,89	IX	38	11,24
Low level of discipline among firefighters	45	15,79	VI	3	5,66	VII	48	14,20
Insufficient qualification of the crew	27	9,47	XI	4	7,55	VI	31	9,17
Lack of money for activities	98	34,39	III	9	16,98	V	107	31,66
Insufficient training for TSO members	102	35,79	II	19	35,85	II	121	35,80
Outdated equipment	76	26,67	V	26	49,06	I	102	30,18

Cont. table 5.

Mental load resulting from the tasks performed by the firefighter	33	11,58	IX	1	1,89	IX	34	10,06
Investments related to the fire station building	104	36,49	I	17	32,08	III	121	35,80
Staff shortages	94	32,98	IV	16	30,19	IV	110	32,54
Other (what kind?)	17	5,96	XIII	-	-	-	17	5,03
Total:	751	263,51		106	200,00		857	253,55

*data does not add up to 100% because respondents were given any choice; %¹ - percentage calculated from the size of the NRFS category = 53 people; %² - percentage calculated from the size of the NRFS category = 285 people; %³ - percentage of all respondents = 338 people; Place - options to choose among the distinguished categories of firefighters.

Source: Authors' own research.

Both groups of firemen agree that inadequate training is one of the primary issues with VFDs, ranking second in significance among the obstacles. Other problems rated similarly by the separated categories of firefighters are: personnel shortage - 4th place in terms of importance; poor work organization - 8th place in terms of importance; and mental burden resulting from firefighter tasks - 9th place in terms of importance. The membership of VFD units in the VFD is a criterion that differentiates respondents' attitudes in the remaining selections. Among the most significant challenges in carrying out tasks, both types of firemen mention comparable elements; they only assign them a different rank. For example:

- investments related to the fire station building are being replaced on the first place among brigades in the NRFS system; third in units outside the NRFS,
- lack of money for activities; obsolete equipment: fifth place among firefighters in the NRFS system; first in units outside the NRFS,
- low level of discipline among firefighters, sixth place among firefighters in the NRFS system; seventh in units outside the NRFS,
- insufficient qualification of the crew, eleventh place among firefighters in the NRFS system; sixth in units outside the NRFS.

It should also be noted that druhs from VFD units affiliated with the NRFS report more diverse obstacles in completing the duties of a firefighter than those from outside the system. Statistically, one respondent reports 2.63 difficulties in the first of the investigated groups, while 2.00 in the second. The firefighters rank various challenges differently, not just in the critical issues described above, but also in ones they mention less frequently. A lack of discipline, for example, is scored VI by firefighters from NRFS VFD units, but VII by those outside the system. When it comes to harsh working conditions, the gap between the two groups is considerably wider. This difficulty is ranked 14th in the first of the assessed categories, while firefighters outside the system rank seventh. Furthermore, firemen from NRFS units in the VFD differentiate better between the challenges they encounter while executing jobs - a level extending from I to XIV. Meanwhile, respondents from outside the system regard many challenges identically. For example, tough working circumstances, poor interpersonal interactions, and low levels of discipline among firemen are ranked as VII in importance. The range of importance of problems ranges from I to IX.

8. Conclusions and findings

According to the results of the study of VFD units, membership in the NRFS system has a significant impact on local authorities and the firefighters themselves. It is a factor that stimulates improved funding of firemen, including the retrofitting of proper equipment (Table 2), which clearly affects their ability to carry out their jobs in the case of municipal governments. For firemen, membership in the NRFS is a factor that improves the frequency with which they participate in rescue and firefighting operations (Table 3), resulting in a gain in experience, which surely influences the effectiveness of their activities. Furthermore, the inequalities between firefighters in the system and those outside the system are reflected in perceptions on firefighters' skills (Table 4). VFD unit representatives in the NRFS better assess their own and their teammates' abilities. Belief in team members' competence boosts trust in their ability to properly execute activities during an action; it also implies a better level of acceptance of their own team members, which affects their effectiveness indirectly. Outside-the-system firefighters have lesser confidence in themselves and their teammates; they are more likely to assess individuals with whom they do not directly collaborate. The discrepancies between NRFS and non-NRFS units are likewise related to perspectives on the problems in their VFD units (Table 5). And they implicitly confirm the preceding statements. The most pressing worry for firefighters whose units do not belong to the NRFS is outdated equipment. Non-NRFS firefighters are more likely to complain about insufficient crew qualifications, while non-NRFS firemen who participate in actions less frequently complain about excessive duty load (see Table 3). Many concerns, in the opinion of these firefighters, are of a similar type, which can be read as a symptom of the problems confronting these firefighting units. We appear to be dealing with a type of "divergence" of the TSO system. There are still issues that VFD units in NRFS and outside NRFS face (Table 5), such as poor training and staff shortages, although there are growing disparities between them. Participation in NRFS activities also helps VFD units gain more funds for upgrading their units and, as previously said, develops trust in the skills of their own team. Both of these elements have an impact on the condition of s and the effectiveness of firefighters' efforts.

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THE INFLUENCE OF EXTRAVERSION AND TEMPERAMENT ON MOTIVATIONAL FACTORS FOR LEARNING

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Purpose: The aim of the article is to examine the influence of extraversion and temperament according to the Hippocratic typology on factors motivating and demotivating for learning.

Design/methodology/approach: The results of the study were obtained through a literature analysis and a survey (n = 448) conducted among individuals aged 19-26. The study identified the key motivating and demotivating factors for learning, and subjected them to analysis based on temperament types according to the theory and typology of Hippocrates (choleric, melancholic, sanguine, phlegmatic), as well as one of the most commonly occurring personality traits in various motivation theories, namely extraversion.

Findings: The research has shown that extraversion does not significantly impact the significance of motivating factors for learning. However, it plays a significantly more important role in the case of demotivating factors for learning. There was also observed a slight influence of temperament type on the impact of individual factors on motivation. The most significant differences were found between the sanguine and melancholic types. Individuals with temperament traits attributed to the sanguine type indicated a stronger significance of many motivating and demotivating factors compared to those who did not identify with this temperament type.

Research limitations/implications: The limitations of the article include the fact that selected personality traits and temperaments were self-reported by the respondents. No psychological tests were applied to precisely determine the personal characteristics of the respondents. Another limitation may be the focus solely on one target group of individuals aged 19-26.

Practical and social implications: The results indicate that extraverts react more strongly to demotivating factors than introverts. However, extraversion does not seem to be significant in terms of motivating factors. Educators and managers should pay special attention to the demotivating factors mentioned in this article, especially when dealing with extraverted individuals with a sanguine temperament. The findings from these studies can be valuable for educators but also for, for example, training center managers.

Originality/value: The research has shown that extraversion is significantly relevant in the context of demotivating factors for learning, while it does not have a significant impact on motivating factors.

Keywords: motivation, personality, temperament, students, learning.

Category of the paper: research paper.

1. Introduction

Motivation is a highly significant aspect of social and economic life. It influences productivity and the quality of life, ranging from motivation to learn new skills, to motivation for work, self-development, investments, purchases, volunteering, and even motivation for maintaining one's own health. Therefore, motivation is the subject of research in various scientific disciplines within the field of social sciences such as psychology, education, management, as well as in the field of medical sciences and health sciences (Government website, 2023). There are numerous motivation theories attempting to explain why people undertake specific actions and what factors influence their behavior. In management literature, often mentioned theories include Maslow's hierarchy of needs (Cox, 1987; Maslow, 1954), Douglas McGregor's Theory X and Theory Y (McGregor, 1960; Pardee, 1990), McClelland's theory (McClelland et al., 1953), Herzberg's two-factor theory (Herzberg, 1968), Vroom's expectancy theory (Pardee, 1990; Vroom, 1964), and Self-Determination Theory (SDT) (Ryan, Deci, 2000, 2017), among others. These theories have formed the basis for many scientific studies. Based on these theories, researchers attempt to develop their own motivation theories incorporating new elements and factors identified during their investigations. These theories take into account the changing conditions of work and the functioning of contemporary individuals in social and economic environments. They are most commonly applied in the context of work motivation and less frequently in other areas and activities of human life. For instance, motivation for maintaining health, pursuing one's passions, engaging in volunteer work, or starting one's own business. Motivation can arise from a multitude of factors, including internal factors related to personality and temperament.

There arises a question about the significance of selected motivating and demotivating factors in terms of personality traits and temperament. The aim of the paper is to analyze popular theories related to personality and temperament. The second objective is to determine how selected personality traits and common temperament types influence the significance of individual motivating and demotivating factors. The subject of the study is motivation for learning.

In the course of researching motivation for learning, the following research question was addressed:

Does a chosen personality trait (introversion and extraversion) and temperaments according to Hippocrates (choleric, sanguine, melancholic, phlegmatic) influence the significance of selected factors on motivation?

The publication is organized as follows. Chapter 2 presents and describes issues related to selected theories of human personality and motivation. Chapter 3 describes the conducted research and the obtained results. In the final part of the article, a discussion is conducted, the article is summarized, and directions for further research are proposed.

2. Relationships between personality traits, temperament, and motivation

Personality is one of the key aspects of psychology and plays a significant role in understanding human behavior and predicting how an individual will act in various situations. Personality is shaped by various factors, including genetics, upbringing environment, life experiences, cultural influences, and many others. There are numerous personality theories that attempt to explain how human personality is formed and developed, as well as how to study and measure it. Among frequently mentioned personality theories are Carl Gustav Jung's psychodynamic theory, Raymond Cattell's personality trait theory (later developed by Isabel Briggs Myers and Katharine Cook Briggs), and the Five-Factor Model of personality (Big Five). Carl Gustav Jung introduced the concepts of introversion and extraversion. Cattell developed a model of personality traits, describing personality through approximately 16 key traits such as extraversion, neuroticism, and openness to experience. Isabel Briggs Myers and Katharine Cook Briggs further developed these ideas, creating the popular system known as the "Myers-Briggs Type Indicator" (MBTI). Due to criticism from parts of the scientific community, a more modern scientific approach involves using the Big Five model proposed by Paul Costa and Robert McCrae (Costa, McCrae, 1992, 2008). This model describes personality through five major factors: openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism. Each of these theories involves one of the most popular personality traits - extraversion and introversion. The Five-Factor Model of personality structure by Costa and McCrae has contributed to the development of psychometric methods for personality assessment, including personality inventories such as the NEO-PI-R and its modified version, the NEO-FFI (Zawadzki et al., 1998).

In the literature, personality is often distinguished from temperament. It is assumed that temperament is one component of our personality. Many articles mention the four temperament types originating from the theory proposed by Hippocrates. These are sanguine, choleric, phlegmatic, and melancholic. Hippocrates identified four basic fluids in the body (blood, yellow bile, phlegm, and black bile) (López Beltrán, 2007; Merenda, 1987). The dominance of one of these fluids was believed to determine temperament. Although medical science has corrected knowledge about bodily fluids, the four main temperament types have persisted in common language to this day. Many people often identify with one or two temperament types and can preliminarily determine them independently.

In the modern period, one of the prominent researchers of temperament was Professor Jan Strelau. He is the author of the Regulative Theory of Temperament (RTT) (Strelau, 1996). According to Strelau, temperament regulates behavior in two aspects: energetic and temporal. Characteristics in the domain of energetic features include:

- Sensory sensitivity (the ability to react to subtle sensory stimuli).
- Emotional reactivity (the way of reacting to emotional stimuli).
- Endurance.
- Activity (engaging in activities that provide stimulation).

Temporal characteristics include:

- Quickness (the ability to react quickly and maintain a high pace of activity).
- Perseveration (the tendency to repeat and continue behaviors).
- Rhythmicity (the tendency to maintain a regular lifestyle even when circumstances do not require it).

The theory formulated by Strelau is multidimensional, assuming that temperament manifests itself in all human behaviors and is observable already in infancy. The primary form of temperament results from biological evolution. Temperament traits are relatively stable, with changes occurring slowly throughout an individual's life due to the influence of interactions between biological mechanisms responsible for temperament and environmental factors (Spielman et al., 2020).

In scientific research practice, various psychometric tools are used to study and describe personality. Among frequently utilized tools are: MMPI (Minnesota Multiphasic Personality Inventory), 16PF (Cattell's Personality Questionnaire), NEO-FFI (Personality Inventory in the Big Five model) (Wikipedia, 2023c; IPIP, 2023). MMPI contains 567 questions, while 16PF has around 300 questions to be answered with true, false, or do not know (Wikipedia, 2023a, 2023b). On the other hand, NEO-FFI consists of about 60 self-descriptive statements on a five-point scale (Website, 2023c). Additionally, there are freely available or partially free (e.g., for research or non-commercial purposes) popular personality tests, such as HEXACO-PI-R (Website, 2023a), IPIP-NEO (Website, 2023b), 16Personalities (NERIS Analytics Limited., 2021), etc.

Motivation for learning is one of the areas of scientific research (Huitt, 2001), based on fundamental theories related to motivation. It often links motivation to emotions, satisfaction, and even self-esteem. In the behavioral approach, attention is given to consequences. The use of positive reinforcements encourages improvement in motivation, while the application of punishments acts as a deterrent, resulting in a decline in internal motivation for learning (Huitt, Hummel, 1997). The use of reinforcements and punishments may also impact personality. Hence, the question often arises whether personality and motivation are interconnected and in what way.

To further analyze the literature, Google Scholar and Scopus databases were utilized. A combination of keywords such as motivation, personality, learning, and working was applied. The results are presented in Table 1.

Table 1.

The number of results from the Google Scholar and Scopus databases for various query variations

Queries to the Scopus database	Number of articles
(TITLE-ABS-KEY (motivat*) AND TITLE-ABS-KEY (personal*) AND TITLE-ABS-KEY (work*))	17057
(TITLE-ABS-KEY (motivat*) AND TITLE-ABS-KEY (personal*) AND TITLE-ABS-KEY (lear*))	12230
(TITLE-ABS-KEY (motivation) AND TITLE-ABS-KEY (personality) AND TITLE-ABS-KEY (work*))	2825
(TITLE-ABS-KEY (motivation) AND TITLE-ABS-KEY (personality) AND TITLE-ABS-KEY (learning))	1908
(TITLE (motivat*) AND TITLE (personal*) AND TITLE (lear*))	104
(TITLE (motivat*) AND TITLE (personal*) AND TITLE (work*))	71
(TITLE (motivation) AND TITLE (personality) AND TITLE (learning))	37
(TITLE (motivat*) AND TITLE (personal*) AND TITLE (lear*) AND TITLE (stud*))	28
Query to the Google Scholar (option: review articles)	
personality learning	125000
motivation personality	21300
motivation personality working	23500
allintitle: personality learning	70
allintitle: motivation personality	29

Note. TITLE-ABS-KEY - means searching for a specific character string in titles, keywords, or abstracts.
*- replaces any sequence of characters. allintitle: - searches for keywords only in titles.

3. Materials and Methods

3.1. Research sample and questionnaire

The research was conducted from 2022 to 2023 on a group of students majoring in management, logistics, production engineering, and business analytics, aged 19 to 26. Based on the analysis of scientific literature, personal observations, and preliminary research conducted in the form of open-ended questions, motivating and demotivating factors for learning were identified. An electronic questionnaire was constructed, and in addition to questions related to the identified factors, respondents were asked to indicate their gender, personality traits, and temperament. Respondents did not have major difficulties in determining one of the personality traits, such as extraversion, on a five-point scale. They had slightly more difficulty determining their own temperament. Therefore, to facilitate this, very brief characteristics of the 4 temperament types were also provided:

- Choleric (energetic, impulsive, and sometimes unrestrained individuals; their feelings arise rapidly and can be intense).
- Phlegmatic (unimpassioned and emotionally reserved individuals, yet consistent in their feelings and persevering in action).
- Sanguine (sensitive individuals who react quickly and strongly, while also being resilient and adaptable to circumstances).
- Melancholic (unimpassioned, gentle, and passive individuals, also less persevering; their feelings may be strong but develop slowly).

Respondents could select no more than two temperament types with which they most identified. After excluding qualitatively doubtful responses, 448 answers were considered for statistical analysis. Table 2 presents the profile of respondents.

Table 2.
Profile of respondents

Demographic items		Frequency	Percentage (%)
Gender			
Female		245	54.7
Male		203	45.3
Age			
19-26		448	100
(P1) Personality 1 (own opinion)			
Introvert, rather introverted		150	33.5
Ambivert (balanced)		178	39.7
Extrovert, rather extrovert		120	26.8
(T1) Temperament (own opinion)			
Choleric (Ch)			
	NO (0)	313	69.9
	YES (1)	135	30.1
Phlegmatic (F)			
	NO (0)	360	80.4
	YES (1)	88	19.6
Sanguinarian (S)			
	NO (0)	208	46.4
	YES (1)	240	53.6
Melancholic (M)			
	NO (0)	380	84.8
	YES (1)	68	15.2

Source: own work.

The list of factors motivating and demotivating learning is presented in Table 3 and Table 4.

Table 3.
Motivating factors for learning

ID	Motivating factors
MF1	Small but immediate reward (e.g., pluses)
MF2	Topics related to interests
MF3	Desire to be one of the best in the group
MF4	Avoidance of being one of the worst in the group
MF5	Interesting practical knowledge
MF6	Interesting theoretical knowledge
MF7	Small immediate penalty for lack of preparation (for learning)
MF8	Obtaining a certificate of acquired skills
MF9	Intriguing tasks
MF10	Group work
MF11	Positive atmosphere in classes
MF12	Possibility of obtaining a scholarship
MF13	Listening to music in the background

Source: own work.

Table 4.
Demotivating factors for learning

ID	Demotivating factors
DF1	Stress in classes
DF2	Noise
DF3	Too much material to study
DF4	Public questioning "at the board"
DF5	Peer reluctance to learn
DF6	Material that is too difficult
DF7	Unfair grading by the teacher
DF8	Impractical knowledge
DF9	Long, monotonous classes
DF10	A lot of theory, little practice
DF11	Unpleasant teacher
DF12	Cheating by other peers (e.g., copying tasks)
DF13	Outdated and boring material
DF14	Criticism from the teacher
DF15	Nice weather
DF16	Unpleasant atmosphere in the group
DF17	Competition for grades in the group
DF18	Various distractions (Facebook, messages, YouTube) (During COVID-19)
DF19	Lack of physical contact with peers (During COVID-19)
DF20	Lack of physical contact with the teacher (During COVID-19)

Source: own work.

Cronbach's alpha coefficient for questions regarding motivating factors (MF1 - MF13, 13 items) was 0.757, and for questions related to demotivating factors (DF1 - DF20, 20 items), it was 0.847. The obtained results confirmed the high and acceptable reliability of the research tool and its results.

3.2. Statistical Analysis

For the statistical analysis, data from 448 questionnaires were utilized ($n = 448$). During the analysis, a comparison of responses was conducted using non-parametric statistical tests for the selected personality trait of the 4 temperament types. Descriptive statistical analysis regarding quantitative advantages primarily involved obtaining measures such as the arithmetic mean (Mean), standard deviation (SD), and median (Mdn). A Likert scale was applied. The Mann-Whitney U test was used to compare two groups with distributions other than normal. The significance of differences between layer weights was checked using the chi-square test. Statistical hypotheses were verified using statistical tests, considering significance at $\alpha \leq 0.05$. In multivariate analysis, correspondence analysis was used to examine the correlation between temperament, gender, and the personality trait of extraversion. The results were analyzed in the form of a two-dimensional plot depicting relationships between individual groups.

3.3. Results

In the analyzed population, there were 448 respondents aged 19-26. Thanks to the obtained results, motivators and demotivators for learning could be ranked from the most significant.

Respondents indicated that the most motivating factors for learning include: topics related to interests (MF2, 4.11 ± 1.05), interesting practical knowledge (MF5, 3.95 ± 1.06), obtaining a certificate of acquired skills (MF8, 3.93 ± 1.13), as well as a positive atmosphere in classes (MF11, 3.84 ± 1.12).

The most demotivating factors for learning are: long, monotonous classes (DF9, 4.29 ± 0.96), impractical knowledge (DF8, 4.14 ± 1.02), unfair grading by the teacher (DF7, 4.07 ± 1.11), too much material to learn (DF3, 4.05 ± 1.06), outdated and boring material (DF13, 4.02 ± 1.05), a lot of theory and little practice (DF10, 3.98 ± 1.05), but also an unsympathetic teacher (DF11, 3.97 ± 1.12). The results are presented in Table 5 for gender and extraversion (extravert, ambivert, introvert).

Table 5.

The ranking of the shared significance of factors for motivation to learn (all responses and based on the extraversion trait)

ID	All (All=448)			Extravert (E=120)	Ambivert (A=178)	Introvert (I=150)
	Mean	Median	SD	Mean \pm SD	Mean \pm SD	Mean \pm SD
1	2	3	4	6	7	8
DF9	4.29	5.00	0.96	4.29 ± 0.87	4.36 ± 0.94	4.2 ± 1.04
DF8	4.14	4.00	1.02	4.15 ± 0.93	4.15 ± 1.07	4.13 ± 1.04
MF2	4.11	4.00	1.05	4.23 ± 0.96	4.11 ± 1.05	4.01 ± 1.12
DF7	4.07	4.00	1.11	3.98 ± 1.16	4.14 ± 1.07	4.05 ± 1.1
DF3	4.05	4.00	1.06	3.98 ± 1.12	4.06 ± 1.1	4.09 ± 0.98
DF13	4.02	4.00	1.05	3.95 ± 1.08	4.08 ± 1.05	4 ± 1.04
DF10	3.98	4.00	1.05	3.98 ± 1.1	4.02 ± 1.02	3.93 ± 1.05
DF11	3.97	4.00	1.12	4 ± 1.15	4.01 ± 1.12	3.91 ± 1.11

Cont. table 5.

MF5	3.95	4.00	1.06	4.02 ±1	3.98 ±1.06	3.85 ±1.1
MF8	3.93	4.00	1.13	4 ±1.08	3.96 ±1.14	3.84 ±1.16
MF11	3.84	4.00	1.12	3.88 ±1.15	3.86 ±1.09	3.78 ±1.12
DF4	3.70	4.00	1.30	3.35 ±1.35	3.71 ±1.32	3.96 ±1.18
DF1	3.68	4.00	1.30	3.28 ±1.37	3.76 ±1.23	3.91 ±1.25
DF2	3.62	4.00	1.24	3.39 ±1.32	3.65 ±1.19	3.77 ±1.2
DF6	3.62	4.00	1.15	3.5 ±1.18	3.65 ±1.16	3.67 ±1.11
DF16	3.58	4.00	1.22	3.53 ±1.27	3.54 ±1.24	3.68 ±1.14
MF9	3.56	4.00	1.16	3.53 ±1.15	3.52 ±1.22	3.63 ±1.1
DF14	3.55	4.00	1.24	3.25 ±1.2	3.62 ±1.31	3.7 ±1.16
DF18	3.35	3.00	1.34	3.38 ±1.34	3.31 ±1.32	3.37 ±1.38
MF6	3.33	3.00	1.12	3.33 ±1.14	3.37 ±1.12	3.31 ±1.1
DF15	3.21	3.00	1.38	3.36 ±1.42	3.22 ±1.33	3.09 ±1.4
DF19	3.17	3.00	1.40	3.45 ±1.38	3.15 ±1.43	2.99 ±1.36
MF10	3.07	3.00	1.22	3.23 ±1.22	3.13 ±1.19	2.85 ±1.24
MF4	3.06	3.00	1.40	3.03 ±1.49	3 ±1.43	3.16 ±1.3
MF12	3.02	3.00	1.50	3.08 ±1.5	2.94 ±1.49	3.07 ±1.51
DF12	2.90	3.00	1.38	2.73 ±1.39	2.85 ±1.41	3.09 ±1.32
MF13	2.83	3.00	1.45	2.91 ±1.48	2.81 ±1.46	2.81 ±1.41
DF17	2.78	3.00	1.37	2.53 ±1.28	2.9 ±1.43	2.83 ±1.33
MF1	2.75	3.00	1.27	2.77 ±1.22	2.75 ±1.31	2.73 ±1.26
DF20	2.73	3.00	1.36	3 ±1.38	2.63 ±1.34	2.63 ±1.36
MF3	2.68	3.00	1.31	2.79 ±1.35	2.64 ±1.35	2.63 ±1.25
DF5	2.52	2.00	1.20	2.31 ±1.14	2.46 ±1.17	2.75 ±1.24
MF7	2.35	2.00	1.31	2.28 ±1.29	2.28 ±1.35	2.49 ±1.28

Source: Own work.

Considering one of the personality traits, which is extraversion, statistically significant differences were found between two groups (Extraversion, Introversion). Interestingly, these differences were observed only in demotivating factors. Motivating factor M10 (group work) was ultimately considered neutral, even though it initially appeared as a motivating factor in preliminary studies. They are presented in table 6.

Table 6.

Differences in the impact of individual motivating and demotivating factors on motivation. Mann–Whitney U test results for variable Personality: Introwertyk (I = 150), Ekstrawertyk (E = 120)

Variable	Test Probability (p)	Significance	Introvert	Extravert
MF10	0.0179	*	2.85 ±1.24	3.23 ±1.22
DF1	0.0001	***	3.91 ±1.25	3.28 ±1.37
DF2	0.0181	*	3.77 ±1.2	3.39 ±1.32
DF4	0.0001	***	3.96 ±1.18	3.35 ±1.35
DF5	0.0029	**	2.75 ±1.24	2.31 ±1.14
DF12	0.0313	*	3.09 ±1.32	2.73 ±1.39
DF14	0.0014	**	3.7 ±1.16	3.25 ±1.2
DF19	0.0043	**	2.99 ±1.36	3.45 ±1.38
DF20	0.0290	*	2.63 ±1.36	3 ±1.38

Note: * p < 0.05 ** p < 0.01, ***p < 0.005.

Source: Own work.

The impact of the temperament type specified by the respondents on motivating and demotivating factors was also examined. Respondents could select 1 to 2 temperament types that most characterized them. In most cases, there were no significant differences in the impact of individual temperaments on motivators and demotivators. The most significant differences were observed in sanguine individuals, for whom individual motivators are more relevant (indicated by * (+)). On the other hand, respondents with a melancholic temperament showed a lesser impact of individual motivators and demotivators on motivation (indicated by * (-)) than the rest of the research sample. This particularly applied to motivators such as the desire to be one of the best in the group (MF3), interesting practical knowledge (MF5), the possibility of obtaining a scholarship (MF12), as well as demotivators such as impractical knowledge (DF8) and (during covid-19) lack of physical contact with peers (DF19). The significant results are also presented in Table 7.

Table 9.

Differences in the impact of individual motivating and demotivating factors on motivation. Mann–Whitney U test results for variable Temperament: Choleric (Ch = 135), Melancholic (M = 68), Phlegmatic (F = 88), Sanguine (S = 240)

ID	Choleric YES (Ch = 135)		Melancholic YES (M = 68)		Phlegmatic YES (F = 88)		Sanguine YES (S = 240)	
	p	Significance	p	Significance	p	Significance	p	Significance
MF3			0.0131	* (-)				
MF5			0.0310	* (-)	0.0199	* (+)	0.0358	* (+)
MF7					0.0180	* (-)		
MF9							0.0290	* (+)
MF12			0.0060	** (-)			0.0178	* (+)
MF13							0.0332	* (+)
DF1					0.0253	* (-)	0.0225	* (+)
DF4	0.0284	* (-)						
DF7							0.0250	* (+)
DF8			0.0120	* (-)			0.0376	* (+)
DF17					0.0360	* (-)	0.0052	* (+)
DF19			0.0347	* (-)				

Note: * p < 0.05 ** p < 0.01, ***p < 0.005.

Source: Own work.

The correspondence analysis was conducted between temperament, gender, and the personality trait of extraversion (Figure 1). It can be observed that the melancholic and phlegmatic temperaments are closely associated with individuals having introverted traits. On the other hand, the choleric temperament is in proximity to the extraverted personality trait. Meanwhile, the sanguine temperament is situated near ambiverts, between introverted and extraverted traits. This partially confirms the connection proposed by Hippocrates between the names of temperaments and the personality traits of extraversion and introversion.

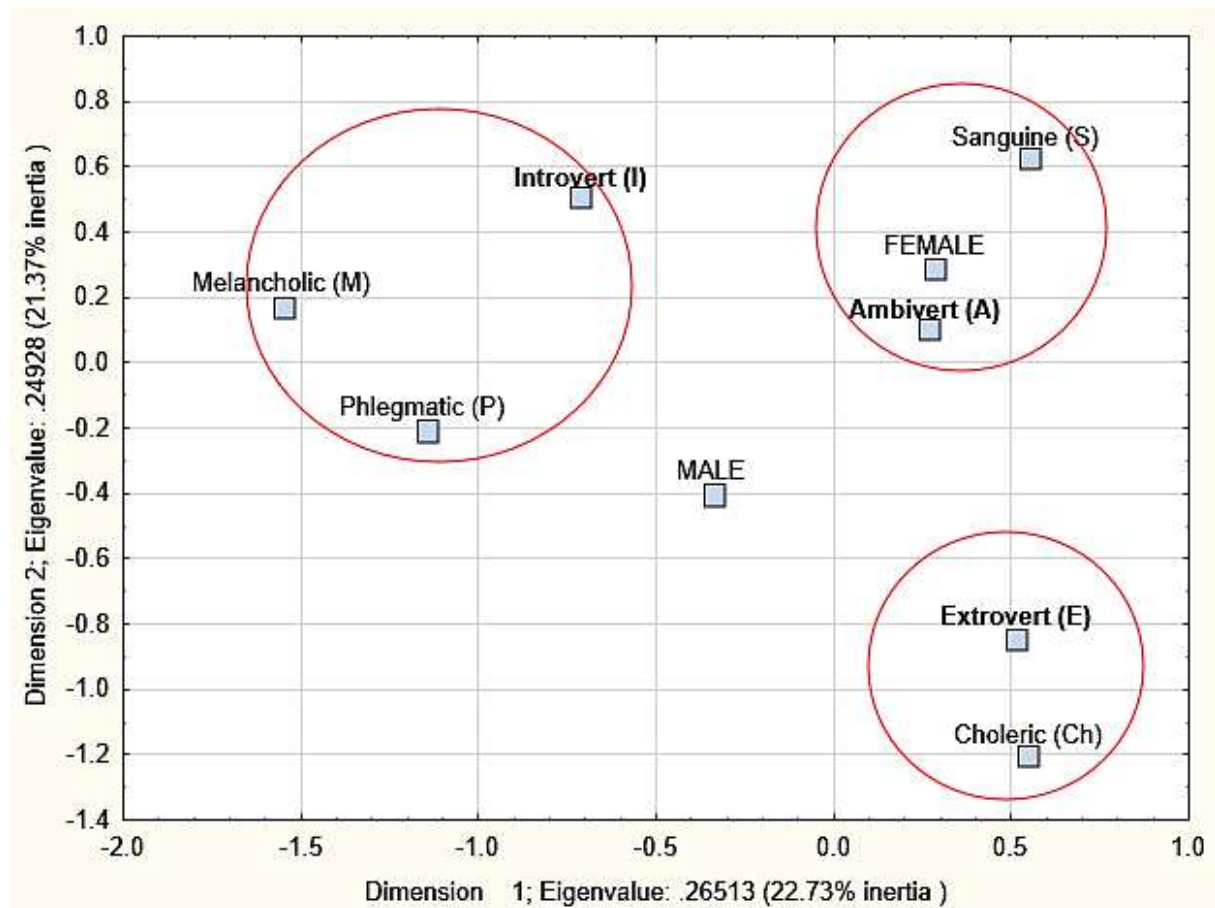


Figure 1. The correspondence analysis: Gender, Temperament and Personality (introvert, ambivert, extrovert).

4. Discussion and summary

In the study, the decision was made to use a self-assessment mechanism in which respondents determined their own temperament and introversion. However, in many studies (Gwiazdowska, Klinkosz, 2012), instruments such as the NEO-FFI personality inventory and the LMI achievement motivation inventory (Klinkosz, Sękowski, 2006, 2013) are often used, which are considerably more time-consuming for respondents.

In a study from 2018 (Klinkosz et al., 2018), an analysis was conducted on 233 Polish university students and 188 German university students regarding motivation and personality. The research presented numerous relationships between achievement motivation and personality traits among students. Conscientiousness was recognized as the strongest predictor of success motivation for students from various fields of study and in different countries. In this study, conscientiousness was not analyzed; only extraversion was examined, which turned out to be significant and influencing only demotivating factors. Slight differences in various temperaments proposed by Hippocrates were also observed. Especially individuals

exhibiting traits of the sanguine temperament are more sensitive to various motivating and demotivating factors among the surveyed representatives of Generation Z.

In Kyllonen's work (Kyllonen et al., 2014), a review of numerous studies was conducted, showing that personality factors and motivations are associated with educational outcomes from early childhood to adulthood. The data also considered that personality and motivation change over time, despite the common belief that we have a personality we were born with. Average changes in personality occur over a lifetime. As we grow and enter adulthood, we become more conscientious, caring towards others, socially dominant, and emotionally stable. This change suggests that personality can be considered a skill that can be developed like other skills (Kyllonen et al., 2014; Roberts et al., 2006; Roberts, DelVecchio, 2000). Therefore, studying learning motivation should be conducted in different age groups and generations.

Personality and motivation also play a role in income (Gwiazdowska, Klinkosz, 2012) or benefits. For students, income or benefits can include acquired knowledge, skills, certificates, diplomas, etc. In many publications, e.g., (Conard, 2006; Nofle, Robins, 2007; O'Connor, Paunonen, 2007), it has been shown that conscientiousness, as one of the Big Five traits, and especially its aspects such as achievement striving, self-discipline, and diligence, allow predicting academic success from early grades to college. Other Big Five factors were less consistent in predicting school performance; however, there is some evidence that neuroticism, especially its anxious and impulsive aspects, can hinder learning, while openness may enhance it (Kyllonen et al., 2014). Interestingly, conscientiousness is associated with morningness (Randler, 2008).

In the studies of Ahmadi-Azad et al. and Anggraini et al. (Ahmadi-Azad et al., 2020) (Anggraini et al., 2021), it has been demonstrated that a teacher's personality in the learning process is one of the important factors for achieving success in language learning. A positive atmosphere resulting from the teacher's personality can encourage students to participate in foreign language learning (Ahmadi-Azad et al., 2020). It has also been shown that higher self-efficacy leads to more frequent use of various learning strategies, increased effort, sustained persistence, and higher achievements in various tasks (Bandura et al., 1999; Lee, Klein, 2002; Schunk, 1990). Providing students with extensive feedback and helping them gain an initial level of competence in a specific field will lead to an increased sense of self-efficacy (Kyllonen et al., 2014).

In this article, popular theories related to personality traits and temperament were analyzed, and the results of our own research conducted among 448 Generation Z respondents were presented. Although this work addresses issues strongly related to psychology, the research findings can be valuable and useful not only for educators but also for managers and project leaders. It is crucial to pay attention to the differences in the perception of various motivating and demotivating factors among individuals with different personality traits and temperaments. Temperament and extraversion can influence the significance of specific motivational and,

especially, demotivational factors. Regarding motivating factors, no statistically significant differences were found between the examined groups. However, much less variation is observed in the case of different temperament types, which may be due to respondents' difficulties in independently determining their dominant temperament type on a scale from zero to one. In the future, it is recommended to expand research on motivation, temperament, and personality traits, considering other characteristics such as openness to experience, conscientiousness, agreeableness, and neuroticism, and utilizing available psychological testing tools.

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IT PROJECT MANAGERS' COMPETENCIES REQUIRED ON THE MARKET – GENERATIVE AI ENHANCED ANALYSIS

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Purpose: The primary objective of this study is to investigate the competency profiles of IT project managers as demanded in the job market. To achieve this, we conducted a comprehensive analysis of job postings, focusing on the real-world competency requirements for project managers within the IT sector. This approach enables an in-depth understanding of the specific skills and qualifications that employers are actively seeking in potential project management candidates.

Design/methodology/approach: This research utilized an innovative approach by applying generative AI for the analysis of a large data set, offering a unique perspective in evaluating IT project manager competencies in the job market.

Findings: Our research identified nine distinct IT project manager profiles, which revealed communication as the most crucial of all competencies across all profiles, while competencies such as power and interest, along with procurement, were found to be less significant.

Research limitations/implications: The research was based on the data gathered during a period of three months. However, it demonstrates the possibilities of further applications of this designed research process.

Practical implications: The research highlights the diverse range of competency requirements for project managers in IT industry.

Originality/value: This article features the use of ChatGPT, an innovative tool, to augment the analysis conducted.

Keywords: IT project, project managers' competencies, competency profile, generative AI.

Category of the paper: research paper.

1. Introduction

IT projects play a pivotal role in today's rapidly evolving technological landscape, serving as the foundations for innovation and competitiveness across various industries. IT projects are definitely essential for companies to quickly develop in the digital age, enabling the

implementation of cutting-edge software, infrastructure, and systems that drive efficiency and productivity. Effective IT project management is critical not only for delivering on time or within budget, but also for ensuring that these investments align with strategy and keep pace with ever-changing technologies. Thus, the role of IT managers and their competencies seem to be undeniably important.

It is apparent that project managers (PMs) play a prominent role in all kinds of projects, and those in IT are no exception. There are numerous studies confirming the role of managers in project success: For instance, a study conducted by Toney (2001) showed that PMs have a direct influence over 35-47 per cent of project success. Similarly, Müller and Turner (2007) demonstrated a positive correlation between the PM's leadership competencies and project success. However, in order to perform their activities thoroughly and to lay the foundations for such initiatives, PMs have to develop various but complementary competencies such as personal, performance, perspective and interpersonal (Moradi et al., 2020).

Undoubtedly, nowadays employers recognize the pivotal role of PMs and their indispensable competencies in orchestrating complex projects to ensure their successful delivery. The number of job postings signals the need for PMs, and the content of postings demonstrates the expectations as to the most important competencies. These job postings offer interesting research material (Karakatsanis et al., 2017; Puolitaival et al., 2023; Zheng et al., 2020) enabling us to follow not only changes in the job market but also to investigate the structure and contingencies of the main requirements for managers in various types of projects. Due to the role of IT projects and – in consequence – IT PMs, we decided to examine if and how the peculiarity of IT ventures is reflected in the online content of IT PM job advertisements. In our research, using generative AI (chatGPT 4.0), we developed a list of IT PM job competencies, breaking down the competency components according to IPMA ICB 4.0 (International Project Management Association, 2015). This was followed by conducting a comparative analysis of these competencies providing classification into nine profiles as well as analysing the peculiarity of each profile.

Our research process was oriented towards answers to two main research questions: what are the real-world demands for PMs' competencies in the IT area? How do we classify IT PMs from the perspective of employers' expectations?

This paper is structured into seven sections. First, there is the introduction; second, the summary of the literature review on IT PMs' competencies is presented by addressing those main studies made prior in this field; third, the significance of online job postings as research data is briefly explained; The fourth is dedicated to presenting our research method, and the fifth section demonstrates research results, which is followed by a discussion with further research avenues. Finally, the seventh section provides concluding remarks.

2. IT project managers' competencies: research perspectives

According to Moradi et al (2020), the studies on PMs' competencies can be traced back to the papers by Gaddis (1959) and Lawrence and Lorsch (1967), indicating a very long and fruitful tradition of exploring projects from the perspective of their managers, along with expectations or requirements for specific tasks and competencies, and the role of those competencies in project success or failure. The studies enabled the identification of various competencies required, allowing categorization and prioritization, as well as analysis from contingency views linking expectations with sectors, types, scales, life cycles or countries of project realizations (Cha, Maytorena-Sanchez, 2019; Müller, Turner, 2007; Müller, Turner, 2010; Shenhar 2001). The research on IT PMs can be regarded as a part of the PMs' competency studies, where attention should be paid to potential distinctive features of IT projects and their consequences.

It needs to be emphasized that the term "competencies" possesses multifaceted meanings, as it can refer to the diverse range of skills, knowledge, and abilities essential for PMs' professional success. The interpretation can vary depending on the context: according to Stevenson and Starkweather (2010), there has been a long debate in HR research on understanding the term "competency". However – as a summary – when discussing competencies, we underline the importance of knowledge, skill, ability, or characteristics associated with high performance on a job. Although these definitions differ in particular points, they have a similar main message: competency is a range of different characteristics, behaviours, and traits that are required for effective job performance (Abraham et al., 2001). Regarding projects, we can understand the competency of PMs with the capability to use skills, knowledge and personal characteristics that enhance the efficiency and effectiveness of their job performance, and subsequently increase the likelihood of project success (Moradi et al., 2020).

As it was indicated above in extensive literature on the subject, it is possible to find important references on PMs' general competencies. Similarly, there are standards or frameworks like ICB, the APM Body of Knowledge, PMBOK and Project Manager Competency Development that have focused attention on PMs' competencies. For instance, IPMA ICB 4 introduces 28 competencies of PMs divided into three main groups – people, practice and perspective (International Project Management Association, 2015). However, the discrepancies between the results of previous studies and standards of practice have been also explored (Moradi et al., 2020), indicating some notable differences such as in appraising importance, priorities, or impact of context.

What seems to be important from the perspective of our research is the distinction of the studies of PMs' competencies into two streams – studies from the supply side or the demand side (Crawford, 2005; Zeng, 2020). In general, literature is dominated by research focused on

the supply side, and numerous studies have attempted to identify essential competencies, and so providing insight into which competencies should be indispensable in PMs' education and training. Another growing stream of research attempts to identify PMs' key competencies from the perspective of industry demand. For instance, Ahsan et al. (2013) show that industry job advertisements emphasize "soft skills" and competencies in a manner different to those in literature, and differences are found across countries and between industries.

With the growing quantity of studies on required and expected PMs' competencies, we can observe the increasing number of lists presenting prospective templates for the exemplary and 'best' PM. For instance, Moradi et al. (2020) indicated 98 PMs' competencies, structuring them into four categories: personal (27 competencies), performance (26 competencies), perspective (8 competencies) and interpersonal (11 competencies). As for IT project studies, Stevenson and Starkweather (2010) performed two-phased research investigating the characteristics necessary to achieve project success. First, after identifying and rating preferred IT project management competencies, they created an index which comprised fifteen of the most valued project management competencies. Next, they asked executives in the US to rank their preferences in terms of importance on a seven-point Likert scale. The results indicated that executives valued six critical core competencies: leadership, the ability to communicate at multiple levels, verbal and written skills, attitude, and the ability to deal with ambiguity and change, as opposed to other competencies such as experience, work history, education, and technical expertise.

The findings of these subsequent studies provided disparate conclusions, e.g., Varajão et al. (2019), when exploring features of information system PMs, demonstrated the register of the top twelve competencies: communication, engagement and motivation, project requirements and objectives, leadership, reliability, results orientation, conflict and crisis, project orientation, teamwork, interested parties, resilience, and ethics. In resembling studies, Cha and Maytorena-Sanchez (2019), when analysing the software project life cycle, discovered the importance of cognitive, functional, and social competencies, as well as added meta-competences, which are understood as managing self-knowledge.

The advancement of IT projects and the diverse outcomes of prior research provide the rationale for delving deeper into the proficiencies of IT PMs. Our inquiry seeks to extend beyond a mere revision of the register of anticipated competencies, and aims to delve into the contextual analysis of the contemporary picture of the IT industry.

3. Job postings as research material in PMs' competencies studies

Frequently, inquiries into the necessary project management competencies were founded upon surveys administered among practitioners and executives tasked with the implementation of IT projects (Stevenson, Starkweather, 2010; Varajão et al., 2019). Thus the subjectivity, sample size and contextual aspects of the results were repeatedly shown as major points in the research limitation sections. In eliminating the bias related to opinion surveys, some new studies (e.g., Zeng, 2020; Puolitaival et al., 2023) adopted an approach based on analysing job advertisements as a direct observation of firms' demands for PMs' required responsibilities and competencies.

However, it is apparent that nowadays the recruitment process has largely moved online, and job advertisements have become an online service creating an important part of a growing trend towards a more digitalized hiring process. Alongside increased flexibility and cost-cutting, this trend brings benefits to scholars offering large sets of research data.

First, the availability of a substantial number of job advertisements effectively addresses the limitations related to the sample size; as with the digitalization of recruiting activities, comprehensive job advertisement data sets have become available. Thus, job advertisements provide a valuable opportunity to investigate the demand for PMs' competencies at an industry level in a more direct and versatile manner (Ahsan, Ho, 2022; Karakatsanis et al., 2017). On the other hand, this approach brought some new challenges related to data analysis as a huge scale of data sets poses the challenge of efficiently mining valuable information from unstructured job-description texts. For smaller sample sizes, a combination of qualitative and quantitative content analysis methodologies, as described by Ahasan and Ho (2022), were employed, for example, utilizing NVivo software for data coding. Conversely, in cases involving larger sample sizes, data mining techniques emerged as notably beneficial and increasingly applied. Some pioneering works (Karakatsanis et al., 2017) used automatic text-mining methods to extract the major dimensions of competencies as presented in job description texts. Karakatsanis et al. (2017) demonstrated the general usefulness and applicability of the Latent Semantic Indexing (LSI) model for highlighting job trends in different industries and geographical areas, as well as for identifying occupational clusters or temporal changes in job markets.

Other studies, e.g., Zeng et al. (2020), applied topic modelling methods, a commonly used text-mining (data-mining) approach. In their study, Zeng et al. (2020) used a large data set of 243,521 job advertisements that covered nearly the whole online job market for construction PMs in China over one year, in order to track the demands for competencies at an industry level. In their research, a text-mining method called structural topic model (STM) was used to analyse the descriptions of the PM competency requirements to identify the major competency dimensions emphasized in the advertisements.

As the literature review demonstrates, the utilization of job advertisements for PM recruitment provides an avenue for analysing extensive data sets, facilitating an in-depth understanding of employer expectations regarding the essential competencies for a given position. It seems inevitable that the advancement of data-mining techniques and artificial intelligence concurrent with the escalating volumes of data, will allow for not only the acceleration of analyses but also the generation of innovative insights and predictions.

4. Research method

The research process was structured into four distinct stages. The initial stage focused on data collection, targeting websites associated with the IT industry in Poland. Key platforms for this purpose included NoFluffJobs, JustJoinIT, and BullDogJob. NoFluffJobs is notable for requiring salary ranges in job postings, thereby providing valuable compensation data. JustJoinIT differentiates itself by featuring a map pinpointing job location, while BullDogJob allows for the submission of company reviews alongside job listings. This data collection phase involved weekly visits to these three websites over the first quarter of 2023, commencing on January 15th and concluding with the final data retrieval on April 16th, 2023. The data was compiled in both HTML and PDF formats, contingent on the offerings of each website. For the purposes of this study, all job postings categorized under 'project manager' or 'project management' were included. This resulted in an aggregate of 270 job postings, with 48 sourced from BullDogJob, 105 from JustJoinIT, and 117 from NoFluffJobs.

The second stage entailed extracting data from the accumulated files utilizing the Python programming language. This step was instrumental in standardizing the diverse data formats into a unified Microsoft Word document, thereby facilitating subsequent analytical procedures. To ensure the integrity and accuracy of the data, a manual verification process was implemented. This process involved meticulously cross-referencing the content of the Word document with the original files to confirm the consistency and correctness of the extracted information.

The subsequent stage involved an in-depth analysis utilizing ChatGPT 4.0, a generative AI software. This tool played a pivotal role in augmenting examination of job offers collated in the earlier stages. The use of generative AI in text mining proved advantageous, enabling multi-faceted analysis with minimal researcher intervention. ChatGPT 4.0 individually assessed all 270 job postings, extracting and interpreting required competencies as per the standards outlined in IPMA ICB 4.0. This analysis encompassed various dimensions including compensation, contract types (either employment or B2B [business-to-business] cooperation), requisite seniority levels (junior, middle, senior), work arrangements (remote, on-site, or hybrid), and congruence with IPMA ICB 4.0 competencies. Additionally, the availability of

each job offer was documented. All gathered data was systematically consolidated into an Excel spreadsheet for ease of interpretation. Regarding compensation, figures were standardized in PLN on a monthly basis. Job offers originally listed in EUR were converted to PLN using a conversion rate of 4.47, and rates presented on a daily or hourly basis were recalculated to reflect a monthly equivalent, assuming nineteen working days per month. This comprehensive data set facilitated the identification of the most in-demand and least required competencies within the IT job market.

The concluding phase of this research involved utilizing ChatGPT 4.0's generative AI capabilities to cluster the 270 job offers based on required competencies. This step highlighted the profound efficacy of ChatGPT in handling complex data set analyses. The performance of ChatGPT in this context mirrored the capabilities of established commercial software, as noted by Peng et al. (2023). A notable feature of ChatGPT is its adaptability in processing various input forms, including attachments and its integration with specialized plugins. The 'AskYourPDF' plugin, for instance, facilitated the efficient interpretation of PDF files, especially those with straightforward formatting. Similarly, the 'Advanced Data Analysis' plugin also allowed for the effective handling of more complex documents. The versatility and evolving nature of ChatGPT are evident in its frequent updates, which occur approximately every two to four weeks, continually enhancing its analytical prowess. This dynamic evolution positions ChatGPT as a robust tool in the realm of data analysis, particularly in clustering job offers based on competency requirements, as demonstrated in this research.

Figure 1 schematically represents the research process, which has been detailed in the preceding text.

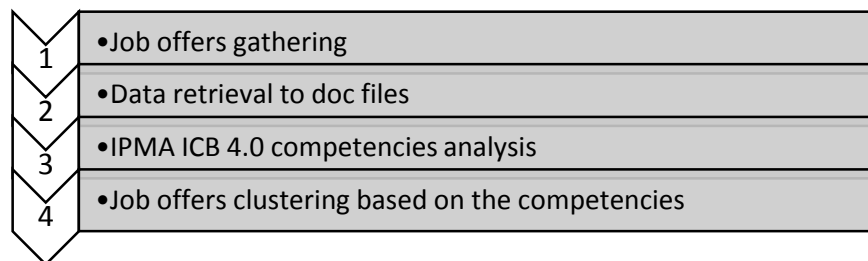


Figure 1. Data analysis procedure.

Source: Own elaboration.

It is crucial to recognise several restrictions related to the application of generative AI, particularly ChatGPT, in analytical processes. A key aspect requiring vigilant user oversight is ChatGPT's propensity for 'hallucinations', as identified by McKenna et al. (2023). These inaccuracies arise from the AI's reliance on patterns of memorization and term frequency inherent in its training model. Another significant factor is the 'discussion temperature', a concept discussed by Peng et al. (2023), which governs the level of creativity in ChatGPT's responses. A lower discussion temperature correlates with reduced creativity, yielding more precise and factual outputs. In our analysis, given the emphasis on accuracy and relevance to

the compiled data, the discussion temperature was set to zero. This setting was chosen to maximize the precision of ChatGPT's responses, aligning with the analytical objectives of this study.

5. Research results

The empirical research analysis reveals a diverse interpretation of the PM role within the job market. The job offers which were examined not only reflect varied expectations of PM competencies, but also exhibit a range of cooperation modalities, compensation structures, and work conditions. This diversity underscores the multifaceted nature of the PM role and highlights the heterogeneity in employer expectations and job offer characteristics in this field.

The initial stage of our analysis is descriptive in nature. Of the 270 job offers analysed, 105 provide options for either employment or contractual engagement. Specifically, 99 offers are exclusive to a B2B cooperation model, while 66 are solely for employment contracts. A notable divergence is observed in the remuneration ranges between these two models. For employment contracts, the salary ranges are generally lower compared to the B2B options; the minimum salary offered is consistent across both models at 4000 PLN per month. However, the maximum salary for B2B contracts significantly surpasses those of employment contracts, reaching over 56,000 PLN as opposed to the latter's 30,000 PLN maximum. This disparity is also reflected in the median salaries, as detailed in Table 1. These findings align with expectations considering the different financial implications for companies in terms of cost deductions associated with each employment model.

Table 1.

Remuneration comparison for B2B and CoE cooperation models

Description	B2B (in PLN)	CoE (in PLN)
Minimum	4 000	4 000
Lower bound median	14 000	10 830
Higher bound median	20 000	16 000
Maximum	56 060	30 000

Source: Own elaboration.

Regarding the work models, there are three options described in the job description: remote work, stationary, and hybrid. The most popular is the remote option – indicated in 145 out of 270 job offers, while only 20 required a fully stationary way of working. Seniority is another interesting element: there were only 23 job offers that junior PMs were searching for, while 126 were middle (regular) and 121 with senior expertise in the project management area.

Leveraging the capabilities of ChatGPT 4.0, the job offers were methodically analysed for alignment with the IPMA ICB 4.0 competency framework. Each job offer was scrutinized to ascertain whether specific competencies were referenced within the job description.

This thorough analysis culminated in the creation of a comprehensive list of competencies, which is displayed in Table 2. This table categorizes the competencies within their respective competency areas and ranks them according to their frequency of occurrence in job descriptions. Such an arrangement offers a clear and quantifiable insight into the most sought-after competencies in the project management job market.

Table 2.
IT PMs' competencies as indicated in the job offers

Competency area	Competency	Number of job offers containing the competency
Practice	Plan and Control	264
	Stakeholder	249
	Organization and information	245
	Requirements and objectives	232
	Scope	228
	Time	219
	Resources	210
	Quality	166
	Risk and opportunity	161
	Change and transformation	145
	Project design	139
	Finance	132
	Procurement	30
People	Personal communication	264
	Relations and engagement	240
	Teamwork	226
	Leadership	220
	Results orientation	203
	Resourcefulness	189
	Self-reflection and self-management	165
	Personal integrity and reliability	110
	Negotiation	58
	Conflict and crisis	40
Perspective	Governance, structures, and processes	173
	Culture and values	142
	Strategy	133
	Compliance, standards, and regulations	61
	Power and interest	20

Source: Own elaboration.

Table 2 showcases that within each competency area, certain competencies are notably prevalent. 'Plan and control' and 'Personal communication' are the most frequently mentioned, appearing in 264 out of the 270 job offers analysed. Additionally, 'Governance, structures, and processes' is also significant, leading in the area of 'Perspective' competency, being mentioned in 173 offers. Notably, the 'Practice' competency area exhibits the highest average occurrence rate, standing at 178.46, with 'Plan and control' being the predominant competency. The 'People' competency area follows closely, with an average occurrence of 171.50. In contrast, the 'Perspective' competency area registers the lowest average occurrence at 105.8. The marked disparity between the 'Perspective' area and the others underscores the greater emphasis placed on 'People' and 'Practice' competencies in the project management job market.

Furthermore, the analysis extended to grouping the identified competencies into clusters, forming distinct competency profiles. These clusters were created upon the relative importance of specific competencies within the context of each job offer. This nuanced classification was enabled by ChatGPT's analysis, which took into account not only the presence of a competency, but also its level of necessity—distinguishing between essential requirements and those merely considered as 'nice to have.' As a result of this in-depth analysis, ChatGPT identified nine distinct clusters, numbered from 0 to 8. The characteristics of each cluster, including the specific competencies that define them and their relative importance within the job market, are visually represented in Figure 2. This figure, generated by the generative AI tool, provides a clear graphical representation of the competency clusters, offering an insightful overview of the competency landscape in IT project management speciality.

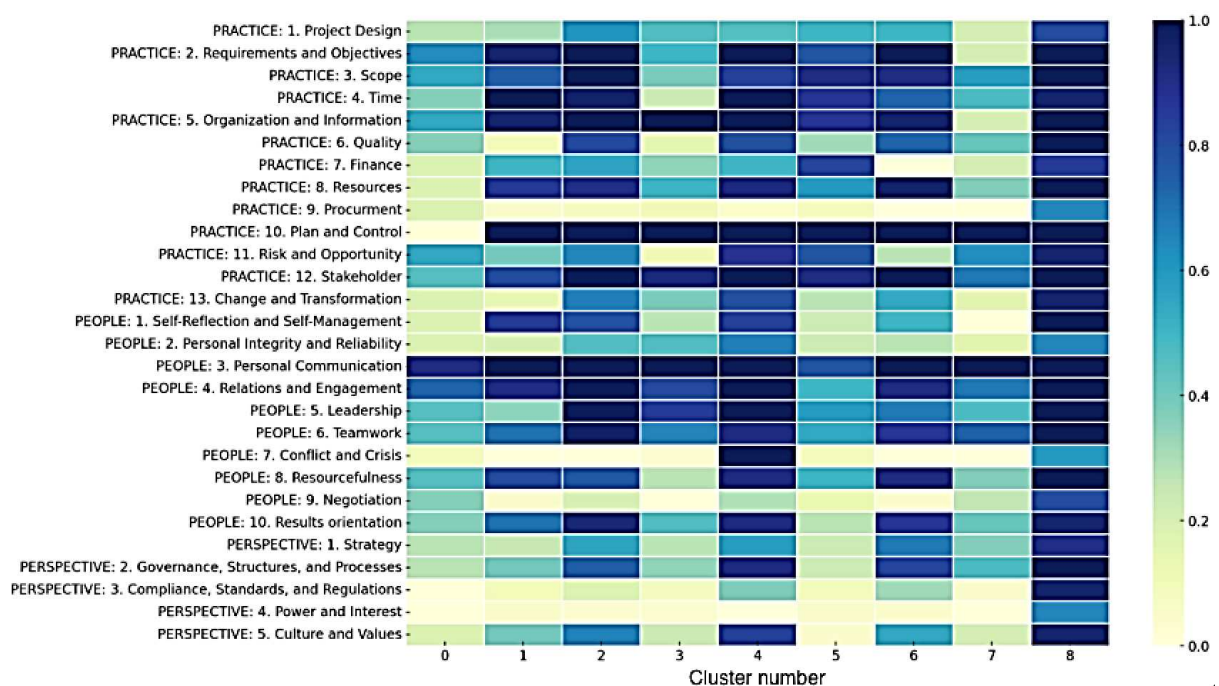


Figure 2. Cluster competency characteristics in detail.

Source: Own elaboration.

The analysis of the competency matrix yields several key insights. Notably, 'Personal communication' emerges as a universally required competency across all identified profiles. This observation strongly emphasizes the need for excellent communication skills in PMs, irrespective of their specific profile. On the other end of the spectrum, competencies such as 'Power and interest' as well as 'Procurement' are considerably less prominent, with their significance primarily confined to the eighth profile. Additionally, it is intriguing to note the relatively subdued emphasis on 'Negotiation' as well as 'Conflict and Crisis' competencies within the job market, based on this research. Such findings provide valuable indications about the competencies currently prioritized in the IT project management field.

The competency profiles discerned through the research highlight the feasibility of identifying distinct sets and combinations of project management competencies. These profiles, each uniquely characterized by a specific assemblage of competencies, have been succinctly described and named in Table 3. Additionally, this table includes the number of job offers corresponding to each profile, providing a quantitative perspective on the prevalence of these profiles within the job market. This detailed categorization not only aids in understanding the various competency demands in the field of project management but also illustrates the diverse expectations of employers in the IT industry.

Table 3.
PM competency profiles – description and structure

Profile	Denomination	Number of job offers	Description
0	Entrant	11	This cluster can be perceived as a starting point for junior PMs.
1	Project objectives oriented	20	The most important requirements are competencies related to project objectives such as scope and time, as well as planning and organizing.
2	Team management oriented	106	PMs here are expected to be team players with competencies related to leadership and teamwork.
3	Essential and team-oriented	26	PM competencies are focused on communication and organization.
4	Team management and governance	24	Communication and teamwork are strongly underlined with quite strong governance, as well as culture and values.
5	Team manager and member	22	Competencies appear to be a good fit for a project team member where the PM role is separated from the team and the leader.
6	All-embracing	22	Expected middle-level competencies, but with an orientation towards leadership and governance.
7	Relation-oriented	19	This profile is focused on communication and relationship competencies.
8	Completely professional	20	High competency is required in all of the areas.

Source: Own elaboration.

The market analysis indicates a relatively balanced demand for the various competency profiles identified, with each profile being nearly equally sought after by employers. An exception to this trend is observed in profile 2, which uniquely represents a middle-level competency across various areas yet is distinguished by a pronounced emphasis on project objectives and teamwork. In contrast, profile 0 predominantly aligns with junior-level PMs and is associated with the lowest salary ranges. At the opposite end of the spectrum, profile 8 stands out, demanding high-level competencies across the board: correspondingly, job offers within this profile tend to offer the highest salary ranges. This range of profiles from junior to highly experienced levels, each with its distinct competency and salary range, illustrates the diverse spectrum of roles and expectations in the IT project management job market.

6. Discussion

PM competencies are a pivotal element in determining project success. However, these requirements are often not explicitly defined, leading to ambiguity for aspiring PMs in assessing whether their skills align with the role. Additionally, there is a challenge in identifying the areas in which they may need further development. Traditionally, research in this field has predominantly relied on interviews and questionnaires. This approach, while valuable, may not fully capture the actual competencies that companies seek, as evidenced by job offer analysis. The discrepancy between the competencies professed by PMs and those actively sought by employers in job postings can provide unique insights. This underlines the importance of diversifying research methodologies in this domain to include analysis of job market data, which offers a more direct reflection of the IT industry's current competency demands.

In summarizing the findings from the empirical research conducted, it becomes evident that certain competencies are highly sought after in the job market. The most critical competencies, featured in at least 80% of those job offers analysed, predominantly fall within the 'Practice' and 'People' categories, as delineated in the IPMA ICB 4.0 framework. Within the 'Practice' area, competencies such as 'Plan and Control', 'Stakeholder', 'Organization and Information', 'Requirements and Objectives', 'Scope' and 'Time' are particularly emphasized. Similarly, the 'People' category is also in high demand, with competencies like 'Personal Communication', 'Relations and Engagement', 'Teamwork', and 'Leadership' being notably prominent. These insights directly contribute to addressing the first research question, shedding light on the specific competencies that are most valued within the current project management job market.

The analysis of these job offers led to the identification of nine distinct PM profiles, underscoring the versatility and importance of this role across various companies in the IT industry. A key finding from this analysis is the paramount importance of communication skills for PMs. This competency emerged as a consistently high priority across those profiles identified. Additionally, the analysis revealed that a fully professional profile, likely signifying a requirement for extensive experience and senior-level expertise, is sought in 20 of the 270 job offers. This highlights a notable demand in the market for PMs who possess a depth of experience and advanced skills, reinforcing the value placed on seasoned professionals in this field.

The research undertaken substantiates the pivotal significance of the PM role within the IT industry, illustrating that it is perceived and defined in various ways by different employers. The volume of job offers analysed in this study indicates a robust demand, particularly for individuals with 'regular' (mid-level) and 'senior' level expertise. This trend highlights the IT industry's rigorous standards, emphasizing the need for staff who not only possess substantial expertise but also demonstrate the potential for further professional development. The industry's

inclination to engage personnel who are both highly skilled and trainable at a significant rate reflects its commitment to continuous improvement and adaptation in a fast-evolving technological landscape.

7. Contribution and concluding remarks

In conclusion, our research contributes significantly to the understanding of project management competencies in the IT industry in several ways: (1) comprehensive competency analysis: by analysing a large data set of job advertisements, our study uncovers the competencies demanded for PMs in the IT industry. This level of detail and breadth was unattainable with smaller datasets, thereby offering a more comprehensive view of the demand side of the market. (2) Diversity of PM profiles: the study identifies nine distinct PM profiles, each with its unique competency requirements. This highlights the diverse range of competencies sought in the market, with strong communication skills being a common thread across all profiles. (3) Methodology for monitoring industry demands: we propose a innovative method for tracking the evolving demands of the IT industry for PMs by analysing job market advertisements. This approach not only provides current insights but also serves as a potential inspiration for future research endeavours. (4) Innovative use of generative AI in data mining: the application of generative AI for data analysis represents an innovative aspect of our research. This approach has enabled the rapid processing of large data sets and the discovery of patterns and correlations that might be less apparent to human analysis.

From a practical standpoint, our study introduces a tool designed for talent management, tailored to bridge the gap between the specific demands of IT firms and the competencies of individual PMs. This tool is not only beneficial for organizations in aligning their recruitment and development strategies with market demands but also offers significant value to individuals aspiring to enter the project management profession. By providing insights into the current competency requirements in the IT industry, it enables prospective PMs to tailor their skill sets accordingly and chart a strategic path for their career development. This dual applicability enhances the utility of our research, making it a resource for both corporate talent management and individual career planning.

The findings of our analysis open several avenues for future research. Given the rapid development and increasing popularity of generative AI, its application in data mining, particularly with large data sets, is becoming more efficient and valuable. Future studies could replicate our methodology to track changes in the IT job market over time, providing comparative insights as the market evolves. Additionally, this approach can be extended to analyse other professional roles, potentially uncovering unique market trends and competency demands in different fields. Moreover, a comparative study incorporating traditional research

methods, such as interviews or questionnaires, could be insightful. Such a comparison would enable a deeper understanding of the market's competency requirements versus the competencies currently possessed by professionals. This could highlight potential gaps in project management education and training, suggesting areas for curricular development to better prepare future PMs for the demands of the IT industry.

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